

ISSN 1682-6566

AGRICULTURAL RESEARCH FOR ENHANCING LIVELIHOOD OF NEPALESE PEOPLE

Proceedings of 2nd SAS-N Convention, 30 July - 1 Aug 2003 Kathmandu

Bal K Joshi, Samundra L Joshi and Krishna P Paudyal, Editors



SAS-N



AGRICULTURAL RESEARCH FOR ENHANCING LIVELIHOOD OF NEPALESE PEOPLE

Proceedings of 2nd SAS-N Convention, 30 July - 1 Aug 2003, Kathmandu

Bal K Joshi¹, Samundra L Joshi² and Krishna P Paudyal³, Editors

¹ Agriculture Botany Division, NARI, Khumaltar, Kathmandu

² Entomology Division, NARI, Khumaltar, Kathmandu

³ Animal Health Research Division NASRI, Khumaltar, Kathmandu

Society of Agricultural Scientists-Nepal (SAS-N)

© SAS-N, 2004, December

Society of Agricultural Scientists-Nepal (SAS-N)
C/o National Animal Science Research Institute, Khumaltar
PO Box: 3733 Kathmandu Nepal
Phone: 5524040
Fax: 5521197
Email: nasri@wlink.com.np

Citation

Joshi BK, SL Joshi and KP Paudyal, eds. 2004. Agricultural research for enhancing livelihood of Nepalese people. Proceedings of 2nd SAS-N Convention, 30 July - 1 Aug 2003 Kathmandu.

FOREWORD

Agriculture is the livelihood of majority of the Nepalese people and this is consistently moving ahead independently throughout the country. Research and development on agriculture contribute significantly to meet the goals and objectives set in UN Millennium Development Goal (MDG), 10th five year plan (2059-064) and World Trade Organization (1995). Long term Agriculture Perspective Plan (APP) (2052/53-2071/72), NARC Vision for 20 years (2002) and National Agriculture Policy (2061) were developed and formulated for better management of agriculture business. With the aim of reviewing the progress and problems in agricultural research and development, SAS-N organized a convention second time with the theme of Research for Enhancing Livelihood of Nepalese People from 30 July - 1 Aug 2003 in Kathmandu.

Organizing a convention at certain interval does not only provide a forum for sharing research results but also strengthen the scientists' capacity in agriculture research and development. This convention was multi-sectoral and relatively the number of papers presented was significantly higher than the earlier conventions. Most of the papers were from Nepal Agricultural Research Council however participants were from different governmental and non governmental organizations. Recommendations made during this convention are very useful for strengthening the agriculture business in Nepal.

This proceedings, which cover all agricultural sectors is a valuable resource for researchers, development workers, planners and farmers. Hopefully, it would be of much significance to all related scientists, professionals and technicians as well. The findings after investing money, time and scientists' efforts are contributing to increase the agricultural productivity which helps ultimately to reduce the poverty and to secure the food.

Mr. BK Joshi, SL Joshi and KP Paudyal deserve our special thanks for their commendable editorial works. Our sincere congratulation is due to all the authors for their invaluable papers. Thanks are also due to Mr. DMS Dongol and Mrs. Ganga Shrestha for their painstaking support of word processing of the entire document.

Dr. Madhav Joshi
General Secretary
Society of Agricultural Scientists-Nepal

Preface

The Society of Agricultural Scientists Nepal (SAS-N) is a professional organization that serves as a common forum for the agricultural scientists and researchers in Nepal. The society organizes its convention in every 3-year interval. The First Convention was held on 29-31 March 1999 and the proceedings of first convention has been a reliable source of scientific information on agriculture. The Proceedings contained 46 papers. Further to SAS-N progression, this publication is the outcome of the Second Convention held on 30 July-1 Aug 2003, organized by SAS-N and NARC. The theme of the Second Convention was 'Agricultural research for enhancing livelihood of Nepalese people' with the sub-themes focusing on poverty reduction/income generation, food security, environment, gender and equity consideration, agro-biodiversity, linking research with development, technology transfer, commercialization and resource management.

A total of 101 papers on different research works and current issues were presented in different disciplinary sessions namely: 1) Agronomy, Soil and Agri-Engineering, 2) Plant Protection, 3) Horticulture, 4) Plant Breeding and Biotechnology, 5) Animal Science and Fisheries, 6) Socio -economics and Miscellaneous and 7) Cross-cutting, each session followed by discussion and suggestion. In this document the presented papers are grouped under 13 headings: invited papers (2), agri-engineering (3), agronomy (23), biotechnology (4), entomology (4), plant breeding (17), pathology (8), soil science (1), animal breeding and management (6), animal health and nutrition (6), fishery (8), pasture and fodder (2) and socio-economics (6). The papers were presented by the participants from NARC, DOA, DLS, CEAPRED, IAAS, CIMMYT, Helvatas and others covering important organizations working on agricultural research and development in the country. Majority of the papers present research results and others are review. Among the papers presented, full texts of the eight papers are not included in this proceedings for the reason they were not submitted within the stipulated time, however their abstracts are published. In addition, description of other events and outcomes of the convention are included. We believe, this document would be very useful to policy makers, extension workers, scientists/researchers involved in agriculture and some farmers. This will also help disseminate the national information on agricultural research system of the country in international arena.

We would like to thank the executive committee officials of SAS-N, specifically Dr Adarsh Pradhan for giving us an opportunity to review and edit these papers. All contributors (authors) deserve high appreciation for their hard working in writing papers and presenting the research findings. We are thankful for the encouragement and advice we received from Ashok Mudwari, Hari P Bimb, Madhusudan P Upadhyay, Buddhi Raj Khadge, Fanindra P Neupane and helps from BB Khatri, YR Pandey, BP Sharma, AP Nepal, K Manandhar, G Raut and J Thapa. We acknowledge the co-operation we received from all scientists, researchers and SAS-N members. Finally we wish to thank DMS Dongol and G Shrestha for word processing and formatting the manuscripts in this form.

Editors

BK Joshi
SL Joshi
KP Paudyal

Contents

INVITED PAPERS

1.	Food security and poverty reduction in the context of the 10 th 5 year plans <i>SL Chaudhary</i> -----	1
2.	Prospects of botanical pest management in Nepal <i>FP Neupane</i> -----	6

AGRI-ENGINEERING

3.	Development and testing of low cost solar dryer for drying agricultural commodities <i>S Shrestha and RG Rasaily</i> -----	11
4.	Improved tubular corn sheller: Appropriate drudgery reducing agricultural equipment for maize growers <i>KB Shrestha, SK Adhikary, RG Rasaily and GL Shrestha</i> -----	15
5.	Testing and evaluation of mini SRR dryer in Nepal for rice crop <i>GB Manandhar, R Rasaily, GL Shrestha and RR Bakker</i> -----	19

AGRONOMY

6.	A review on management of fruit drop in mango and citrus <i>IP Gautam</i> -----	28
7.	Adoption of Boro rice in Parsa and Bara <i>KP Bhurer, DB Gharti, G Sah, ML Sah and S Justice</i> -----	33
8.	Appropriate plant spacing for cauliflower intercropping under maize <i>PP Khatriwada</i> -----	36
9.	Assessment of factors responsible for yield decline in Toria <i>TB Ghimire</i> -----	41
10.	Cultivation of medicinal and aromatic plants in Nepal: An overview <i>TP Barakoti</i> -----	47
11.	Effect of enriched CO ₂ on rice under open top chamber condition at Khumaltar <i>K Sherchan, S Shrestha and A Sharma</i> -----	60
12.	Effect of sprout manipulation of diffused light stored seed potatoes on subsequent field growth and tuber yield at Lumle <i>BK Dhital and SJ Wilcockson</i> -----	67
13.	Effect of time of grafting and budding on trifoliate rootstocks for mandarin orange saplings production <i>IP Gautam, DN Sah and B Khatri</i> -----	78
14.	Effects of sulphur levels on onion (<i>Allium cepa</i>) bulb production in acid soils of Malepatan <i>BH Adhikary, MS Ghale, BB BC, C Adhikari and DB Ranabhat</i> -----	82
15.	Effects on the cabbage (<i>Brassica oleraceae</i> var. <i>capitata</i>) head production to different molybdenum levels in acid soils of Malepatan <i>BH Adhikari, MS Ghale, C Adhikari and BB BC</i> -----	85
16.	Efficacy of growth regulators on in vitro microtuberization of potato (<i>Solanum tuberosum</i> L.) under different incubation conditions <i>BM Sakha and AK Bhatiya</i> -----	88
17.	Evaluation of rootstocks on mandarine (<i>Citrus reticulata</i> Blanco) with respect to vigor and citrus decline in Pokhara <i>TK Lama and PP Shrestha</i> -----	89
18.	Exploration of saffron (<i>Crocus sativus</i> L.) cultivation under high hill condition <i>BN Chaudhary and YR Pandey</i> -----	92

19.	Farmers' perception and reactions to various green manure species: Results of a participatory research conducted in Chitwan and Nawalparasi districts <i>DP Sherchan, B Emmett, P Stevens and FL Sinclair</i> -----	97
20.	Identification of appropriate planting time for rainy season tomato production in the hills of Nepal <i>KP Upadhyay, KB Paudel, IP Gautam, JN Chaudhary and B Khatri</i> -----	98
21.	Improving manure quality and its use in maize and upland rice production in the hills of western Nepal <i>BP Tripathi and JE Jones</i> -----	105
22.	Potential of promising varieties of garden pea in relation to determinant characters, the efficiency of green pod yield and monetary returns under the mid-hills environment of Dailekh <i>TB Poon, HN Regmi, BB Pokhrel, OB Oli and SR Sharma</i> -----	111
23.	Present status of cole crops cultivation in hills of Nepal <i>S Piya and PP Khatiwada</i> -----	115
24.	Productivity and profitability measurement of potato crop under rice-based cropping sequences <i>BB Khatri, SL Shrestha, GP Rai and D Chaudhari</i> -----	121
25.	Relative response of potato cv Desiree with N and K nutrients <i>SL Shrestha, BB Khatri, GP Rai and D Chaudhari</i> -----	126
26.	Response of cabbage to nitrogen and phosphorus during rainy season in high hills <i>PP Khatiwada and S Piya</i> -----	131
27.	Response of red creole onion sets to different planting dates on off season production under the mid hill conditions of Dailekh <i>TB Poon and HB Regmi</i> -----	137
28.	Role of sucrose on vase life of cut spike of <i>Gladiolus</i> cv Pacifica <i>HN Regmi and G Upreti</i> -----	141

BIOTECHNOLOGY

29.	Buckwheat diversity in Nepal in the context of morphological, biochemical and molecular analysis <i>HP Bimb</i> -----	146
30.	Embryo culture for inter specific hybridization in the genus <i>Oryza</i> : A simplified technique of hardening improves the field plant establishment <i>RK Niroula, LP Subedi, RC Sharma and MP Upadhyay</i> -----	147
31.	Study on <i>Ziphinema americanum</i> (Nematode: longidoridae) group by DNA fingerprinting <i>KK Bhattarai and M Maurice</i> -----	153
32.	Transgenic plants: A source for edible vaccines <i>HK Prasai</i> -----	154

ENTOMOLOGY

33.	Comparative toxicity of some botanical products against corn grain weevil, <i>Sitophilus zeamais</i> (Mostch.) under storage condition <i>YP Sah</i> -----	161
34.	Effect of different doses of Bojo (<i>Acorus calamus</i> L.) rhizome dust against weevil on stored wheat grains <i>RB Paneru, VR Duwadi, R Khanal and YP Giri</i> -----	169
35.	Monitoring field status of naturally occurring egg parasitoids of citrus green stink bug, <i>Rhynchocoris humeralis</i> Thunberg and their identification <i>R Manandhar, PN Sharma and SR Devkota</i> -----	174
36.	Population dynamics of citrus psylla (<i>Diaphorina citri</i> Kuwayarna) in the western hills of Nepal and spread of citrus greening disease <i>R Manandhar, S Malla and DN Sah</i> -----	178

PLANT BREEDING

37.	Agro-morphological characterization of common bean (<i>Phaseolus vulgaris</i> L.) at Jumla <i>RK Neupane, R Shrestha, ML Vaidya and EM Bhattarai</i> -----	187

38.	Characterization and evaluation of indigenous garlic (<i>Allium sativum</i> L.) germplasms of Nepal <i>RB KC, MD Sharma, DM Gautam and DR Panthee</i> -----	196
39.	Chickpea improvement in Nepal: Progress and prospect <i>NK Yadav and DN Pokhrel</i> -----	200
40.	Correlation and path analysis in F ₁ and F ₂ generation of garden pea <i>DK Choudhary and RR Sharma</i> -----	204
41.	Evaluation of cauliflower varieties and their planting dates for commercial production under Jumla agro-ecological condition <i>YR Pandey</i> -----	207
42.	Identification of suitable wheat genotypes for far western high hills of Nepal <i>ML Vaidya</i> -----	211
43.	Identification of suitable rice genotypes for high altitude region of Nepal <i>ML Vaidya</i> -----	214
44.	Improvement of banana productivity through varietal and husbandry practices in the western hills of Nepal <i>YR Pandey, DN Sah and AB Pun</i> -----	216
45.	Participatory plant breeding in rice: Experience of National Rice Research Programme, Hardinath <i>B Chaudhary, S Gyawali, KD Joshi, SP Khatriwada, K Shrestha, A Mudwari, MP Upadhyay, BK Joshi, BR Sthapit and HK Shrestha</i> -----	222
46.	Performance of bush type French bean in the hills of Nepal <i>KB Paudel, JN Chaudhary, IP Gautam, KP Upadhyay and B Khatri</i> -----	227
47.	Performance of cauliflower varieties under different agro-ecological domains of western hills of Nepal <i>AB Pun, YR Pandey and YP Yadav</i> -----	235
48.	Performance of true potato seed progenies for transplanted crop in eastern Tarai <i>RC Adhikari and DK Chaudhary</i> -----	239
49.	Performance of vegetable soybean in the hills of Nepal <i>KB Paudel, JN Chaudhary, IP Gautam, KP Upadhyay and B Khatri</i> -----	244
50.	Production potential of different pea (<i>Pisum idvum</i> L.) genotypes in acid soils of Malepatan <i>MS Ghale, BH Adhikari, BB BC and C Chaudhary</i> -----	249
51.	Rice genepool for mid and high hills and its conservation in Nepal <i>BK Joshi</i> -----	252
52.	Status of agro-biodiversity in Upper Arun River valley, Sankhuwasabha <i>KB Karki and BK Joshi</i> -----	265
53.	Varietal performance of Boro rice at Regional Agriculture Research Station, Parwanipur <i>KP Bhurer, ML Shah, MP Shah and DB Gharti</i> -----	271
PLANT PATHOLOGY		
54.	Assessment of <i>Helminthosporium</i> leaf blight of wheat under different resource conserving technologies in rice-wheat system <i>DB Gharti, G Sah and JB Prasad</i> -----	279
55.	Diversity and population dynamics of soil fungi in resource conserving technology of rice- wheat systems in Nepal <i>S Sharma, E Duveiller, M Rutherford, G Shah, D Sharma and DB Gharti</i> -----	282
56.	Guava decline or wilt caused by <i>Fusarium oxysporiu</i> fsp. <i>sidii</i> in Pokhara Nepal <i>TK Lama</i> -----	292
57.	Identification of suitable approaches for controlling blue mould disease in cellar store <i>KP Upadhyay, KB Poudel, IP Gautam, DN Sah, JN Chaudhary and B Khatri</i> -----	294
58.	Integrated disease management of potato through farmer field school: A new approach in participatory technology transfer in Nepal <i>TL Lama</i> -----	302
59.	Literature review on stalk rot disease of cauliflower in Nepal <i>DP Dhakal</i> -----	310
60.	<i>Phyllosticta</i> leaf spot disease of ginger: Management and its economic analysis under mid hill conditions of Nepal <i>BP Sharma and JR Acharya</i> -----	318

61.	Status of Diseases of large cardamom in Nepal <i>DP Dhakal and SK Shrestha</i> -----	---	324
SOIL SCIENCES			
62.	Estimation of plant nutrients content in biogas slurry and losses during handling <i>KB Karki</i> -----	---	330
ANIMAL BREEDING AND MANAGEMENT			
63.	Blending and evaluation of angora wool to produce high quality products <i>D Neupane and T Dhaubhadel</i> -----	---	335
64.	Effect of space density on white leghorn <i>SB Shrestha</i> -----	---	338
65.	Hill goat selection programme in the eastern Nepal <i>PK Pokharel and SP Neopane</i> -----	---	345
66.	Indigenous buffaloes of Nepal: Status of their improvement <i>SP Neopane and K Mishra</i> -----	---	346
67.	Production performance of turkey at Parwanipur <i>M Karki, T Dhaubhadel and NP Osti</i> -----	---	347
68.	Selection for nematode resistance: An alternative approach for parasite control in sheep <i>BS Shrestha</i> -----	---	353
ANIMAL HEALTH AND NUTRITION			
69.	Assessment of quality frozen semen used for artificial insemination <i>KP Paudel, A Shah, LP Ghimire and BR Joshi</i> -----	---	362
70.	Efficacy of Titepati (<i>Artemesia vulgaris</i>), Lazzabati (<i>Mimosa pudica</i>) and Supari (<i>Areca catechu</i>) against gastrointestinal nematodes of goats <i>SR Aryal and SP Shrestha</i> -----	---	366
71.	In vitro nuclear chromatic decondensation test: A quick method of assessing sperm nuclear quality <i>KP Paudel and S Kumar</i> -----	---	369
72.	Optimizing growth potential of indigenous Khari and Sinhal goat breeds of Nepal with health and nutrition management <i>BR Joshi, BS Shrestha and K Mishra</i> -----	---	370
73.	Replacement of maize by wheat with supplemental methionine and lysine for broiler production in low protein diets <i>NP Osti, SK Khanal and MR Tiwari</i> -----	---	377
74.	Study on some epidemiological aspects and treatment of bovine piroplasmosis in Morang district of Nepal <i>M Neopane, SN Deo, SP Shrestha and MR Acharya</i> -----	---	381
FISHERY			
75.	A case study on participatory approach of Phewa lake fisheries management, research and conservation for livelihood improvement of fishers in Pokhara, Nepal <i>TB Gurung, SK Wagle, JD Bista, RP Dhakal, PL Joshi, R Batajoo, P Adhikari, AK Rai</i> -----	---	382
76.	An outbreak of <i>Aeromonas caviae</i> infection in rainbow trout fish at Godawari <i>A Rayamajhi</i> -----	---	393
77.	Brood fish management status and suggestions to control inbreeding in carp hatcheries in Nepal <i>SK Wagle and N Pradhan</i> -----	---	398
78.	Cage culture of rainbow trout (<i>Onchorynchus mykiss</i>) in stagnant water of lake and reservoir <i>JD Bista, TB Gurung, SK Wagle, GB Karki and RP Dhakal</i> -----	---	406
79.	Cold water mountain aquaculture: Technology adoption and livelihood in Nepal <i>SR Basnet, GP Lamsal, PL Joshi, AK Rai and TB Gurung</i> -----	---	412
80.	Cryopreservation and its implication for fish seed production <i>SR Basnet, GP Lamsal and AP Nepal</i> -----	---	418
81.	Growth performance and quality of meat in relation to nutrient level of rainbow trout fed on different protein level diets <i>AP Nepal, GP Lamsal, N Pradhan and SK Shrestha</i> -----	---	422

82.	Qualitative analysis of post harvested fish <i>K Bajracharya and NK Roy</i> -----	---	427
PASTURE AND FODDER			
83.	Diversity of fodder and grasses in Sankhuwasabha <i>BK Joshi and KB Karki</i> -----	---	432
84.	Seed production of oat varieties in relation to cutting management under rainfed condition <i>M Karki and BR Banstola</i> -----	---	442
SOCIO-ECONOMICS			
85.	A review on ten years (1991-2000) outreach research findings of Horticultural crops in research command area of ARS, Lumle <i>AB Pun and YR Pandey</i> -----	---	447
86.	A socio economic survey on evaluation of technology transfer on soil fertility from farmers to farmers in the western hills of Nepal <i>MB Nepali, KR Joshi and BB Pant</i> -----	---	457
87.	Addressing poverty reduction through agricultural research <i>YN Ghimire, TP Pokhrel, HK Shrestha and RB Bhujel</i> -----	---	462
88.	Biological and socio economic verification of cross breeds Pakhribas pig for wider adoption and adaptation in the eastern hills <i>MP Aryal and P KC</i> -----	---	469
89.	Diagnosis of yield stagnation problem in rice in Sunsari and Morang irrigation project area <i>HK Shrestha, YN Ghimire, P Thakur, DK Chaudhary and EM Bhattarai</i> -----	---	473
90.	Farmer to farmer diffusion: Technology dissemination approaches in diverse environments <i>CL Paudel, B Bajracharya and BP Tripathi</i> -----	---	479
91.	Maize husbandry practices study at outreach research sites Pakhribas <i>RB Katuwal</i> -----	---	485
92.	Maize in transition from food to feed crop: Policy implication and sustainability issues <i>KR Paudyal and NP Osti</i> -----	---	492
93.	Opportunity of early mid hill potato in Tarai markets of Nepal <i>TR Chapagain and BB Khatri</i> -----	---	502
94.	Marketing management of maize seed produced by community farmers: An experience in the western hills of Nepal <i>KR Joshi and YP Yadav</i> -----	---	508
95.	Modeling decisions: An agricultural-anthropological perspective <i>BK Acharya</i> -----	---	515
96.	Opportunities and constraints of off-season vegetables marketing in Tarai and Indian markets <i>KP Shrestha, S Baidya and NS Thakur</i> -----	---	523
97.	Opportunities and constraints of sunflower cultivation in Nepal <i>RN Chaudhary</i> -----	---	532
98.	Rice varietal evaluation and its scaling-up at Chapagaun, Lalitpur <i>R Khadka, M Joshi, TP Pokhrel and YN Ghimire</i> -----	---	536
99.	Rice-wheat system in Kathmandu valley: A socioeconomic analysis <i>YN Ghimire, TP Pokhrel, HK Shrestha, NS Thakur, R Khadka, M Joshi, B Shrestha, N Pandey, SM Amatya and S Guatam</i> -----	---	542
100.	Study on socioeconomic condition of goat farming: A case study of command areas under ARS Bandipur <i>NS Thakur, MR Tiwari, M Joshi, B Shrestha and L Pandey</i> -----	---	552
101.	Surface seeding of wheat in wetland: Economics and scope <i>HK Shrestha and YN Ghimire</i> -----	---	561
Second SAS-N convention and best paper awards -----			566
Recommendations -----			567
SAS-N introduction and publications -----			569
Authors index -----			570

Food Security and Poverty Reduction in the Context of the 10th Five Year Plans

Shankar L Chaudhary

Department of Agriculture, HMGN, Kathmandu

INTRODUCTION

Nepalese agrarian economy is based on complex farming systems where crop cultivation, livestock raising and utilization of forest resources are closely interlinked. It's economy with agriculture represents the major share of GDP (40%) living in rural areas and depends mostly on agriculture for their livelihood. Agricultural productivity is very low (\$140 per agricultural worker) by international standards. Even though land productivity is higher (at \$ 649 per hector of agricultural land), the small land holdings size (about 0.9 ha) implies that household income is also low. Since vast majority of the population depends on agriculture for their livelihood and most of this population is poverty is widespread in the country. A glimpse on the occupational structure of Nepal can be useful to understand some patterns of rural livelihoods. The 1991 census reveals that 81% of the total population were engaged in agricultural followed by 6.18% in service sector, 4.23% in production, 2.98% in sales and 1.78% in professional technical occupational category. Rural people are also dependent on forest for fuel wood, timber and the forest products for their livelihood. The only non-agricultural production in the rural area is the traditional handicraft production (mainly the production of goods such as baskets traditional knives, brass and copper utensils, indigenous clothes, paper and wood works). Given the low productivity of agriculture a large number of rural youths depend on migratory employment for their livelihood.

Migratory movement of labor (defined as inter-district and international out-migration for work) is relatively large in scale in the rural area. Such movements can be divided into two categories, seasonal and permanent. The seasonal stream is more widespread. Lack of work in the mountains and hills during the slack agricultural season in the winter, low wage rates and lack of income from levels of human deprivations, including lack of access to education and health annually force a large number of workers to move to Tarai and cities and towns of Nepal and India looking for work. Such migratory stream is more widespread in the mid-western and far-western mountains and hills. In mid-western and far-western "Bonded Labor" or *Kamaiya* is another problem where more than 150,000 people (more than 20 thousand families) are under extreme poverty line. Income from migrant labor forms a high proportion of the total household income. The income is primarily used for buying the household necessities and paying debts and accumulation of assets. In fact, seasonal migration is no longer limited to people from the hills and mountains. Even the people of the Tarai migrate to urban areas of Nepal or to the more intensive agricultural areas of North India and maintain their livelihood for at least 6-9 months. Besides the migratory employment paid portorage has also been an important economic activity for the rural livelihood. portorage is an increasingly part time employment in the hills of Nepal pursued by men seeking employment to implement their income. The tragic irony is that paid Porte rage contributes to the employment problem it is seeking to avoid. The phenomenon of paid portorage manifest the inability of the hill population to produce enough for itself. Almost all the households engaged in paid porter age are food deficit households.

Increasing agricultural productivity is therefore critical to overall growth of the Nepalese economy and to reduction of poverty. His Majesty the Government of Nepal (HMGN) has been well cognizant of these facts for a long time. Since the Mid-1990s it has adopted a strategy and plan, called the Agricultural Perspective Plan (APP) that considers agricultural growth as the key sector to poverty reduction in Nepal. The APP has informed the formulation of the 9th five-year plan (1996-2001) and the 10th five-year plan (2002-2007). Besides the APP, other important changes have occurred over the 9th five-year plan period including, market reforms, decentralization and support for participatory approach.

In October 2001, HMGN signed a partnership agreement with ADB aiming to reduce the incidence of poverty to less than 10% by year 2017.

PRESENT SCENARIO

The agricultural sector performance review suggests that the following issues need to be considered. Agricultural labor productivity is low and is the main reason for widespread poverty (Annex 1). Ninth five-year plan performance is found as follows.

- Little diversification of agriculture
- Production growth of cereals weak
- Mixed performance of cash crop
- High value low volume crops showed a strong performance.
- Overall low productivity of land and labor
- Livestock sub-sector growing strongly and more rapidly than population
- Increasing demand and investment by farmers including the poor considering livestock an important investment
- Commercialization of forest products is still low and the concept of private forests is still under developed
- Pursuance of the principles of participatory joint management and hand over of irrigation to farmer's group has not visible increased in yield and cropping intensity or significant change in cropping pattern
- Irrigated farms have average net value of production /ha. One third higher than none irrigated farms and cropping intensity 16% higher.
- Agricultural labor has been found the most important input to production
- Fertilizer represents 8% of economic cost of production of paddy and 26% of cash, cost of production availability of fertilizer has increased considerably even though some problems in quality have emerged. FYM is used in great quantity and partially compensates for the low use of fertilizer.
- Farmers use seed mostly saved from their own stock, even in case of improved seed, replacement is quite low and limits the opportunity for rapid growth in production.
- Labor quality, measured by educational level is improving considerably in rural areas.
- Supply of Agricultural credit is likely to be less than 50% of the targeted needs, traditional agricultural does not show higher returns and has a low credit capacity, credit is not viable in an environment where farmers demand subsidies for investment and operation but viable only under commercial agriculture.
- Due to the lapses in effective co-ordination at central, regional and district level the concept of APP has largely lost its significance.

TENTH FIVE YEAR PLAN

Based on geographical possibilities with the available resources and using them in a coordinated manner for food security and poverty reduction is the need of the time. This is the priority of the 10th five-year plan (Annex 1). To achieve these goals there are some limitations eg

- Lack of sufficient credit in agriculture
- Agriculture production is not commercialized, it is substantial type of farming
- Low productivity in agriculture
- Lack of crop intensifications
- Lack of balanced doses of fertilizer
- Inadequate amount of improved seeds
- Insufficient irrigation facilities
- Production is higher than other country
- More risks involved in agriculture
- Lack of post harvest processing facilities and procurements

Solution for food

For security and poverty reductions some measures exercised are as follows.

- According to APP, agriculture should come as a lead sector. Program should be developed based on ecology as Tarai, mid-hills and high hills for food grain crops, cash crops, livestock and horticulture and off season vegetables respectively.

- Develop agriculture growth center and traditional farming can be converted into commercialized farming.
- Agriculture research and extension should focus on priority crops.
- Production of enough export commodities quality production can be increased for WTO.
- Involvement of Gender in the agriculture and develop their capacity
- According to principle of decentralization more resources and programs should be diverted to local levels
- Develop improved breeds of animals and their by-produce high quality and quantity of meat and milk products
- Production of fish farming can be tied up with the market demand
- Agriculture farms/stations should be oriented in income-generated activities.
- Food deficit districts should be oriented more in vegetable seeds, fruits, herbs and cash crop production programs
- Expansion of marked linkages, agriculture collection centers, wholesale markets, suspension bridges and market information services (MIS) should be developed.
- Regular supply and desired quantity of mineral fertilizer should be available
- Private sectors as CBOs, local bodies, NGOs all should be developed and participated for agriculture commodities and quality seeds.
- Poverty reduction through co-operates should be developed. Potential role of co-operatives should be linked but there is no clear link eg

Potential approach, with singular focus on credit supply
 Non-targeting of the poor
 Lack of participation and ownership of the poor
 Non-responsiveness to the felt needs of the poor

SOME SPECIAL ECONOMIC ACTIVITY PROGRAMS FOR DEPRIVED AND UNTOUCHABLES

There are some weak sections of the society, to whom they do not have access to current and modern economic activities. They do not have sufficient lands for modern economic activities. They do not have sufficient lands for modern farming and empowerment so some priority programs are fixed which are as follows.

1. *Natural lakes, ponds and swampy areas*: in these areas poor people will grow fish and raise their income for social and economic empowerment
2. *Vegetable farming*: This is one of the important high value crops (HVC) for economic generation and also these seasonal and off seasonal vegetables are good source of food crops in emergency and in famine condition in a short period of time.
3. *Banana and papaya farming*: Small and poor farmers can raise these fruit crops and earn good money within a year. From one hector of land more than Rs100,000 can be earned
4. *Mushroom farming*: For poor and landless farmers this is good business. From HMG, seeds (spawns) can be supplied in a subsidized rate and free technical services are provided. Low rate of interest and easy way of credit will be supplied to the farmers. This type of work has been started in 10 districts, Saptary, Dhanusha, Sirha, Sarlahi, Mhotari, Morang, Sunsari, Surkhet, Achham and Baglung. In every district, 10 groups are formed and Rs50000 as seed money is produced to each group. In 10 districts, about 2500 target families will be involved in this type of work.

BIBLIOGRAPHY

Agriculture marketing information bulletin. Special issue 2002.
 Agriculture sector in the Ninth plan. A statistical review of sub region.
 Chaudhary SL. 1985. Nutritional requirement for major field crops of Nepal. GTZ.
 Chaudhary SL. 1994. A hand book of manures and fertilizers guide to vegetable crops. FAO.
 Statistical information on Nepalese Agriculture 2001/2002.
 The 10th five-year plan. HMG.
 The 9th five-year plan. HMG.

Annex 1.

A. Agriculture production

Commodity	96/97	97/98	98/99	99/00	00/01	01/02	Annual growth, %
Cereals	6425640	6360790	6465315	6985317	7171782	7247289	2.44
Major cash crop	2764430	2863876	3201701	3427661	3678194	3783853	6.48
Minor cash crop	4631	3899	5368	6077	7372	7807	11.01
Spice crops	96689	102064	108164	110446	124513	132375	6.48
Pulses	223000	211250	228840	237325	243243	250400	2.34
Fruits	62919	65205	67493	70067	73775	77537	4.27
Vegetables	1357435	1449475	1342567	1489665	1652980	1738087	5.07
Meat	174268	180675	185034	189160	194258	198895	2.68
Milk	1012163	1048040	1072945	1097023	1124132	1158780	2.74
Egg ('000, n)	421460	440910	460625	480800	507323	538420	5.02
Wool	623624	623300	615713	615081	613824	609102	0.47
Fishery	23200	24866	25780	31723	33250	35000	8.57

B. Per capita production of agricultural commodities

Commodity	Unit	96/97	97/98	98/99	99/00	00/01	01/02	Annual growth, %
Cereals	kg	307	298	296	312	313	309	0.13
Potato	kg	48	45	50	53	57	59	4.21
Pulses	kg	10.7	9.9	10.5	10.6	10.6	10.7	0
Fruits	kg	19.9	21.4	20.5	21.9	20.7	20.7	0.79
Vegetables	kg	65	68	61	67	72	74	2.63
Egg	n	20.6	21.1	21.5	22	22.7	23.5	2.67
Fishery	kg	1.11	1.16	1.18	1.42	1.45	1.49	6.07

C. Edible cereal grain production in Nepal 1992/93 - 2000/2001

Crop	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
Rice	1393697	1827110	1577820	1949761	2002747	2035725	2074193	2259393	2356646
Maize	1100452	837653	883267	929513	894779	940767	920094	1007178	1001478
Wheat	595998	687426	709304	786936	827438	806849	855647	934559	914885
Millet	194407	224958	219262	236478	236982	233764	238968	242331	231915
Barley	7572	7965	8107	11190	10641	10244	8710	8478	8255
Total	4292126	4585112	3397760	3913878	3972587	4027348	4097612	4451939	4513179

D. Production target in 10th five year plan

Crop	Unit	9 th plan	Target for 10 th plan
Cereal	Mt/Yr	7171773	8741325
Pulse	Mt/Yr	243243	286200
Oilseed	Mt/Yr	132331	148200
Vegetable	Mt/Yr	1652979	2314000
Potato	Mt/Yr	1300000	1811000
Tobacco	Mt/Yr	3973	4085
Jute	Mt/Yr	16392	19710
Fruits	Mt/Yr	486945	585374
Honey	Mt/Yr	155	235
Silk	Mt/Yr	314	132
Mushroom	Mt/Yr	100	160
Fish	Mt/Yr	33270	49490
Sugarcane	Mt/Yr	2211781	2607000
Cotton	Mt/Yr	459	840
Spices	Mt/Yr	124513	172255

E. Population engaged in agriculture by region

Region	Population census 1991			Population census 2001		
	Eco active 10+	Pop eng in agric	%	Eco active 10+	Pop eng in agric	%
Eastern mountain	172980	15779	91.2	222132	183140	82.4
Eastern Hill	660041	60246	91.3	839346	669252	79.7
Eastern Tarai	895845	60014	67	1301501	737715	56.7
Central mountain	252698	23225	91.9	281169	220142	78.3
Central Hill	1122451	48947	70.3	1523408	800166	52.5
Central Tarai	956621	71652	74.9	1430130	865310	60.5
Western mountain	10939	764	69.9	14657	9407	64.2
Western Hill	1020179	90381	88.6	1300762	941928	72.4
Western Tarai	480580	38685	80.5	731097	442540	60.5
Mid-west mountain	147483	13813	93.7	104121	88279	84.5
Mid-west Hill	556691	51423	91.4	627206	476600	76
Mid-west Tarai	319284	24708	77.4	505037	279335	55.3
Far western mountain	170969	15717	91.9	220524	178935	81.1
Far western Hill	347548	32363	93.1	409936	329502	80.5
Far western Tarai	225280	18454	81.9	389172	273971	70.4
Nepal	7339589	1596178	81.2	9900198	6496221	64.6

F. Value of agriculture output current prices

Commodity	96/97	97/98	98/99	99/00	00/01	01/02	Annual growth, %
Cereals	52939	93904	61886	72106	66245	63890	3.83
Major cash crops	8837	9319	12832	14124	14094	18897	16.42
Minor cash crops	63	76	114	137	169	151	19.1
Spice crops	2208	2419	2955	4097	4488	4033	12.8
Pulses	8193	6850	8130	8494	8895	9235	2.42
Fruits	9043	8410	10665	11729	14330	13979	9.1
Vegetables	14202	17860	20379	20300	81868	23219	10.33
Livestock product	30507	22869	37028	40375	43719	46614	
Fishery	1502	1707	1851	2540	2755	3120	15.74
Total	127494	134414	155840	173902	176563	183138	7.51

Prospects of Botanical Pest Management in Nepal

Fanindra P Neupane

Center for Environmental and Agricultural Policy Research, Extension and Development (CEAPRED),
Shantibasti, Nayabato, Lalitpur <info@ceapred.org.np>

ABSTRACT

Natural pesticides derived from plants are known as “botanical pesticides”. Most of the Ayurvedic plants also yield pesticides, which have been used in agriculture since ancient time. Their use has been reduced since the arrival of synthetic pesticides, which have created havoc in human civilization and now people have been slowly following the principles of integrated pest management (IPM). Botanical pesticides, one of the alternatives to synthetic pesticides are very safe to human beings, domestic and wild animals and beneficial organisms and fit very well with IPM. Nepal is very rich in floral diversity having 5,345 species of flowering plants. Of this, 324 species have pesticidal properties. Of them, about two dozen plants are ranked highly potential and are being used in various areas of agriculture, especially in organic farming. However, there are several constraints in the use of botanical pesticides such as lack of conservation plans of the valuable plants, research on and extension of them, verification of local technologies on them, etc. Concerned agencies should give proper attention in this area.

Kew words: Botanical pesticides, IPM, pesticidal plants

INTRODUCTION

Use of synthetic pesticides in Nepal

A large number of crops are grown in Nepal for human food, fiber, shelter, fuel, animal feed, fodder, medicine and so on. All of them are attacked by different kinds of pests (insects, mites, rodents, birds, slugs, snails, etc) and disease causal organisms (bacteria, fungi, viruses, nematodes, etc), which cause various degrees of loss (Neupane 2002, Shrestha 1990).

In modern agriculture pests and diseases are controlled mostly with synthetic pesticides which not only control the target pests, but also control other non-target organisms (parasitoids, predators, plant pollinators, soil micro-organisms, aquatic organisms, etc) and wild animals. Commercialization of agriculture has pushed farmers for more use of agro-chemicals.

The use of pesticides has been increasing rapidly in recent years. In 2000 Nepal imported around 176 mt (in terms of actual ingredients) of pesticides costing Rs133174000. It consists of insecticides, fungicides, herbicides, acaricides, rodenticides and others. The largest quantity of pesticides is used in rice (40-50%) followed by grain legumes (14-20%), fiber crops (13-15%), and vegetable and fruits (10-20%) (Manandhar and Palikhe 1999).

The cultivation of vegetable crops in market assessable areas has been increasing rapidly. Farmers have been using too much of pesticides. In a study conducted by CEAPRED in Panchkhal VDC of Kabhrepalanchowk district it has been found that there is excessive (in terms of times of application for a crop for its growing season) use of pesticides on potato and vegetable crops. The certified waiting periods (time between last application of pesticide and harvest of a crop) for several pesticides on vegetable crops have not been followed by growers (Shrestha and Neupane 2002). This situation has resulted in high amount of pesticide residue in vegetable crops sold in the market, which is dangerous to human health.

Use of botanical pesticides in Nepal

Several alternatives are now available to synthetic pesticides for pest management. Of them, pesticides from plant origin (known as botanical pesticides) are very important. The use of plant products as pesticides on crops and household pest management is not new to Nepal. Our farmers have been using such plants since ancient times. Most of the Ayurvedic plants also possess pesticidal properties.

Since the arrival of modern synthetic pesticides in the market, our farmers also have been totally dependent on them and slowly gave up the use of pesitcidal plants. Now there are very rare farmers who use plant products for pest management.

EFFECT OF BOTANICAL PESTICIDES ON PESTS

Plant derivatives act as repellents, antifeedants, oviposition deterrents, antifertility agents, toxicants, fumigants, juvenile hormone analogues (JHP), growth inhibitors, chitin synthesis inhibitors, cytotoxins, alarm pheromones, ovicidals, chomosterilants, behaviour and physiological disturbance creators, etc in various pests. They are relatively safe to man, domestic and wild animals, bio-control agents and the environment as a whole as compared to the synthetic pesticides. These ideal properties should make botanical pesticides popular among users.

Effect of pesticidal plants on the biology of insects

Some of the pesticidal effects, for example toxicants and physiological disturbance (deformity) are confirmed from the following experiment conducted at the Institute of Agriculture and Animal Science, Rampur, Chitwan in 1997. Water extracts of fresh leaves of Neem (*Azadirachta indica*), mug-wort (*Artemisia vulgaris*), custard apple (*Annona reticulata*), Indian privet (*Vitex negundo*) and chinaberry (*Melia azedarach*) and mature dry fruits of chinaberry (prepared by crushing the leaves and fruits with the help of an iron mortar and pestle and soaking in water for six hours) were applied on maize green leaves (through dipping the leaves in each extract and then drying them) and then fed to field collected larvae (4th and 5th instar) of rice ear-cutting caterpillar (*Mythimna separata*) for 48 hours. Then the larvae were transferred to fresh untreated leaves and reared until the adults emerged.

Observations were taken on larval and pupal mortality, pupal period, adult emergence and deformity (Table 1). Neem leaves provided highest (70%) mortality of larvae followed by chinaberry leaves. In case of pupal mortality, Indian privet did better (50%) followed by custard apple leaves (40%), chinaberry leaves (30%) and both Neem leaves and mug-wort leaves (20% each). When both larval and pupal mortalities are considered, the plants stand in descending order as follows: Neem (90%), chinaberry (50%), custard apple (50%), Indian privet (50%) and mug-wort (30%).

There was no marked difference in pupal period among the treatments. The mean range of this period varied from 12.20 ± 0.42 to 14.42 ± 1.98 days. The lowest adult emergence was recorded in Neem treatment (10%) and highest in chinaberry fruits and untreated control (90% each). The other plants recorded 50-70% adult emergence.

Table 1. Effect of water extracts of some pesticidal plants on the biology of rice ear-head cutting caterpillar, Rampur, Chitwan, 1997

Treatment†	Mortalities, %‡			Pupal period, days (Mean $\pm$ SD)	Adult emergence, %
	Larval	Pupal	Total		
Neem leaves	70	20	90	14.00 ± 0.00 (n=1)	10
Chinaberry leaves	20	30	50	14.06 ± 0.48 (n=5)	50
Chinaberry fruits	0	10	10	13.00 ± 0.86 (n=9)	90
Custard apple leaves	10	40	50	12.20 ± 0.40 (n=5)	50
Mug-wort leaves	10	20	30	14.42 ± 1.98 (n=7)	70
Indian privet leaves	0	50	50	12.80 ± 1.16 (n=5)	50
Untreated control	10	0	10	14.44 ± 1.42 (n=9)	90

† Fresh leaves and mature (dry) fruits were used. ‡ Based on 10 larvae (4th and 5th instars, field collected) per treatment.

Table 2. Basic information of some promising pesticidal plants available in Nepal

S N	English and botanical name	Nepali name	Biologically active component	Pests suppressed	Type of activity
1.	Acanthaceae Malabar nut tree (<i>Justicia adhatoda</i>)	असुरो	Vasicine, vasicinol, vasicinone	<i>Sitophilus oryzae</i> , <i>Callosobruchus chinensis</i> , <i>Epilachna vigintioctopunctata</i> , <i>Aulacophora foveicollis</i>	Antifeedant, insecticidal, antifertility, acaricidal
2.	Annonaceae Custard apple group (<i>Annona</i> spp)	रामफल, सीताफल (सरिफा)	Annonaine, annonidines, linocline, caffeine	<i>Callosobruchus</i> spp., <i>Plutella xylostella</i> , <i>Spodoptera litura</i> , <i>Aphis fabae</i> , <i>Acyrtosiphon pisum</i>	Antifeedant, ovicidal, insecticidal, repellent, nematocidal
3.	Araceae Sweet flag (<i>Acorus calamus</i>)	बोभ्रो	Acoragermacrone, cis-asarone, trans-asarone,	<i>Sitophilus oryzae</i> , <i>Sitotroga cerealella</i> , <i>Callosobruchus chinensis</i> , <i>Bactrocera</i> spp	Antifeedant, repellent, insecticidal, ovicidal, antifertility
4.	Asteraceae Goatweed (<i>Ageratum conyzoids</i>)	अजगन्दा गन्धे भार	Ageratochromene, 6-demethoxyageratochromene	<i>Leptocoris chinensis</i> , <i>Sitophilus oryzae</i>	Anti-Juvenile hormone, oviposition suppressant
5.	Pyrethrum (<i>Tanacetum cinerariifolium</i>)	परिद्रम	Pyrethrins, cinerins, jasmolins	Aphids (<i>Aphis fabae</i> , <i>A. pomi</i>), <i>Earias vittella</i> , flies, grasshoppers, mosquitoes	Insecticidal, repellent, antifeedant
6.	African marigold (<i>Tagetes erecta</i>)	अफ्रिकी सयपत्री		<i>Aphis carceivora</i> , <i>Plutella xylostella</i>	Repellent, insecticidal, fungicidal, nematocidal.
7.	Mexican marigold (<i>Tagetes minuta</i>)	मेक्सिकी सयपत्री	5 E-ocimenone	Mosquitoes, ants, blow flies, fruit flies	Repellent, insecticidal, fungicidal, nematocidal
8.	Euphorbiaceae Castor bean (<i>Ricinus communis</i>)	आडिर	Ricin, ricinine	Aphids, fleas, flies, mosquitoes, housefly	Oviposition deterrent, insecticidal
9.	Fabaceae Groundnut (<i>Arachis hypogaea</i>)	बदाम	Arachine	<i>Callosobruchus</i> spp. stored grain beetles and moths, coccids, mealy bugs, leaf-cutting ants	Insecticidal
10.	Derris (<i>Derris elliptica</i>)	डेरी	Rotenone	Aphids, <i>Callosobruchus chinensis</i> , mosquitoes, cabbage butterflies, <i>Plutella xylostella</i>	Repellent, antifeedant, insecticidal, molluscicidal
11.	Chinese yam bean (<i>Pachyrhizus erosus</i>)	केसर	Rotenone	Aphids, caterpillars, stink bugs, cockroach	Insecticidal, antifeedant
12.	Poonga oil tree (<i>Pongamia pinnata</i>)	करोंगी	Karanjin	<i>Callosobruchus chinensis</i> , aphids, <i>Nephotettix virescens</i> , <i>Sitophilus oryzae</i> , <i>Spodoptera litura</i>	Oviposition deterrent, repellent, antifeedant, insecticidal
13.	Meliaceae Neem (<i>Azadiracta indica</i>)	नीम	Limonoids, azadirachtins	Beetles, flies, mosquitoes, stink bugs aphids, leaf – and plant-hoppers, whiteflies, crickets, psyllids, caterpillars, grasshoppers, thrips, mites, etc	Antifeedant, repellent, insecticidal, acaricidal, fungicidal, nematocidal, growth inhibiting, antiviral
14.	Chinaberry (<i>Melia azedarach</i>)	बकाइनु	Tetranortriterpenoids, melianthrol	Beetles, caterpillars, grasshoppers, cockroaches, aphids, beetles, etc	Antifeedant, oviposition deterrent, growth inhibiting, repellent, insecticidal, fungicidal
15.	Ranunculaceae Aconite (<i>Aconitum ferox</i>)	विष्मा	Aconitine	<i>Aphis maidis</i> , <i>Athalia proxima</i> , <i>Aulacophora foveicollis</i> , <i>Lipaphis erysimi</i>	Insecticidal, antifeedant
16.	Sapotaceae Mowra (<i>Madhuca indica</i>)	मौवा		<i>Callosobruchus chinensis</i> , <i>Musca domestica</i> , <i>Myzus persicde</i>	Insecticidal, antifeedant, nematocidal, fungicidal
17.	Siolanaceae Angel trumpet (<i>Datura metel</i>)	कालो धतुरो	Atropine, hyoscine, scopolamine	<i>Aphis gossypii</i> , <i>Epilachna</i> spp., <i>Lipaphis exysimi</i> , <i>Spodoptera litura</i> , Chiggers	Antifeedant, insecticidal
18.	Thorn apple (<i>Datura stramonium</i>)	सेतो धतुरो	Withanolides	Aphids, caterpillars, maggots, stink bugs	Antifeedant, insecticidal
19.	Tabacco (<i>Nicotiana rustica</i> and <i>N. tabacum</i>)	सुर्ती	Nicotine	Aphids, caterpillars, flea beetles, leaf miners, thrips	Repellent, insecticidal, acaricidal, fungicidal
20.	Verbenaceae Indian privet (<i>Vitex negundo</i>)	सिमाली	Bicucine, corydine, cryptopine	Stored grain beetles and moths, caterpillars, clothes moths, house fly	Ovicidal, insecticidal, antibacteria
21.	Zingiberaceae Ginger (<i>Zingiber officinale</i>)	अदुवा		Aphids, thrips, whiteflies, root-knot nematodes, <i>Callosobruchus chinensis</i>	Fungicidal, nematocidal, insecticidal, repellent

Source: Dhaliwal and Arora 2001, Neupane 2000, Jacobson 1990.

Other potential plants

Sweet basil (*Ocimum basilicum*), holy basil (*O. sanctum*), chilli (*Capsicum frutescens*), garlic (*Allium sativum*), madre (*Gliricidia sepium*), turmeric (*Curcuma domestica*), coriander (*Coriandrum sativum*), eupatorium (*Eupatorium adenophorum* and *E. odoratum*), lemon grass (*Cymbopogon citratus*), onion (*Allium sepa*) and tomato (*Lycopersicon esculentum*) are potential and easily available plant for suppressing several types of pests.

STATUS OF PESTICIDAL PLANTS IN NEPAL

Grainge and Ahmed (1988) have reported more than 2400 species of higher plants in the global level possessing some kind of pesticidal properties. They have recommended 42 species as the ideal performers for suppressing agricultural pests in most parts of Asian farming systems.

Nepal is very rich in higher plant diversity having 5,345 species (Press et al 2000). Of them 324 species have certain pesticidal properties and among the 42 species mentioned above, 23 species are available in Nepal (Neupane 2000).

USES OF PESTICIDAL PLANTS

Crude form

Most of the pesticidal plants used by farmers are in the crude form such as green leaves (as dry powder or water extracts), flowers, fruits, bark, root, rhizome, stolon, seed, etc.

Extracted form

Azadirachtin, the principal pesticidal component of Neem plant is extracted from the seeds with chemical solvents. Many companies in India formulate Neem based products for managing various pests (insects, fungi, bacteria, nematodes, etc). Some of these products are also available in Nepal.

BASIC INFORMATION ON SOME PROMISING PESTICIDAL PLANTS AVAILABLE IN NEPAL

Some basic information on these plant species is presented in Table 2. They are distributed in different physiographic zones of Nepal (Neupane 2000, 2003). Except very few plants, which are cultivated (tobacco, pyrethrum, groundnut, marigold, Chinese yam, Neem, ginger), are collected from the forest and uncultivated areas. Many of these plants are over exploited.

Neem is the most potential one among the pesticidal plants, which yields very potent pesticidal compounds (including azadirachtin), which are being successfully used in suppression of various pests (insects, fungi, nematodes, mites, etc) in wide range of field crops and stored products (Jacobson 1989a, Saxena 1989, Grainge and Ahmed 1988). This plant is very widely distributed in many parts of the world. A lot of research has been conducted on this plant and good amount of literature is available (Arnason et al 1989, Grainge and Ahmed 1988, Jacobson 1989a, 1989b, 1990, Jotwani and Srivastava 1984, Neupane 2000, Schmutterer et al 1981, Schmutterer and Asher 1981, 1987). This plant is available in Tarai, Inner Tarai, and river basins of Nepal. It can be cultivated very easily.

CONCLUSION

Although Nepal is very rich in pesticidal plants, they have not been utilized due to several reasons such as domination of synthetic pesticides, slow action of botanical pesticides including their unavailability, time taken for their collection and preparation, lack of knowledge about their use, etc. The following recommendations are made for enhancing the use of botanical pesticides in agriculture, floriculture and household pests.

Conservation

Most of the pesticidal plants are also used for medicines and they have already been over exploited. Hence, there should be long term conservation plan for such plants.

Research and extension

Very low emphasis has been given to research aspects on pesticidal plants. Strong research is needed and the knowledge and technologies generated in this area are to be disseminated among the farmers.

Verification of local technologies

Farmers have been using, though in limited scale, pesticidal plants in various ways in very crude forms. Cocktails of cow urine and several plants (fermented products) have been claimed to be effective in pest management. Such local technologies have to be verified by authentic scientific organizations.

Documentation of indigenous knowledge

Documentation of indigenous knowledge related to use of pesticidal plants in agriculture is very much lacking, which should get emphasis by various organizations involved in the area of crop protection.

Propagation of Neem

Since Neem has the top grade natural pesticidal compounds and grows well in Tarai, Inner Tarai and river basins, it should get top priority in afforestation programs. Farmers should be encouraged to plant enough number of this plant in their farm.

Awareness creation

Awareness should be created amongst the farmers on botanical pesticides.

REFERENCES

- Arnason JT, BJR Philogene and P Morand. 1989. *Insecticides of plant origin*. American Chemical Society, Washington, DC, USA. X+213 pp.
- Dhaliwal GS and R Arora. 2001. *Integrated pest management*. Kalyani Publishers, Ludhiana, Punjab, India. XXII+427 pp.
- Grainge M and S Ahmed. 1988. *Handbook of plants with pest-control properties*. John Wiley and Sons, New York. XVII+470 pp.
- Jacobson M, ed. 1989b. *Focus on phytochemical pesticides. Vol. I. The Neem tree*. CRC Press, Boca Raton, Florida, USA. 178 pp.
- Jacobson M. 1989a. Botanical pesticides: Past, present, and future. **In:** *Insecticides of plant origin* (JT Arnason, BJR Philogene and P Morand, eds). American Chemical Society, Washington, DC, USA. Pp.1-10.
- Jacobson M. 1990. *Glossary of plant-derived insect deterrents*. CRC Press, Boca Raton, Florida, USA. VII+213 pp.
- Jotwani MG and KP Srivastava. 1984. A review of Neem research in India in relation to insects. **In:** *Natural pesticides from the Neem tree (Azadirachta indica A. Juss) and other tropical plants* (H Smutterer and KRS Asher, eds). GTZ Press, Eschborn, Federal Republic of Germany. Pp.43-56.
- Manandhar PP and BR Palikhe. 1999. Current situation in Nepal. *Paper presented at the regional workshop on management of persistent organic pollutants (POPs)*, 16-19 March 1999, Hanoi, Vietnam.
- Neupane FP. 2000. *Jadibutidwara Kira Nyantran (Insect control with botanicals)*. Sajha Prakashan, Pulchok, Lalitpur. X+243 pp. (in Nepali).
- Neupane FP. 2002. *Balibiruwaka Shatru Ra Tinako Roktham (Crop pests and their control)*. Sajha Prakashan, Pulchok, Lalitpur. XX+582 pp. (in Nepali).
- Neupane FP. 2003. Status of botanical pesticides in Nepal. **In:** *Integrated pest management in Nepal* (FP Neupane, ed). Himalayan Resources Institute, New Baneshwor, Kathmandu, Nepal. Pp.7-96.
- Press JR, KK Shrestha and DA Sutton. 2000. *Annotated checklist of the flowering plants of Nepal*. Natural History Museum, London. X+430 pp.
- Saxena RC. 1989. Insecticides from Neem. **In:** *Insecticides of plant origin* (JT Arnason, BJR Phyogene and P Morand, eds) American Chemical Society, Washington DC, USA. Pp. 110-135.
- Schmutterer H and KRS Asher, eds. 1984. *Natural pesticides from the Neem tree (Azadirachta indica A. Juss) and other tropical plants*. Ibid. 587 pp.
- Schmutterer H and KRS Asher, eds. 1987. *Natural pesticides from the Neem tree (Azadirachta indica A. Juss) and other tropical plants*. Ibid. 703 pp.
- Schmutterer H, KRS Asher and H Rembold, eds. 1981. *Natural pesticides from the Neem tree (Azadirachta indica A. Juss)*. GTZ Press, Eschborn, Federal Republic of Germany. 297 pp.
- Shrestha K. 1990. *Nepalama Tarakari Balika Mukhya Rogharu (Major disease of vegetable crops in Nepal)*. HGM/Nepal, Vegetable Development Division and Fresh Vegetable and Seed Production Project (FAO), Khumaltar, Lalitpur. XVI+112.
- Shrestha PL and FP Neupane. 2002. Socio-economic contexts on pesticide use in Nepal. **In:** *Proceedings of international workshop on environmental risk assessment of pesticides and integrated pest management in developing countries, 6-9 Nov 2001, Kathmandu Nepal* (A Herrmann and S Schumann, eds). Selbstverlag, Institut fur Geographie und Geoökologie, der Technischen Universität, Braunschweig, Germany. VIII+205-223 pp.

Development and Testing of Low Cost Solar Dryer for Drying Agricultural Commodities

Shreemat Shrestha and Rabi G Rasaily

Agricultural Engineering Division, NARC Khumaltar

ABSTRACT

Open solar drying has been traditionally practiced in drying agricultural commodities in Nepal. Open sun drying are prone to the contamination of dust, insects etc. To address these problems, different types of cabinet type solar dryers are developed but are not adopted by Nepalese farmers due to high cost and unavailability of the construction materials in the remote areas. To overcome these problems the low cost solar dryer was developed and comparative testing of it with wooden and metallic (galvanized sheet (GI) sheet fabricated) solar dryer was performed for mushroom drying in Agricultural Engineering Division (AED), Khumaltar. The new model of low cost solar dryer is constructed by using the local construction material mud brick/ stone mud mortar and can be constructed of different size according to the requirement of the farmer. Only the external material used is transparent ultra violet (UV) protected polythene sheet, black board paint and GI net. The cost of low cost solar dryer of size 0.8- x 1.5-m is about Rs500 where the wooden and metallic solar dryers of similar size costs about Rs2500 and 6000 respectively. The capacity of the low cost solar dryer of size 0.8- x 1.5-m is of 3 kg of mushroom drying per batch. The duration of drying of mushroom to MC level below 10% is attained within 2 days of drying. The moisture curve of the mushroom in the low cost solar dryer, metallic dryer and the wooden dryer indicated that there is no significant difference at high and low moisture level. The temperature curve of the solar dryers indicated that the rate of increase of temperature of mud dryer is less in the initial 2 hours and after this, it is found to be more than the wooden dryer. The low cost solar dryer can be one of the appropriate options in drying the agricultural commodities in the remote areas due to its performance comparable with the modern solar dryers, and low cost of construction.

Key words: Low cost mud dryer, mushroom drying, solar dryer

INTRODUCTION

Development and dissemination of horticultural technologies have significantly contributed in the enhancement of the socio economic status of the farmers in Nepal. However, the farmers growing fruits and vegetables are exposed to high risk due to the fluctuating market price. In some years it is learnt that the farmers have to throw their products as garbage due to low price resulted by mismatch between the demand and supply. Moreover the farmers in the remote areas could not get benefit of the modern agricultural technologies due to poor market access mainly high transportation costs of bulky agricultural produce (specially fresh fruits and vegetables). By realizing the severity of these issues by various studies have suggested on the need of appropriate post harvest technologies for the perishable commodities (HMG/FAO 1994). Moreover to empower rural women, promotion of small-scale income generating technologies including post harvest technologies could play a crucial role (Kaul and Abraham 1988).

Drying of the perishable commodities is one of the simple post harvest technology to enhance the storability and transportability of the product. The monthly daily global solar radiation in Nepal varies from 120 to 260 w/m², with annual total sunshine duration ranging from 1900 to 2500 hrs (Rijal 1984). Open sun drying has been traditionally practiced in drying agricultural commodities in Nepal. However, open sun drying is prone to the contamination of dust, insects etc resulting less attraction of the consumer on the sun dried products in Nepal. It takes longer time and the required level of moisture content of the product for safe storage is difficult to attain due to drying in ambient condition. Different types of cabinet type solar dryers are developed and used by various agencies in Nepal. However, these solar dryers have not been able to establish credibility because of high

capital investment required and lack of specific designs for different products and quantities (Banskota and Sharma 1999). Difficulty in its transportation and unavailability of the construction materials in the remote areas are also hurdles in adoption of the solar dryers. To address these problems the low cost solar dryer was developed and comparative testing of it with wooden and metallic solar dryer was performed for mushroom drying in Agricultural Engineering Division (AED), Khumaltar.

MATERIALS AND METHODS

GI sheet made solar dryer

It is the commercially available model. It has total projected glass area of 0.668 sq. m and two layers of racks. Black paint inside the dryer and triangular corrugations at the bottom facilitates absorption of the incident solar energy. For the movement of air i.e. dry air entry and moist air exit, air inlet and exhaust is provided at bottom and top of dryer respectively. To control the movement of air exhaust control regulator is also provided. The cost of this dryer is about Rs6000.

Wooden solar dryer

As the GI sheet type commercial dryer is fabricated in modern workshop using modern construction material, it is difficult to be fabricated at village level. Moreover, the cost of the dryer is found to be more for the rural farming community to adopt this model. Hence following modifications were made to fabricate the wooden cabinet dryer. Instead of GI sheet wooden frame structure is used. For the absorption of incident energy inside the dryer thin GI sheet is used with black board paint. As glass pane is fragile and not generally available in rural areas, UV protected polythene sheet is used to transmit the incident solar energy in the cabinet. Rest of the design including size and shape is similar to the GI type. This dryer is fabricated at the cost of Rs2500 in Kathmandu.

Low cost solar dryer

For further reduction of the cost and simplification of construction using local construction material, low cost mud type solar dryer is developed (Figure 1). The farmers themselves can construct it by using local construction material. Since it is the fixed type dryer, location of the dryer construction should be identified carefully. It is to be constructed in south faced dry area, without trees or structures near by to avoid obstruction to solar radiation. An inclined (10 degree) platform (facing south) is constructed by lining with locally available material viz black slate / stone mud / brick, wood bamboo etc. Rectangular drying box of required size and 12 cm height is constructed using stone mud or brick mud wall around. For the facilitation of air inlet small bamboo pipes were inserted during construction of the wall and for the exit of the moist air from the dryer slots were made on the edge of walls. Mud plaster is applied on the both side of the walls and at the top to make the level surface so that the wooden frame perfectly fits on it. Once the mud dryer is dried, black board paint is applied in the drying chamber. The wooden/ bamboo tray and wooden frame for UV plastic cover is fabricated according to the size of the dryer. Here all the materials used for construction of the dryer are of local material except blackboard paint and UV stabilized polythene sheet. This dryer is fabricated at the cost of Rs500.



Figure 1. Low cost solar dryer.

Testing methodology

Initial moisture content of the drying material (mushroom is used for this study) is examined by oven dry method. Equal weight of mushroom is loaded in each dryer by spreading over the trays of the dryers and dryers were exposed to solar radiation. Temperature of each dryers and the ambient temperature is recorded in regular interval. The moisture content of the sample of the mushroom is measured in regular interval. Solar radiation data of each

drying day is collected from the meteorological station Khumaltar. The efficiency of the dryer is calculated by using following formula. The test was performed with 3 replications.

$$\text{Efficiency of the solar dryer, \%} = \frac{\text{Energy used to remove the moisture from mushroom}}{\text{Incident solar energy in the dryer}} \times 100$$

RESULTS AND DISCUSSION

The test was conducted in the second week of March 2003 at Khumaltar with 3 replications. Temperature of loaded dryers and ambient temperature are plotted in Figure 2. The ambient temperature between 11:30 to 14:30 is above 25° Celsius. In the GI dryer, it was observed that the rate of rise in temperature is high at latter stage it was gradual rise at low rate. In the case of low cost mud dryer, the rate of rise of temperature was high (but at lower rate than that of GI dryer) and at latter stage smooth rise similar to that of GI dryer. With respect to wooden dryer, the temperature gradient was more or less consistent.

The figure indicates that temperature of loaded GI and mud dryer shows similar pattern. The maximum temperature recorded on the testing day in the GI, wooden and low cost mud dryer are 56, 42 and 47.5°C respectively. Similarly, the average temperature of the GI, wooden and low cost mud dryer is 42.58, 37.13 and 34.79°C respectively.

The variation of temperature of dryers are mainly due to the thermal properties of the construction material and its design. Due to presence of thick cloud, the temperature of all the dryers dropped from 2 pm to 3 pm. Rate of decrease in temperature is found to be more in G I dryer than in wooden and mud dryer. It also indicated that there is need of better insulation in GI and wooden dryer. The figure has indicated that use of low cost material mud and brick as construction material has also shown favorable results with respect to the temperature characteristics of dryer.

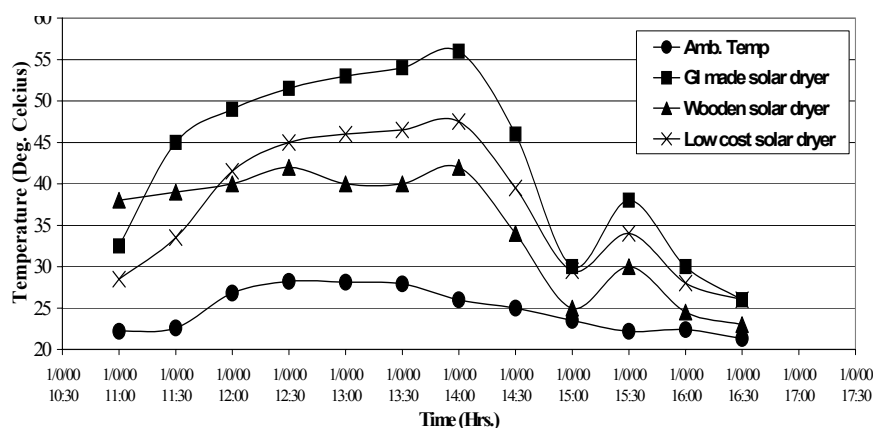


Figure 2. Temperature variation in dryer.

The initial moisture content of mushroom is found to be at the range of 906 to 940% at dry basis, which is equivalent to 90.36 to 90.38% at wet basis. The moisture content of the mushroom is found to be similar to that reported by Crisan and Sands (1978). Variation of moisture (at dry basis) of drying mushroom during the course of drying is presented in Figure 3. The figure indicates that the moisture curve of all the 3 dryers was similar. However, the rate of removing moisture from mushroom by GI dryer is found to be more than that of wooden and low cost mud dryer. It is mainly due to the higher temperature attained in GI dryer comparative to the wooden and low cost mud dryer.

Table1. Comparative performance of solar dryers

Type of solar dryer	Projected area	Average initial MC	Average final MC	Average efficiency	Variance
Low cost mud solar dryer	1.180	91.23	9.74	16.14427	1.96
GI sheet made solar dryer	0.668	91.47	8.95	31.64497	0.91
Wooden solar dryer	0.668	91.15	9.76	31.33473	1.00

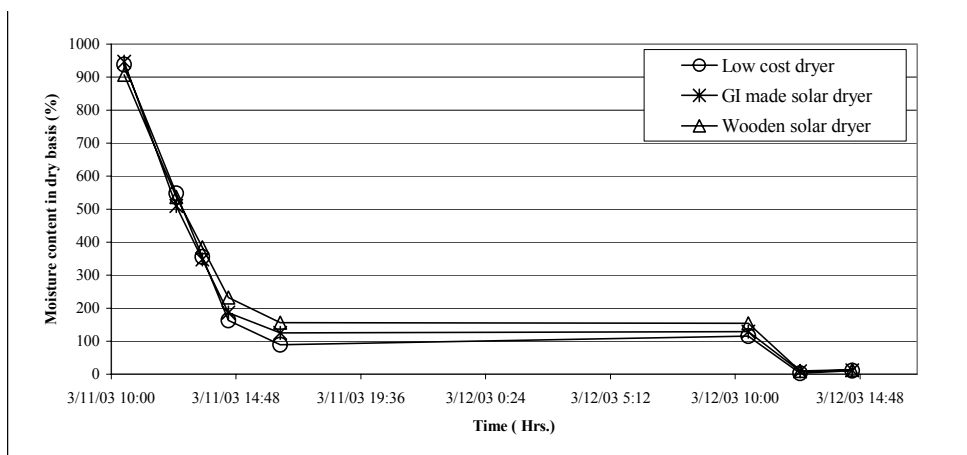


Figure 3. Moisture curve of mushroom in the different dryers.

Comparative performance of solar dryer is presented in Table 1. Initial weight of mushroom used in tests for all dryers was 3 kg. The average initial moisture content of mushroom used in all dryers was at 91%. After one and half day of drying the moisture content of mushroom of all three dryers were at the range of 9%. In comparison with other dryers, the average final moisture content of mushroom dried in GI solar dryer is found to be 0.8% less than that of other solar dryers. It is mainly due to comparatively high temperature attained in GI dryer. With respect to the efficiency of the dryers, GI and wooden dryers is found to be almost same i.e. at the range of 31%. The efficiency of the low cost mud dryer is found to be at the range of only 16%. The variance of the efficiency is found to be within the acceptable limit and the results are found to be significant at 95% confidence level. Even though, the same quantity of mushroom is dried to same range of moisture level in low cost solar dryer at same period of time, the low efficiency of it is due to more projected area (almost twice) in comparison to other dryers. Hence there is scope of improvement in low cost dryer specially, with respect to air circulation within the dryer and cover/lid. It was observed that moisture condensed on the cover polythene sheet of low cost dryer at the initial stage of drying which was rectified by increasing the dryer angle and opening more grooves for facilitation for removal of moist air from dryer. The presence of big cover has disadvantage on the operation of the dryer because if it is opened, the temperature drops significantly reducing the drying efficiency.

CONCLUSIONS

Wooden type and low cost solar dryer for drying perishable commodities is fabricated and tested. These types of dryer can be fabricated locally in rural areas itself. The moisture level of mushroom (equal weight) can be brought below 10% within one and half day in all the solar dryers studied. The efficiency of the low-cost solar dryer, wooden dryer and metallic dryer is 16.14, 31.33 and 31.64 respectively. By comparing the efficiency, final moisture content and cost of the dryer, the low cost solar dryer and wooden solar dryer is found to be appropriate options for village level drying of mushroom and other perishable agricultural commodities. The low cost solar dryer and wooden solar dryer is to be further modified by testing it in the farmer's field with other perishable commodities to cater their needs and requirements as well as to improve its efficiency.

REFERENCES

- Banskota K and B Sharma. 1999. Pattern of energy use in Nepal. **In: Energy use in mountain areas** (K Rijal, ed). Trends and patterns in China, India, Nepal and Pakistan. ICIMOD, Kathmandu.
- Crisan RV and A Sands. 1978. *Biology and cultivation of edible mushrooms*. Academic Press, London.. P.137.
- HMG/ FAO. 1994. *Project impact on vegetable development in Nepal*. HMG/ FAO Fresh Vegetable and Vegetable Seed Production Project, Khumaltar, Kathmandu.
- Kaul TN and SP Abraham. 1988. Mushroom cultivation and socio economic development of women. **In: Science and technology and development** (JP John, CL Chopra and SK Chowdhary, eds). Department of Science and Technology, New Delhi and Regional Research Laboratory, Jammu.
- Rijal K. 1984. *Availability of solar energy in Nepal*. Water and Energy Commission Secretariat. Khumaltar, Kathmandu.

Improved Tubular Corn Sheller: Appropriate Drudgery Reducing Agricultural Equipment for Maize Growers

Khadga B Shrestha, Shree K Adhikary, Rabi G Rasaily and Gauri L Shrestha

Agricultural Engineering Division, NARC, Khumaltar, Lalitpur

ABSTRACT

Shelling corn or maize is, in general, the responsibility of the farming woman, whether child, youth or aged. The corn shelling operation is usually carried out manually and hence, a tedious job. It consumes a lot of time, labor and energy of the women force in agriculture. Relieving these agricultural women workers from such drudgery is a major challenge for researchers and development workers in the country. Though some farmers in the country use manual corn sheller developed by Agricultural Tools Factory (ATF) at Birgunj or Development Consulting Services (DCS) at Butwal to some extent, but access to such modern corn-shelling device is beyond the imagination for the majority of the women from the rural sector. Realizing the drudgery of the rural farming community, scientists at Agricultural Engineering Division (AED) under NARC have developed different prototypes of improved tubular corn sheller including manual as well as pedal operated equipment. Various prototypes of both manual and pedal operated corn shellers were designed, fabricated and tested by the researchers at the AED. These AED prototypes of the manual corn shellers are the improved version of the International Rice Research Institute (IRRI) design, while the design of the pedal corn sheller is of the AED itself. During performance testing of the manual corn sheller, the shelling capacity and the efficiency were found to be 13.8 kg/h (146 cobs/hr) and 94.6% respectively at 9.2% moisture content of maize kernels. Similarly, in case of pedal operated tubular corn sheller, the shelling capacity of 27.9 kg/hr (318 cobs/hr) and the shelling efficiency of 93.1% were obtained at maize kernel moisture content of 12.7%. The shelling capacity of pedal corn sheller was 102% more than that of manual corn sheller.

Key words: Corn sheller, drudgery reduction, rural community, equipment

INTRODUCTION

Shelling maize or corn manually, though a pleasant and time-passing operation to some, it is a tedious work for majority of the maize growers as it is a time and labor consuming operation. Most of the farmers, when they need to shell maize in large bulk, prefer to execute shelling operation by beating the sack filled with maize ears. Maize shelling in Nepal is assumed to be the women's job though some male members also prefer to help their female partners. In order to release female members from the farming community, several attempts have been made by various agencies or institutions.

Agricultural Implements Research and Development Centre (AIRDC), Agricultural Tools Factory Limited (ATF), Development Consulting Services (DCS), Rural Save Grain Programme (RSGP) made appreciable contribution towards design, development and dissemination of the manually operated corn sheller.

It was the Department of Shree Panch Tribhuvan Village Development (DSPTVD) that introduced the Indian hand-held corn sheller among the Nepalese farmers in 1954 (2011 BS). The corn sheller basically consisted of a conical metallic tube with longitudinal fins. Introduction of such device relieved the Nepalese maize growers to some extent. However, the operators suffered hand pains when it was used for a prolonged period.

With the establishment of the Agricultural Implements Research and Development Center (AIRDC) at Ranighat, Birgunj, a wooden prototype of the manual corn sheller was developed in 1959 (2016 BS). It was later modified by the AIRDC itself in 1969. The AIRDC also developed the hand-held corn sheller made of iron in 1961. The AIRDC is presently known as the Agricultural Implements Research Center (AIRC).

In 1970, the Agricultural Tools Factory (ATF) Limited at Shreepur, Birgunj manufactured and marketed a bench type corn sheller weighing 5.5 kg. The ATF corn sheller consisted of a cast iron gear and ribbed casing held on a mild steel shaft that was rotated by a wooden handle. The maize was shelled by pushing the cob between the stationary casing and the rotating gear. Clearance between the casing and the gear could be adjusted by means of a compression spring attached to the shaft according to the cob size. The shelling capacity was reported to be 40 kg/hr.

The Rural Save Grain Program jointly launched by His Majesty's Government of Nepal (HMG/N) and Food and Agriculture Organization (FAO) introduced the hand-held tubular corn sheller in 1980. It basically consisted of a tubular pipe with four 7 mm by 5 mm teeth bent inwards. These teeth can be adjusted according to the size of cobs.

The Development Consulting Services (DCS) Butwal, Rupandehi district has developed and introduced a cranking-type bench-mounted tubular corn sheller the shelling unit of which was similar to the one developed by Karunanithi et al (1990) at College of Agricultural Engineering under the Tamil Nadu Agricultural University, Coimbatore, India. The shelling capacity and the efficiency of such corn sheller were reported to be 11.5 kg/hr and 96.4% respectively.

Prior to the establishment of the Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM), the Agricultural Engineering Division (AED) under the Nepal Agricultural Research Council (NARC) was the National Institute (NI) of the Regional Network for Agricultural Machinery (RNAM) for Nepal. The RNAM became Regional Network for Agricultural Equipment and Machinery (RNAEM). The RNAEM was then reorganized and renamed as the APCAEM. The AED, at present, is the NI of the APCAEM.

In 1995, the AED received five different prototypes of agricultural equipment from the RNAM. These prototypes included a manually operated AMDP-IITA corn sheller also. The AMDP-IITA corn sheller was initially developed by the International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria and later modified by the Agricultural Mechanization Development Programme (AMDP) of the National Institute (NI) of RNAM in the Philippines.

While testing, the AED identified following major problems on the AMDP-IITA corn sheller:

- The shelling unit was not detachable and hence cleaning of the equipment was difficult.
- The operation was not comfortable as it should be.
- Using the equipment for prolonged duration caused blister on the user's hand
- Collection of the shelled maize grains on a container was difficult.

In addition to the improvement of a manual corn sheller, the AED also developed and tested a pedal-operated corn sheller.

MATERIALS AND METHODS

A non-detachable type of tubular corn sheller (TCS-K55) was initially conceptualized, designed, fabricated, tested, modified, retested and disseminated at Kuntabesi of Kabhrepalanchowk district.

The design consideration basically incorporated the criteria for drudgery reduction and hence a revolving handle grip and a chute outlet were added to improve the AMDP-IITA corn sheller. The designed equipment was then fabricated in a private workshop at Kuntabesi of Kabhrepalanchowk district. Based on this, the second prototype (TCS-J58) with detachable shelling unit was later developed at the RK Engineering Workshop at Satdobato, Lalitpur. Equipment, thus, fabricated was tested with voluntary participation of user women from maize growing community. The "learning by doing" approach employed during testing resulted appreciable feedbacks from these women volunteers. Incorporating feedbacks from the volunteer women participants, the equipment was improved, tested and modified several times. The process also provided an opportunity to several women from the rural community to observe performance testing. Application of "seeing is believing" effect delivered a positive impact on the voluntarily participating users and observers. The approach was excellent from the cost effective viewpoint. However, testing of pedal-operated corn sheller employed male volunteers, as it is somewhat heavier than the manual-operated corn sheller (Figure 1, 2 and 3).

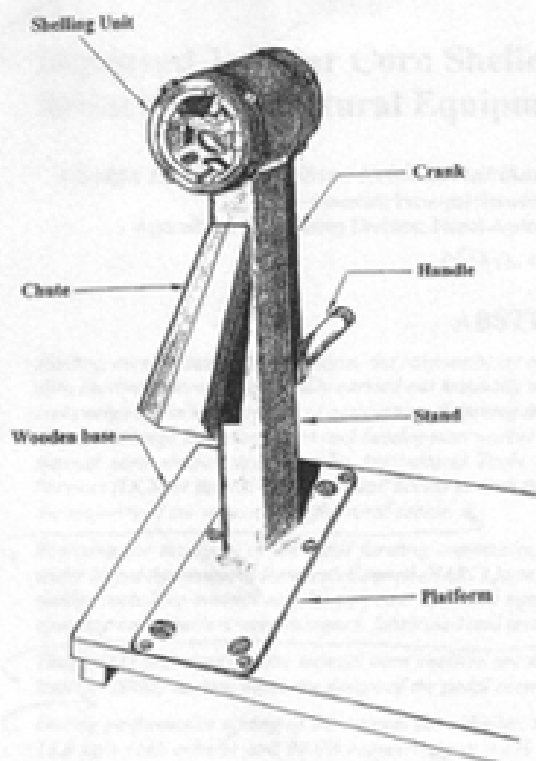


Fig. 1: Manual Corn Sheller

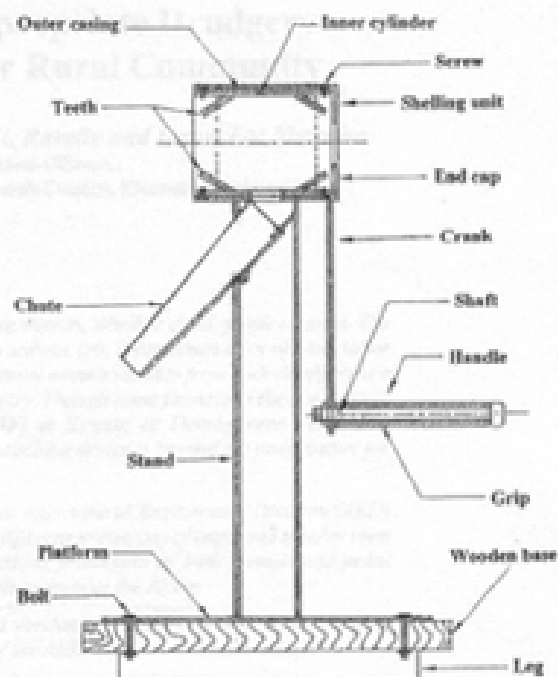


Fig. 2: Sectional View of Manual Corn Sheller

INTRODUCTION

Shelling maize is done manually, though a pleasant and not-gainful operation to most of the maize growers as it is a time and labor consuming operation. Most of the farmers, when they need to shell maize in large lots, they employ a laborer by loading the shelling unit on a bullock cart and make him to shell the maize. This method is not only laborious but also involves a lot of cost. The shelling unit is a simple device which is made by various components or materials.

The shelling unit is a simple device which is made by various components or materials. The shelling unit is a simple device which is made by various components or materials. The shelling unit is a simple device which is made by various components or materials.

It was the Department of Agricultural Engineering, Government of India (DAE) that introduced the manual corn sheller in India. The manual corn sheller was introduced in 1954 (Joshi, 1954). The corn sheller was a simple device which was made by various components or materials. The introduction of the manual corn sheller helped the farmers to shell maize in large lots without the need for a laborer.

Fig. 3: Pedal Corn Sheller

With the establishment of the Agricultural Engineering Research and Development

The research was in fact a collaborative venture of the researcher and workshop owner. The local blacksmiths and workshop owners were simultaneously trained on fabricating improved corn shellers. Development of improved corn shellers also incorporated the inputs from local blacksmiths and mechanics especially for selection of raw materials. This participatory approach was a low cost research work basically suitable for poor country like Nepal. The pedal operated prototype (PCS-A58) was then designed and developed at Lubhu, Lalitpur district.

During the performance testing the manual and pedal-operated corn shellers, time taken during specific shelling operation, weight of shelled maize kernels, weight of unshelled maize kernels on the cobs and number of shelled corn cobs were noted. The unshelled maize grains on the cobs were shelled manually and weighed.

RESULTS AND DISCUSSION

The following test results were obtained from the performance testing of the manual-operated as well as pedal-operated corn sheller:

Table 1. Test result of manual and pedal corn sheller

SN	Description	Manual corn sheller	Pedal corn sheller
1.	Shelling capacity	13.8 kg/hr (146 cobs/hr)	27.9 kg/hr (318 cobs/hr)
2.	Efficiency	94.6%	93.1%
3.	Moisture content	9.2%	12.7%

During performance testing, the shelling capacity of manual corn sheller was obtained as 13.8 kg/hr while the capacity of 27.9 kg/hr (kernel) was found in case of pedal-operated corn sheller. The shelling capacity of the pedal-operated corn sheller was 102% more than that of the manually operated one.

The performance test result also indicated that the shelling capacity of the manual corn sheller was 84% more than that of hand-held corn sheller having a capacity of 7.5 kg/hr (kernel) and 20% more than that of the cranking type corn sheller developed by Karunanithi et al (1990).

Furthermore, shelling efficiency of manually operated tubular corn sheller was found to be 94.6% at 9.2% moisture content while the shelling efficiency of 93.1% at 12.7% moisture content was obtained for pedal operated tubular corn sheller. The manual corn sheller was found to be 1.6% more efficient than the pedal corn sheller.

The pedal operated corn sheller had 102% more shelling capacity and 1.6% less shelling efficiency than that of the manually operated tubular corn sheller.

ACKNOWLEDGEMENTS

The authors are indebted to Mr DL Shrestha of Kuntabesi, Kabhrepalanchowk district, Mr R Shrestha, proprietor of the RK Engineering Workshop, Satdobato, Lalitpur and Mr G Thakur from Agricultural Implements Research Center, Ranighat, Birgunj for fabrication and modification of hand-operated cranking type of tubular corn sheller. It would have been impossible to fabricate the pedal-operated tubular corn sheller without the assistance of Mr HG Maharjan of Lubhu, Lalitpur.

REFERENCES

- Karunanithi R, A Tajjudin and D Asokan. 1990. Cranking-type tubular maize sheller from India. *RNAM Newsletter* No. 38. Regional Network for Agricultural Machinery.
- Sah G. 1992. Development of a manually operated maize sheller. *MSc Thesis*. Department of Farm Machinery, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Testing and Evaluation of Mini SRR Dryer in Nepal for Rice Crop

Gautam B Manandhar¹, Rabi Rasaily¹, Gauri L Shrestha¹ and Robert R Bakker²

¹ Agricultural Engineering Division, Khumaltar, Lalitpur

² International Rice Research Institute, Agricultural Engineering Unit, Philippines

ABSTRACT

Mini SRR rice seed dryer received from IRRI consisted of a cylindrical bin, an electric blower (2.5", 330 watt) with a cylindrical support, a rice husk stove and a metallic pipe. Eight tests were conducted during rainy weeks of July 2002, three at Kavre Palanchowk, four at Dhanusha and one at Parsa district. Grain loaded varied from 145 to 175 kg with moisture content (MC) from 17.8 to 23.5%. Overall drying rate with rice husk as source of heat was found to be 0.45% MC/hour, which is much higher, compared to results of Vietnamese SRR-1 dryer with electricity as heat source. Extrapolation to 13% final MC by simple linear regression showed an association with one another in a linear way ($r = 0.83$). With 250 kg loading, drying cost for one ton rice was found to be Rs476 for IRRI dryer but in replicated dryer without heat insulation on metal pipe, it was found to be Rs874 due to lower blower RPM. However, computations show that even cost of replicated dryer would be paid back within 10 years with 35 days of operation per year. It showed the possibility of commercializing the dryer for the small farmers either for seed or for food grain purpose. Maximum thermal efficiency of 22.4% was obtained at 0.6 kg rice husk/hour and 44.7°C drying air temperature (DAT). With DAT from 44.7°C to 49.0°C at Kavre, germination rate of paddy varied from 77-88%. The study, also aimed at enhancing the coverage of early rice in the country, has shown encouraging result.

Key words: Drying air temperature, drying cost, drying rate, moisture content, payback period

INTRODUCTION

Mechanical drying of rice has not been practiced in Nepal at farmer level. Sun drying is the only pre-dominant method. However, early rice is harvested during the rainy season. For this, farmers need the dryer that could dry the crop as soon as possible. There had been cases of No Harvest as shattering loss is very high in early rice varieties specially CH-45. This happened few years back in Chitwan area due to continuous rain for about a week (GB Manandhar and Scott E Justice, July 2000, unpublished). These days, many farmers sell early rice to the mill owners immediately after harvest, as there is market for wet rice to produce beaten rice.

Adoption of dryer for early rice means not only the conservation of the product or its seed but it would also enable the farmers to wait for better price. It would also help reduce women drudgery as they are mainly involved in crop drying. Hence, it should encourage the farmers for higher coverage of early rice in the country, which was the target of CGISP (1997) to manage Nepal's food deficit situation. Therefore, exploring appropriate methods of mechanical drying is a need of the early rice farmers so that they will not suffer for want of easy inexpensive drying methods to dry rice seeds as well as food grains. The present study is on Mini SRR Rice Seed Dryer, which was provided by Agricultural Engineering Unit, International Rice Research Institute (IRRI), Philippines to test in Nepalese condition for its feasibility. It was tested not only to use it for rice seed but also to see the possibility of using it as a food grain dryer for the small farmers of Nepal.

MATERIALS AND METHODS

Dryer details

Mini SRR rice seed dryer consists of a cylindrical bin (Figure 1) made of welded wire mesh and nylon netting, an electric blower with an inverted funnel and a cylindrical support (inner cylinder) containing a fine wire mesh

on its outer periphery, a rice husk stove and two metallic pipes (with emulsion paint on outer surfaces) to keep them at 90° with each other for heat transfer. One end of the pipe is resting on the stove and the other end of the pipe is attached to the blower. The outlet of the blower is attached to the top of the inverted funnel, which is also tightly attached to the top of the inner cylindrical support, the inside of which serves as a plenum chamber. After loading the grain between the cylindrical bin and inner cylindrical support along with the wire netting, it was covered from the top by a plastic sheet.

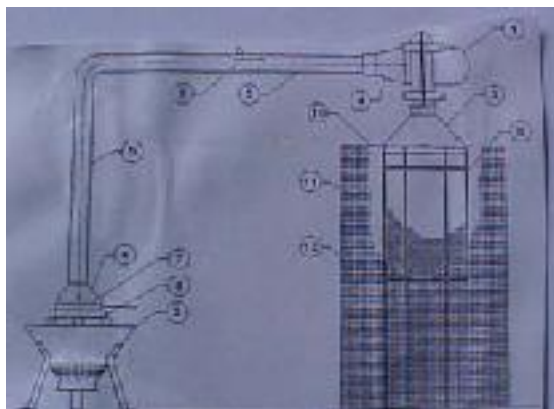


Figure 1. Mini SRR rice seed dryer

1. Electric blower (2.5" size, 330 w, 3000-3600 RPM), 2. Rice husk stove (40 cm Ø x 30 cm height, Lo Trau, Vietnam), 3. Inverted funnel (7 cm x 30 cm x 27 cm long), 4. Enlarged pipe piece, 5. Two metal pipes 6-6.5 cm Ø, 6. Slot to measure drying air temperature, 7. Air entrance, 8. Pipe support, 9. Cylindrical support (made of 7.5 mm metal rods) with fine wire mesh (32 cm Ø x 90 cm height), 10. Plastic cover, 11. Cylindrical bin (φ ≈ 70 cm and height 85 cm) made of wire mesh (1 mm Ø at about 1" gap), 12. Nylon netting.

Rice husk stove heats the ambient air inside an enlarged space of the metallic pipe. The heated air passes through the blower and is forced downwards inside the plenum (inner cylindrical support). As the dryer/bin is placed on the ground and the upper grain surface is covered, the hot air is forced inside the grain surface and after covering a distance equal to the grain thickness, it comes out towards outer cylinder.

Test procedure

The test was conducted during July 2002 at three different sites, farmers' field in Kunta, Kavre Palanchowk district, National Rice Research Program (NRRP), Hardinath, Dhanusha district and farmers' field in Belwa, Parsa district. Eight tests were conducted, three at Kunta, four at Hardinath and one at Belwa. Rice used for testing was obtained from the farmers of respective area. There were electricity interruptions in five tests. At Hardinath, generator (7.3 kw, Kirloskar) was used to complete two tests (conducted simultaneously), as there was a power failure for almost four hours.

The dryer was also replicated/fabricated without heat insulation (emulsion paint) on outer surfaces of metallic pipes by using Indian made blower, available in the local market, with lower RPM (2800) and heavier outer frame. For test 6, replicated dryer was used original dryer received from IRRI was used for all other tests.

Rice varieties used in the experiment were BG 1442 and mixed grain. Total weight of grains used were 160 kg at Kavre, 145 to about 160 kg at Hardinath and 175 kg at Belwa. Initial as well as subsequent moisture contents (MC) of grain were measured by a moisture tester (Wile 55). During the study, grain samples were taken at different time intervals from nine locations (3 points in the periphery and at 3 different heights) to find subsequent MC at various points in the grain mass. MC was also determined by air oven method and calibrated values were used for presentation. Grain temperatures were also measured at 9 locations as for grain MC. Ambient dry bulb temperature, relative humidity and drying air temperature were also monitored at certain intervals, when grain samples were drawn.

While plotting curves to observe moisture reduction pattern etc compared to duration of drying in test 4 and 5 conducted at Hardinath, average drying durations were used for few points in the curve, due to variability of time in testing grain samples. Similar average values were used for tests 6 and 7 conducted also at Hardinath for curves plotting to include more than one curve in the same chart.

Evaluation of dryer

Performance of Mini SRR dryer was evaluated mainly in terms of its drying characteristics like drying rate, net drying time etc. By simple linear regression method, total drying times required to reduce grain MC to 13% were also extrapolated to check the variation in average drying rate. Electric power used by blower and rice husk consumption was also recorded to determine the total power utilized and hence its total cost. The drying costs (per batch and per ton of grain dried) were also computed to determine the economic feasibility. Possibility to commercialize the dryer was also evaluated on the basis of payback period. Thermal efficiency was computed as the ratio of heat associated with the evaporated water to that contained in rice husk utilized (Hall 1970). Germination percentage was also tested for final paddy samples at one site (Kavre). Loading capacity, ease of working with the stove/dryer and in dryer assembly was also monitored.

Evaluation was based on eight tests conducted at three different sites including one hill district. Replicated dryer was evaluated without heat insulation on outer surfaces of hot air flow pipe. Time intervals for grain sampling to monitor subsequent MC in each test were varied depending on ambient temperature and relative humidity that affects on capacity to limit the drying air temperature.

RESULTS AND DISCUSSION

Moisture reduction of rice

Kavre: Higher drying rate of $\approx 0.5\%$ MC per hr was found in test 1 compared to other two tests ($\approx 0.4\%$ MC per hr) due to higher initial moisture content (MC) (Table 1). Figure 2 shows the reduction of more than 3% MC in test 1 after 6 hrs of drying within three hours.

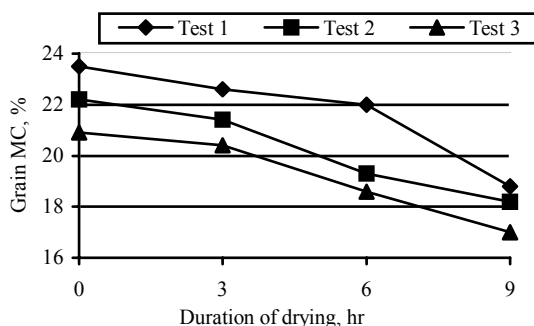


Figure 2. Moisture reduction of rice over duration of drying at Kavre

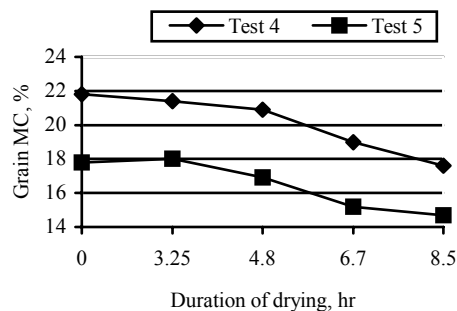


Figure 3. Moisture reduction of rice over duration of drying at Hardinath (Test 4 and 5)

Hardinath: For test 4, Figure 3 shows a slower drying for about three hours compared to test 5 due to lower drying air temperature (DAT, Table 2). But, due to higher initial MC in test 4 (Table 1) higher drying rate of about 0.6% MC per hr was obtained. Figure 4 shows lower drying rate during test 6 compared to test 7 mainly due to lower RPM of blower; replicated dryer with locally available blower was used in test 6. With average DAT of about 59.3°C for 4 tests at Hardinath and that of about 47.5°C for three tests at Kavre (Table 2), it gave almost the same average drying rates (Table 1). Lower average initial grain MC of 20.1% at Hardinath compared to that of 22.2% at Kavre seem to compensate with the higher average DAT at Hardinath.

Parsa: Figure 5 (for test 8) shows a slight increase in MC during the first 1.75 hours of drying. It might be due to contamination of grain with soil particles which when dried gave up moisture, rewetting the grain a little more. Rice received for testing at Parsa was harvested from the field, which was flooded by the nearby river. Similar increases in kernel MC were also obtained during cob-maize drying due to higher initial MC in cob compared to its kernel (Manandhar et al 2000b). In spite of much higher average DAT at Parsa (69.8°C) compared to those of 59.3°C at Hardinath and 47.5°C at Kavre drying rate at Parsa could not be increased for the same reason.

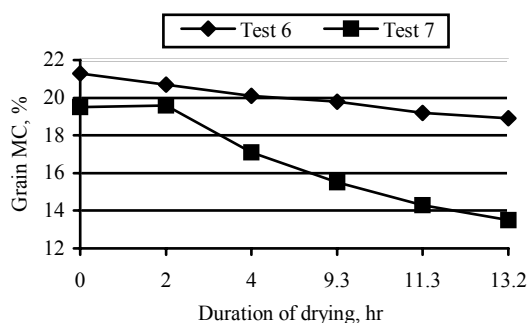


Figure 4. Moisture reduction of rice over duration of drying at Dhanusha (Test 6 and 7)

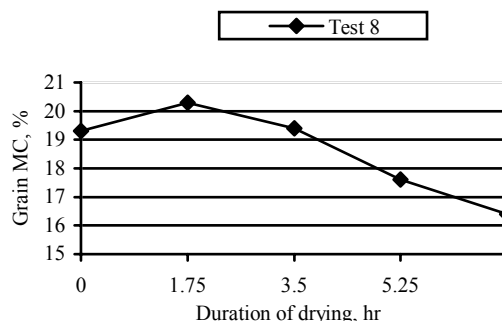


Figure 5. Moisture reduction of rice over duration of drying at Parsa

Overall grain-drying rate from all three sites was found to be 0.45% per hour. This value is close to the average drying rate of about 0.41% MC per hr obtained based on extrapolation of drying time using simple linear regression method required to reduce grain MC to 13% (Annex I, Table 1). Computation of simple linear correlation coefficient (Gomez and Gomez 1984) showed that there is strong evidence that observed drying rates of rice and that computed for 13% final grain MC are associated with one another in a linear way ($r = 0.83$) at 5% level of significance. This drying rate is much more higher compared to 0.08% per hr obtained in SRR-1 dryer (Manandhar et al 2000a). In Bangladesh, Bakker (2001) with this dryer obtained the drying rate of 0.6% MC per hour each with 150 kg at 15.3% MC and 250 kg at 20.6% MC of rice and at DAT of less than 43°C due to better ambient air condition.

Final moisture content variation in the grain mass

Average difference in MC between various points in grain mass among all the tests was observed to be very close to 2.8%/hr (maximum of 4.9% in the first test at Kavre and minimum of 0.9% in the last test at Parsa, Annex III). While testing the same dryer in Bangladesh, Bakker (2001) found the difference of more than 5%. With SRR-1 dryer, Hien et al (1999) found this difference to be about 1.5% only. However, there were many other variations in his studies, like drying duration, use of total energy, ambient air conditions etc, which helped him reduce this difference. The vertical axis of the inverted metallic funnel tilted slightly towards left or right might have caused in more fluctuation to the reduction of grain MC at various points in the grain mass.

Increment in grain temperature

At various peripheries within the grain mass, maximum and minimum differences of 5.8°C and 0.1°C were obtained in test 2 at Kavre and test 4 at Hardinath respectively. Average values showed that, there was a general trend of increase in grain temperature from bottom of the dryer bin to its top (Table 2). After certain MC, grain temp inside the drying bin increases with the reduction of grain MC in the drying process. Typical characteristic of grain temperature variation is presented in Figure 6. Increase in grain temperature in test 6 was lower compared to that in test 7 indicating lower drying rate in test 6. However, this will not hold true in case of power failure during the test, immediate rain in between reduction of drying air temperature, etc.

Ambient air condition

Frequent weather changes with rain during the test periods have varied the ambient air conditions in each test (Table 2). Sample curves showing changes in ambient temperature with corresponding changes in ambient relative humidity each with duration of drying is presented in Figures 7 and 8 respectively.

Variation in drying air temperature

Drying air temperature (DAT) was increased far above the limit allowable for seed drying (Table 2). Main reason was to determine the minimum possible time required to dry rice in humid ambient condition and also to see the possibility of using that dryer for food grain. The next reason was that the farmers wanted to dry their grain as soon as possible. Frequent interruption of electricity accompanied by rainfall also has hastened the farmers for faster drying of grain, otherwise heated grain left inside the bin for a longer time in highly humid ambient air might damage quickly. Average DAT was varied mainly due to frequent change in ambient conditions and partly due to rice husk feeding rate. Sample variations of average DAT being used for tests 4 and 5 conducted at Hardinath was presented in Figure 9.

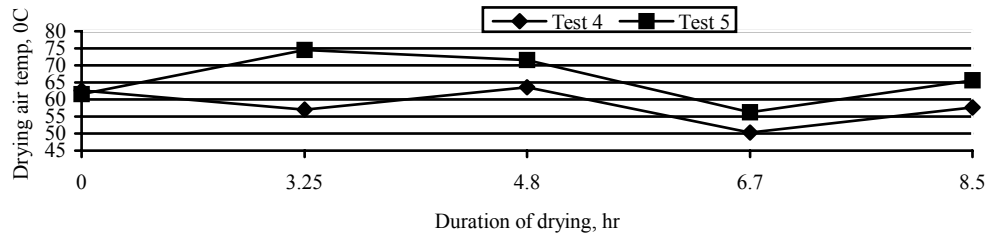
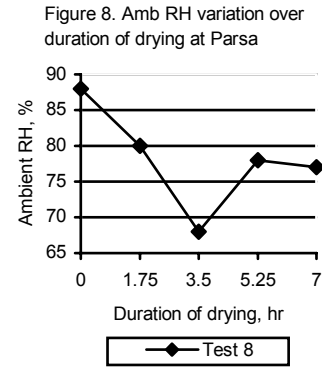
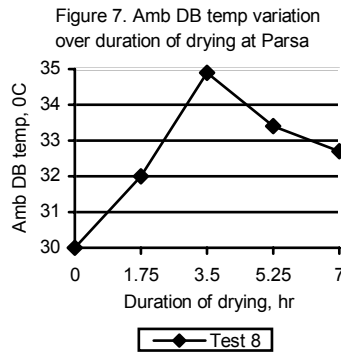
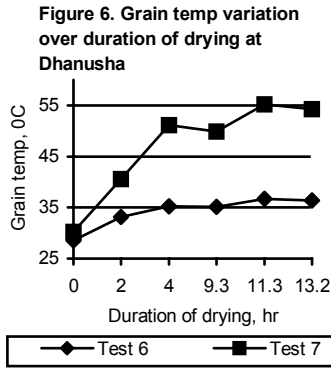


Figure 9. Variation of drying air temp over duration of drying at Dhanusha (Test 4 and 5)

Total energy used (blower and rice husk stove)

Average power consumed to dry about 160 kg of grain from 20.5% to 16.8% average MC was found to be about 7.5 kw that includes 4.7 kw equivalence of rice husk (≈ 9 kg, Table 3). Total power consumed was higher at Parsa due to mixing of grain with soil. At Hardinath, as there were power failures in each test, from 20 minutes to nearly four hours, it also caused to consume more power. The heated grain during power failures absorbs moisture from the humid air. At such times, after pause, feed rate of rice husk was increased to compensate with the increase in grain MC. When power failure lasted longer during 6 and 7 tests, which were conducted simultaneously, a diesel generator (7.3 kw, Kirloskar) was arranged and utilized to complete those tests. Limiting the drying air temp to 43.3°C , 30-40% of rice husk consumption could be reduced.

Table 1. Average moisture contents (%) and drying rates (% per hr) of rice

Testing site	Test no.	Total drying time, hr	Net drying time, hr	IMC, %	FMC, %	Observed drying rate, %/hr	Drying time computed for 13% final MC, hr	Drying rate computed for 13% final MC, %/hr
Kavre	1	10.25	10.1	23.5	18.2	0.525	20.626	0.509
	2	9.0	9.0	22.2	18.2	0.444	19.979	0.460
	3	9.0	9.0	20.9	17.0	0.433	18.333	0.431
	Av	9.92	9.87	22.20	17.70	0.456	19.646	0.467
Dhanusha	4	7.5	7.2	21.8	17.6	0.583	16.478	0.534
	5	9.5	7.8	17.8	14.7	0.397	14.594	0.329
	6	13.7	9.8	21.3	18.9	0.245	51.056	0.163
	7	12.7	8.8	19.5	13.5	0.682	13.866	0.469
	Av	10.85	8.40	20.10	16.18	0.477	26.505	0.320
Parsa	8	7.0	7.0	19.3	16.4	0.414	15.030	0.419
Overall Av		9.26	8.42	20.8	16.8	0.45	21.245	0.414

IMC, Initial moisture content. FMC, Final moisture content. MC, Measured every 3 hrs in Kavre, 1.5 – 2 hrs in Dhanusha and 1.75 hrs in Parsa. Simple linear $r = 0.83$. Replicated dryer without heat insulation in pipes was used in test 6.

Thermal efficiency

Thermal efficiency was varied mainly due to drying air temperature and rice husk feeding rate. Average thermal efficiency was found to be 12.9% (Annex III). Lowest thermal efficiency of 4.4% was obtained in test 6, as more heat was lost from outer surfaces of non-insulated metal pipe in the replicated dryer. Maximum thermal

efficiency of 22.4% was obtained at rice husk feed rate of 0.6 kg/hr and average drying air temperature of 44.7°C.

Table 2. Average grain temperature, ambient air conditions and drying air temperature (DAT)

District	Test no	Av grain temperature, °C			Av	Amb air condition of working shed		Av DAT, °C	Remark
		0.15 m /bottom	0.5 m /mid	0.85 m /top		Temp, °C	RH, %		
Kavre	1	32.8	33.8	35.6	34.0	27.5	85.4	49	Interrupted drizzling
	2	35.1	38.8	40.9	38.2	30.1	77.3	44.7	-
	3	35.1	38.7	40.4	38.0	27.0	82.6	48.9	Rain for $\approx$ 2.5 hour
	Av	34.3	37.1	39.0	36.7	28.2	81.8	47.5	
Dhanusa	4	36.3	36.2	36.2	36.3	27.1	88.0	57.5	Interrupted rainfall for > 3 hr
	5	40.4	42.2	41.6	41.4	32.4	72.0	65.9	-
	6	34.7	33.9	33.9	34.2	28.9	85.5	48.8	Slight rain, continuous
	7	45.2	47.1	48.4	46.9	28.9	85.3	65	Slight rain, continuous
	Av	39.2	39.9	40.0	39.7	29.3	82.7	59.3	
Parsa	8	40.4	43.5	43.1	42.4	32.6	78.2	69.8	-
Overall Av		38.0	40.2	40.7	39.6	30.0	80.9	58.9	

Observations of grain temperature, ambient conditions and drying air temperature every 3 hrs in Kavre, 1.5 – 2 hrs in Dhanusha and 1.75 hrs in Parsa.

Table 3. Observations on blower and heater operation

District	Test no	Blower use (330 w), hr	Power used, kw hr	Rice husk used, kg	Cal value, kw hr	Total power used, kw hr	Duration of power failure, min
Kavre	1	10.1	3.333	8.55	3.637	6.970	10
	2	9.0	2.970	5.40	2.578	5.548	-
	3	10.5	3.465	5.40	2.209	5.674	-
	Av	9.9	3.3	6.5	2.8	6.1	
Dhanusha	4	7.2	2.376	9.90	5.907	8.283	20
	5	7.8	2.574	6.60	3.635	6.209	100
	6	9.8	3.234	15.40	6.751	9.985 §§	229
	7	8.8	2.904	9.90	4.833	7.737 §§	229
	Av	7.5	2.8	10.5	5.3	8.1	
Parsa	8	7.0	2.310	10.00	6.137	8.447	-
Overall Av		8.1	2.8	9.0	4.7	7.5	

Ash cal values not deducted, 1 m rice husk $\approx$ 3.7 Kcal/g. Generator used for $\approx$ 5 hrs not included in total power consumption.

Germination percentage

Average drying air temperature (DAT) maintained during the study at Kavre (Tests 1, 2 and 3) varied from 44.7°C to 49°C (Table 2), which is 5-6°C higher than is allowable for seed drying. However, germination percentage of paddy was measured for this test site and average value was found to be about 84% (Table 4). Germination percentages were not tested for the grain dried at Hardinath and Parsa, as DAT has exceeded much higher than the maximum limit allowable for seed drying (43.3°C).

Drying cost

Initial investment cost of IRRI dryer was based on the test report from Bangladesh (Bakker 2001) in which assumed cost of dial thermometer was reduced (Annex II). For investment on fabricated/replicated dryer, cost of accessories and rice husk stove was estimated. It was also based on assumption that loading capacity of dryer is 250 kg (Bakker 2001) or more. Labour cost was not included and generator used during the simultaneous study in tests 6 and 7 at Hardinath were not considered to calculate the operational cost. Drying cost per ton of grain obtained for IRRI dryer with loading capacity of 250 kg, with rice husk as heat source, was found to be much lower compared to that calculated for rice drying by SRR-1 using electric heater (Manandhar et al 2000b). Drying time was also reduced from 56 to about 20 hrs for IRRI dryer and to 50 hrs for replicated dryer. Drying time in replicated dryer would reduce further with heat insulation (eg emulsion paint) at outer surfaces of hot air flow pipe.

Capacity of the dryer per batch might be more than the quantity (250 kg) loaded by Bakker (2001), which would reduce its drying cost. But, farmers at one time could not provide large quantity of grain due to shortage of labour ie labour were busy in land preparation for monsoon rice. This reflects a common observation that there is a labour bottleneck at turn around times.

Payback period

Drying charge was assumed to be Rs1/kg for which farmers can easily pay, as dried grain could be stored for few months waiting for better selling price. Payback period for IRRI dryer was found to be about 8 and 2 years for 150 and 250 kg grain loading respectively similarly, payback period for the replicated dryer without pipe insulation was found to be about 10 years at 250 kg grain loading (Annex II). With the reduction of drying time in replicated dryer with pipe insulation eg application of emulsion paint at outer surfaces of hot air flow pipe, similar reduction takes place in payback period also.

Table 4. Final germination percentages of paddy dried at Kavre

Test no	Germination percentage at different dryer heights			Av
	0.15 m/bottom	0.5 m/mid	0.85 m/top	
1	91	89	85	88
2	81	73	78	77
3	89	87	84	86
Av	87.0	83.0	82.3	83.7

CONCLUSIONS

Small farmers of Nepal could also use Mini SRR rice seed dryer to dry food grains for the following reasons.

- Lower initial investment of dryer
- Lower power consumption and availability of rice husk in all rice growing areas
- Higher drying rate and lower net drying time compared to SRR-1 dryer because of higher air heating
- The dryer is simple to assemble and easy to operate
- Thermal efficiency of the dryer could also be maintained above 20% with rice husk feed rate of about 0.5-0.6 kg/hour

Possible reasons for slow drying compared to Bakker's study in Bangladesh

- Interruption of electricity during the tests
- Rainfall/higher ambient relative humidity during the tests

Possible reasons for slow drying and higher payback period in the replicated/fabricated dryer

- Lower blower RPM of 2800/changed blade configurations
- Lower drying air temperature attained compared to during IRRI dryer testing.
- Lack of insulation in metal pipes (eg emulsion paint on originally received IRRI dryer pipes)

Possibility for commercialization of dryer for rice

More than 30% areas of holdings have only less than 1 ha of land and another 27.6% are included up to 2 ha of land (CBS 1998). Small farmers do not need higher capacity dryer. Trying to increase the rate of drying with higher capacity dryer might reduce drying cost per unit weight of grain but it would result in higher initial investment followed by higher consumption of power. Gagelonia et al (2001) in 6 t capacity dryer calculated the drying cost per 45 kg of rice to be \$0.4 ($\approx$ Rs30) at 300 t/year of drying but initial cost of dryer was \$6000 ($\approx$ Rs468, 000). So, Mini SRR dryer could be beneficial for the small farmers of Nepal. Moreover, it has following characteristics.

- Similar Indian blower (though with less RPM and heavier outer frame) is available in the local market
- Rice hull stove and other accessories are either available in the market or could be fabricated by any blacksmith provided raw material
- Initial investment of replicated dryer is low and could be recovered within 10 years
- Farmer should be able to afford Rs1/kg as rice drying charge for safe storage or store it for few months for better selling price.
- Rice dried, limiting the drying air temperature to 43.3°C , could also be suitable for seed purpose

- Prototype dryer fabricated in Nepal with heat insulation of metal pipe would result in higher drying rate, lower drying cost and lower payback period.

Recommendations

- Study on use of dryer for multiple crops
- Credit facilities and/or subsidy to the small farmers for purchase of the dryer.
- Modification of dryer to suit medium and larger early rice farmers of the country.
- Community use of similar big dryer
- Extensive demonstration of dryer at all early rice growing areas
- Study on blowers with different blade configurations
- Use of electricity as heat source in mini SRR dryer

ACKNOWLEDGEMENTS

The authors were thankful mainly to the Agricultural Engineering Unit, IRRI, Philippines for providing Mini SRR dryer. They were especially thankful to Mr SE Justice, CIMMYT/Nepal for constant encouragement to work on post harvest engineering activities and also for valuable comments and editing of the manuscript. Mr NS Thakur, Outreach Research Division is very much thankful for partial help in drawing graphs. Special thanks go to Dr EM Bhattarai, from RRP, Hardinath for the help during the test at Hardinath. Mr G Sah, AIRC, Mr U Adhikary, on contract and Mr D Chowdhary, all from AIRC, Ranighat, Parsa, were also equally thankful for helping in many ways during the test at Parsa. They were also thankful to Mr Jeevan KC and Mr JR Basnet, AED, Khumaltar. Thanks go also to Mr H Lama and K Sunar, both from AED for helping in many ways during the tests. Farmers Mr PL Shrestha (Kunta Bazaar, Kavre Palancjowk district) and Mr A Dahait, Belwa, Parsa district and the farmer who helped during the tests at RRP, Hardinath were very much thankful for providing the harvested paddy for testing and evaluation of the dryer.

REFERENCES

- Bakker R. 2001. *Test report on performance of small seed dryer for Bangladesh*. Received by email (19 June 2001). Agricultural Engineering Unit, International Rice Research Institute (IRRI).
- CBS. 1998. *Statistical pocket book*. Central Bureau of Statistics. National Planning Commission Secretariat. His Majesty's Government. Nepal.
- CGISP. 1997. *Community groundwater irrigation sector project, TA 2589 – NEP*. ADB, HMG/N and Dept. of Irrigation, April 1997.
- Gagelonia EC, EU Bautista, MJC Regalado and RE Aldas. 2001. *Flatbed dryer re-introduction in the Philippines*. Agricultural Mechanization in Asia, Africa and Latin America. Vol.32 (3):60-66.
- Gomez KA and AA Gomez. 1984. *Statistical procedures for agricultural research*. 2nd ed. John Wiley and Sons, Inc. New York.
- Hall CW. 1970. *Drying farm crops*. First Indian Edition. Lyall Book Depot, Ludhiana, India.
- Hien PH, LV Ban, BN Hung, DS Thong and M Gummert. 1999. *Development and distribution of low-cost dryer in Vietnam*. Agric. Mechanization in Asia, Africa and Latin America. Vol.30(2):47-53.
- Manandhar GB, SE Justice, KP Hada and SK Adhikary. 2000a. Testing and evaluation of a simple grain dryer for off-season rice. *Paper Presented in a Summer Crop Workshop Organized by Nepal Agricultural Research Council (NARC), ARS, Lumle, 27-29 March 2000*.
- Manandhar GB, SE Justice and SK Adhikary. 2000b. Testing and evaluation of a simple multi crop dryer for maize. *Paper Presented at Winter Crop Workshop Organized by Nepal Agricultural Research Council, RARS, Parwanipur 12-14 Sept 2000*.

Annex I. Constants for simple linear regression equations to extrapolate for 13% final grain moisture content (95% confidence and prediction intervals)

Test no	Constant	Variable	Test no	Constant	Variable
1	24.0458	- 0.53554	5	18.4390	- 0.3727
2	22.3900	- 0.4700	6	21.0720	- 0.1581
3	21.2500	- 0.4500	7	19.7610	- 0.4876
4	22.6660	- 0.5866	8	20.3000	- 0.4857

Annex II Calculation of drying cost and payback period

Annual fixed cost (Rs) of IRRI dryer: 2527.20 (initial investment Rs10, 530) and that of replicated dryer: 1200 (initial investment Rs5000), depreciation at 10 yr, interest at 14% for both.

Dryer type	IRRI dryer	IRRI dryer	Replicated dryer
Investment, Rs	10530.00 (US\$ 135.00)	10530.00 (US\$ 135.00)	5000.00 (US\$ 64.10)
Operation days/yr	35	35	35
Loading cap, kg (24% MC WB to 13%)	150	250	250
Drying duration/batch, hr	20	20	50
Fixed cost per batch, Rs (economic life of 8400 hr, 24 hr/day, 10 yr life)	60.17	60.17	71.43
Electricity consumption, kw hr/batch	6.60	6.60	16.50
Total power charge, Rs/batch	58.80	58.80	147.00
Drying cost/batch, Rs	118.97	118.97	218.43
Drying cost/ton, Rs	793.14 (US\$ 10.17)	475.89 (US\$ 6.10)	873.71 (US\$ 11.20)
Working hr/yr	840	840	840
No of batch/year	42.0	42.0	16.8
Gross income/yr @ Rs 1/kg	6300.00	10500.00	4200.00
Total drying cost/yr, Rs	4996.80	4996.80	3669.60
Net income/yr, Rs	1303.20	5503.20	530.40
Payback period, yr	8.1	1.9	9.4

Interest rate at 14 % per yr. Electricity charge at Rs5.50/ kw hr. Av rice husk consumption at 0.9 kg/hr @ Rs1.25/kg. 1 US\$ = Rs78, Dec 2002.

Annex III. Rice drying at Kavre, Dhanusha and Parsa by mini SRR dryer, July 2002

Observation	Kunta, Kavre			RRP, Hardinath, Dhanusha				Parsa	Av
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	
Loading date, 2002	July 8	July 9	July 10	July 23	July 25	July 26	July 26	July 29	
Bin size (inner ϕ *outer ϕ *ht), cm	32- x 68- x 90-cm (A)						A	A	
Blower specifications	SY 202 (Taiwan), size 2.5", 50-60 cycles, 220 volt, 1.5 amp, 3000-3600 rpm (B)					2800 rpm	B	B	
Rice husk stove details	40 cm top ϕ x 31 cm ht, pot support 18 cm ϕ x 11 cm high x 13 cm inner ϕ								
Wt of grain loaded, kg	160	160	160	160	145	150	150	175	157.50
Grain thickness, cm	17.6	17.8	18.0	17.9	17.3	17.1	17.4	19.5	17.9
Variation of drying air temp, °C	43.3-57.4	32.2-54.4	32.2-62.8	50.3-63.6	56.3-74.5	45.2-53.3	60.6-71	63.4-77.3	32.2 – 74.5
Variation of grain temp, °C	31.6-36.3	30.2-43.6	27.9-42.9	34.5-39.1	28.5-52.5	28.6-36.7	30.2-55.2	38.4-46.0	37.4
Variation of ambient dry bulb temp, °C	25.8-28.7	28.7-31.6	25.7-27.8	25.5-30.2	27.8-34.9	26.9-32.0	26.5-31.8	30-34.9	29.2
Variation of ambient RH, %	79-91	71-80	81-84	80-93	58-85	78-90	75-90	68-88	79.4
Rice husk feeding rate, kg/hr	0.85	0.60	0.51	1.38	0.85	1.57	1.13	1.43	1.11
Final MC difference, %	4.9	3.9	2.5	4.2	2.1	2.0	2.0	0.9	2.8
Wt of dried grain, kg	149.6	152.2	152.5	151.8	139.7	145.6	139.6	168.9	≈150.0
Water evaporated, kg	10.37	7.82	7.52	8.16	5.27	4.44	10.4	6.07	7.51
Rate of moisture evap, kg/hr	1.03	0.87	0.72	1.13	0.68	0.45	1.18	0.87	0.87
Drying cap dry grain, kg/hr	14.81	16.91	14.52	21.09	17.91	14.85	15.86	24.13	17.51
Specific energy requirement, kw hr/kg of water removed	0.672	0.709	0.755	1.015	1.178	2.249	0.744	1.392	1.09
Thermal efficiency, %	18.7	22.4	21.4	12.6	12.1	4.4	15.9	9.2	12.9

Calibrated MC values. Latent heat of paddy was based on drying air temperature and av grain moisture. Replicated bin. Blower from local market.

A Review on Management of Fruit Drop in Mango and Citrus

Ishwori P Gautam

Regional Agriculture Research Station, Lumle, Kaski

ABSTRACT

Mango and Citrus are important fruits in Nepal. They occupied about 9% and 25% of total fruit cultivated areas respectively in Nepal. However, the national productivity of mango (7.0 t/ha) and citrus (10.38 t/ha) is very low. Besides other factors, fruit drop is a serious cause of low productivity in both fruit crops. In nature, fruit drop of mango and citrus have been found very high accounting 99% and 93.52-96.63% respectively. Considering these facts, a number of studies in fruit drop, fruit development stages and their control measures have been reviewed to attract the attention of large number of workers and extension agents for minimizing the fruit drop problem in mango and citrus. The results of the investigations showed that fruit drop is a complex problem involving several factors. Application of recommended dose of fertilizers with spraying 2% urea or 4% calcium nitrate containing 50 mg boric acid/lit water reduced fruit drop. Among the various growth regulators, application of NAA and 2,4-D (10-20 ppm) in mango during April to May found effective for retention of fruits in North India condition. Similarly, in citrus 2,4-D (10-20 ppm), 2,4,5-T and GA were found effective for controlling fruit drop. The application of IAA and NAA were found ineffective due to increase the abscission zone of the fruit.

Key words: Citrus, fruit drop, management, mango

INTRODUCTION

Mango and citrus are important fruits grown in Nepal. Mango ranks first in tropical fruits and it occupies 9% of total fruit cultivated area. Similarly, citrus ranks first in sub-tropical fruits and it covers about 25% fruit cultivated area in Nepal (Shrestha and Verma 1998). The mid-hill is quite suitable for citrus cultivation in Nepal. The national productivity of these fruit crops is very low 7.0 and 10.38 t/ha (APSD 2001/2002) in comparison to its yield potentiality ie 15 and 30 t/ha in mango and citrus respectively. Among the various reasons of low yield, fruit drop is one of the most important causes for a low productivity in both fruit crops.

The term fruit drop may be defined as dropping and shedding of the fruit at different stage of fruit development due to various reasons like lack of nutrients, high and low temperature, hail, hormonal imbalance etc. In nature, fruit drop of mango and citrus have been found very high accounting 99% and 93.52-96.63% respectively (Bose 1990, Kunthe et al 1997). In mango, the cultivars Bombay Green, Langra and Fajri only 0.1-0.25 fruit reach up to maturity stage. However, the study conducted by various workers show that in general, only about 0.1% of perfect flowers develop to maturity.

STAGES OF FRUIT DROP

Mango

The fruit drop in mango is characterized by continuous dropping at all stage of development. The 5-6 weeks after fruit set are critical. Although, the phase of fruit drop in mango is divided into three distinct phases.

Pin-head drop: This drop consist of shriveled floral organs, male flowers, abnormal flower, un-pollinated bisexual flowers and small pin like fruits below 4 mm in diameter. This drop is considered essential and desirable to produce fruits of desired size, grade and quality.

Post setting drop: This includes drop of fruits of 4 mm diameter and above and mostly prominent in mid April. This drop is caused due to competition of fruit and vegetative parts for food supply and moisture. It is reported that, excluding pin-head drop in Langra, Dashehari and Fajri, it was found 81%, 71% and 74% respectively of total fruit set. So this is considered the major fruit drop.

May drop: This was found economically the most important drop. This drop includes fruit ranges from 16-35 mm and extended almost the entire month of May. Unfavourable high temperature, low humidity, high wind, lack of nutrients and hormonal imbalance may be main cause of this drop. Based on the weight basis serious losses of crop was found to occurs only in May drop and in the subsequent drop of solitary fruits (Chadha and Singh 1964). Therefore, to increase the final harvest, the lateral categories fruit drop need to be managed. The initial heavy drop could even be termed as a necessary evil.

Citrus

In North India, most of the citrus species except lemon and certain cultivars of lime flower in Spring, ie February-March and fruit mature in the month of Nov-Feb. The period of development of fruits are 8-9 months. Thus, the abscission of citrus fruits is not restricted to dropping of citrus fruits but may occur at any time. However, in South India, Sathgudi orange flowers twice in year from Dec-April (main) and Sept-Oct (off-season). In Central and West India, orange flower thrice a year at interval of four months ie June, Oct and Feb. Under tropical condition lime, lemon and citron flower continuously throughout the year. In most of the citrus, there are four stages of fruit drop.

Post setting drop

In this stage, shedding of large number of fruitlets and shedding fruits have calyx attached. The cause of the drops is just like mango and is an essential event.

Summer drops

This drop occurs in Ambia Bahar from second April to May. The dropped fruits are soft and lake in turgidity. At this time atmospheric temperature is high as 42-45°C accompanied with hot and dry wind, low RH which may be cause of this drop. In Mirga Bahar, such drop is not observed.

Premature fruit drop

It is mainly rainy season and drop is more severe due to lack of nutrients, poor aeration in soil, auxins deficiency and presence of *Collectotrichum* in pedicle end together cause of formation of abscission layer. Citrus green stinkbug, CGSP (*Rhynchocoris humeralis*) was found major pest for this drop in the western hills of Nepal (Manandhar 2002). He also reported that among total fruit drop in mandarin, half of fruit drop was caused by CGSP.

Pre harvest drop

This is most destructive and occurs during maturation period. The drop fruit contain less number of seeds, less auxins. It is most important for reducing the yield and so need to be controlled.

FACTORS AFFECTING THE FRUIT DROP

Varietal differences

There are large differences in fruit drop in different varieties of mango and citrus. It may be caused due to certain morphological characters like strong fruit stalk. In mango maximum fruit drop was 97.68% in Langra, 97.64% in Fajri and 94.42% in Dashehari (Singh 1994 reported by Chadha and Singh 1964). Similarly the variety Mallika was resistant to fruit drop. In case of citrus, (sweet orange), low fruit drop is recorded in cultivar Hamlin (84.5%) as compare to 87.7%, 89.9% and 92.6% in Pineapple, Blood Red and Valencia respectively (Randhawa 1982).

Tree aspect

In mango the eastern and western aspect of tree exposed to comparatively medium isolation provided to be more congenial for fruit retention than the Northern and Southern aspect. In addition, low isolation in the North and too high isolation in the South, both seemed to be affected fruit retention adversely. Similarly, in mandarin and lime east and south facing aspect, give better and higher production in Nepalese condition (Gautam and Dhakal 1994).

Position of fruits

The position of fruits on tree also affect the dropping of fruits in many crops because fruits inside the crown can not get sufficient light, ventilation and easily attack by insects. In mango, it is reported that there was only 0.14 fruit/panicle located deep in to the crown than 0.29 fruit/panicle located in the periphery of the crown.

Diurnal variation

Large diurnal variation in fruit drop have been recorded in fruit crops. Generally, high amount of fruit drop occurs in mandarin at night time in hills of Nepal. It may be due to very low temperature and easily attack by string bug insect at night time. In Mango, it is found that fruit drop during day time was nearly doubled than that of night hours. It may be due to low prevailing temperature, comparatively calm weather and more satisfactory internal water relation of plants (Randhawa and Chand 1982).

Embryo abortion

It is caused by defective perfect flower, lack of pollination, hormonal imbalance etc. In many fruits embryo is closely associated to dropping of immature fruits. The aborted ovule and degeneration of embryo sac occurs in Haden variety of mango (Young 1942). The abortion of ovule could be due to degeneration either of embryos sac or of the embryo itself or failure of pollination. The second wave of fruit drop in North India in mango was due to abortion of embryo after fertilization (Randhawa 1982). The zygote of fruit rest for 8-10 days after its formation and fruit grow continuously. After that most of the fruits are shed and its appears to be most critical time for survival of fruits.

Lack of nutrients

Properly balanced nutrients is a prerequisite for a tree to be able to carry its crop to maturity. As fruit develop, there is great competition for survival among the fruits. Of the various elements N, Ca, Mg are known to play an active role in normal development of fruits. Girdling of the branches just after fruit set helped in reducing fruit drop In Dashehari through accumulation of carbohydrate. In ctrus, it was reported that zinc deficiency Shamouti orange tree shed 35.8% of total flower compare to 15.56% in normal tree. Similarly, in normal tree June drop decreased by 4.5% with zinc and Mn and increased with copper, iron and cobalt foliar spray (Ali et al 1955).

Hormonal imbalance

Imbalance of hormones is most important cause of fruit drop in many plants. The low level of auxins and high level of ethylene are more responsible for fruit drop. The abscisic acid is responsible to initiate the formation of abscisic layer. The higher amount of auxins, IAA, NAA, 2, 4- D delay or neutralize or prevent the formation of abscisic layer. In mango, it was reported that auxins activity increase with increase the size of fruits, which indicate that there is inverse relationship between auxins activity of seeds and fruit drop. Other hormones like ethylene accelerate abscission whereas gibberelline delay it. The cytokinin also affect the abscission of leaves and transport of auxins. The enzyme cellulase play important role in late abscission by affecting cell wall degradation.

Disturbed water relation

An excessive or deficiency of moisture in soil encourage fruit drop in mango. In Delhi, it was reported that there is direct relation between water table, soil moisture, in fruit drop of mandarin (Dhillan and Singh 1965). In the initial stage of fruit development moisture stress was found detrimental to fruit retention and frequent irrigation is suggested to retain more fruits.

Other climatic factors

Climatic conditions like rainfall, temperature, humidity etc have been variably associated in fruit drop in many fruits. It is felt that during abnormal night temperature, the rate of respiration increased from leaves and young fruit and consequently moisture is withdrawn and ultimately fruit drop occurs in later stage ie after the start of pit hardening. Similarly, moisture stress during summer, excessive rain, high temperature and low humidity are

responsible for excessive fruit drop in citrus. In Shamouti orange, it was observed that the principal factor of fruit drop was low humidity, while high temperature was secondary in important.

Insects and diseases

The major insects and diseases responsible in fruit drop in mango are mango hopper, mealy bug and diseases such as anthracnose, powdery mildew etc. The extent of damage is depend on severity of attack. In mandarin, fruit drop due to infestation of diseases, bird or insect attack from July to October is recorded 16-20% loss of fruits. Similarly, fruit drop due to styler end rot (*Alternaria citri*) was highest (8.9%) in Hamalin and 7.5% in Mosambi. Stem end rot (*Colletitrichum gloeosporioides*) was found high 19.9% in Mosambi and 10.13% in Blood Red orange. The research conducted in western hills of Nepal (600-1000 masl) during 2001/02 reported that 50% fruit drop in mandarin orange was caused by CGSB.

CONTROL MEASURES OF FRUIT DROP

Irrigation, cultural management and mulching during fruit development stage. Application of recommended dose of fertilizers with spraying of 2% urea or 4% calcium nitrate containing 50 mg boric acid. Grow fruit drop resistant varieties like Dashehari in mango and Hamlin in sweet orange in citrus. Use of plant growth regulators at proper dose in appropriate time. The details are given in Tables 1 and 2.

Table 1. Suggested growth regulators to control fruit drop in mango

Variety	Place	Growth regulator	Concentrate, ppm	Time
Alphonso	Florida	NAA / 2,4-D	25	Full size (1/2- 1")
Bom.	Sabour	2, 4-D	5	Pea stage
Green				
Bom.	Delhi	NAA/2,4-D	20-30	April
Green				
Chausa	Delhi	2,4-D	40	May
Dashehari	Delhi	2,4-D	20	April
Fajri	Basti	2,4-D	25	-
Fajri	Patiala	NAA	40	May 15
Gulabkhas	Sabour	2,4-D	10	-
Langra	Patiala	2,4-D	40	May 8
Langra	„	2,4,5-T	20	April 25
Neelum	Anantharajapet	2,4-D	30	One month after fruit set

Table 2. Suggested growth regulators to control fruit drop in citrus

Variety	Growth regulator	Concentrate, ppm	Time
Blood Red	2,4-D	20	August
Mosambi	2,4,5-T	20	August
Jaffa	2,4-D	20	August 15
Jaffa	2,4-D	10	Oct 15
Hamlin	2,4-D/ 2,4, 5-T	10-20	Before start of summer drop
Valencia Late	2,4-D	40	August 15 (0.5 mm dia.)
Valencia Late	GA	25	„
Nagpuri Mandarin	2,4-D and 2,4,5-T	20 and 10-15	„
Kinnow	2,4-D	10-20	Two month before harvesting
Kinnow	2,4-D + Aureofungin	20	First week of Sept

CONCLUSION

A number of studies in fruit drop, fruit development stages and their control measures have been reviewed in mango and citrus. The results of these investigations shows that fruit drop is a complex problems involving several factors. The following conclusion and recommendation can be drawn.

- The ultimate fruit retention on the fruit crop is rather low. The early fruit drop occurs during April while it is not interfering with the essential drop. Spray treatment of this essential drop is found useful.
- Besides varietal and other factors, Eastern and Western aspect of tree appeared to be congenial for final retention of fruits.

- Many factors like climatic condition, disturbed water relation, lack of nutrients, diseases and pest variously contribute to fruit drop.
- Among various growth regulators, use of NAA and 2,4-D in mango have been beneficial. The optimum concentration lies between 10-20 ppm. At higher concentration of 2,4-D fruits and seed development is retarded.
- Best time of hormone application have been found some what April to early May under North Indian condition.
- The single spray have been generally found to enough. Repeated spray gave no additional benefit.
- Fruit drop is found very heavy in almost all citrus sp. In sweet orange, it has been reported from 84-96% in India.
- In citrus 2, 4 -D was effective in controlling pre harvest drop in most varieties at lower concentration of 10-20 ppm. 2,4-5-T, GA also gave effective control in some varieties.
- In citrus use of NAA and IAA were ineffective, mainly because it delay development of abscission zone on fruit stem.

REFERENCES

- Alli M, S Alli and Musahib-UD-DIN. 1955. Vigour and productivity as affected by trace elements in citrus. *Punjab fruit Journal* 19:53-54.
- APSD. 2002. *Statistical information on Nepalese agriculture (2001/2002)*. Agri- business Promotion and Statistics Division, Ministry of Agriculture and Co-operatives, HMG/N. Singha Darbar, Kathmandu, Nepal.
- Bose TK and SK Mitra. 1992. *Fruits: Tropical and sub-tropical*. Department of Horticulture, Bidhan Chand Krish Viswavidalaya, Kalyani, India.
- Chadha KL and KK Singh. 1964. Fruit drop in mango: II. Intensity, periodicity and nature of shedding of immature fruits. *Indian J. Hort.* 20(3-4):172-185.
- Dhillon BS and JP Singh. 1965. Effect of plant regulators and nitrogen application on fruit drop in Nagpuri mandarin. *Indian Journal of Hort.* 22:309-313.
- Gautam DM and DD Dhakal. 1994. *Phal phul Tatha Audhaukik Bali* (Nepali Version). Department of Horticulture, Institute of Agricultural and Animal Science, Rampur, Nepal.
- Kunthe YN MP Kawthalkar and KS Yawalkal. 1997. *Principle of horticulture and fruit growing*. Tenth Revised Edition. Agri-Horticulture publishing House, Nagpur.
- Manandhar R. 2002. Management of citrus green stink bug (*Rhynchocoris humeralis*) through integrated approaches. *Lumle Technical Paper No. 2002/8*. Agriculture Research Station, Lumle, Kaski, Nepal.
- Randhawa GS and KL Chadha. 1982. *Fruit drop and its control in mango and citrus*. Bhatt VS, Director, ICAR, Pusa, New Delhi-110064.
- Randhawa GS. 1982. Fruit drop in mango. *Indian J. Hort.* 20(1):30-33.
- Randhawa GS. 1983. Fruit Drop in Mango. III. Rate and extent of fruit drop by No. and wt. and factor affecting it. *Indian J. Hort.* 21(2):122-131
- Shrestha PP and SK Verma. 1994. Development and out look of citrus industry in Nepal. **In: Proceedings of The National Horticulture Workshop**. January, 1998 Kirtipur, Kathmandu, Nepal.
- Young TW. 1942. Investigation of the unfruitfulness of the Haden mango in Florida. **In: Proceedings Fla. Horti. Soc.** 55:106-110.

Adoption of Boro Rice in Parsa and Bara

Kailash P Bhurer¹, Dhana B Gharti¹, Ganesh Sah², Mishri L Sah³ and Scott Justice⁴

¹ RARS, Parwanipur, Bara

² AIRC, Ranighat, Birgunj

³ SRP, Jeetpur, Bara

⁴ CIMMYT, Kathmandu

ABSTRACT

Four varieties of boro rice namely BG 1442, Saroj, Gautam and Jaya were tested at 3 sites with a view to popularize and let the farmers adopt promising boro rice cultivars in the command area. BG 1442 and Jaya yielded the highest (5543 kg/ha) in Belwa, Parsa. Saroj and Gautam were low yielders (4435 kg/ha). At Fatepur, Bara, Gautam, Jaya, BRRI DHAN 36 and Sugaha local were verified and produced 3210, 3210, 3120 and 1980 kg/ha, respectively. In 2002/03 boro rice varieties such as Prabhat, Gautam, Dhan Laxmi and Richharia were included for verification at Biruwaguthi, Parsa and gave 3343, 4241, 3185 and 2266 kg/ha, respectively. Gautam, Prabhat and Dhan Laxmi can be grown as boro rice.

Key words: Boro rice, Tarai areas, yield performance

INTRODUCTION

There are around 7-10% low lands areas in Nepal, which remains fallow after the harvest of normal rice due to excess moisture and water stagnation due to which any winter crop could not be grown. For such areas, Boro rice is the only alternative before the next rice crop. This would enhance the double rice production in the problem areas where there is a natural resource of water and need not to depend on pumping set and electric motor for irrigation. Such water facility is available in the west of Jeetpur like, Biruwaguthi, Jhabaraha and Manawabajar where there is more than 500 bighas and more than 10 thousand hectares of such land in Bara (Personal communication, DADO, Bara 2003), and Dhanusha Dham, there is Nausaya village having around 200 bighas suitable for boro rice in Nausaya village, Dhanusha.

We organized The First Farmers Field Day on Boro Rice in Nepal on 23 May 2003 at Regional Agriculture Research Station Parwanipur and on-farm at Biruwaguthi. There were altogether 29 farmers from Bara, Parsa, Sarlahi and Dhanusha. Agriculture Development Offices of Bara and Parsa and representatives of rice research program, Hardinath, Dhanusha were also participated. During 2003 high hills rice varieties Chandannath-1, NR10285-15, NR 1028815J-1J-1 and Khumal-11 were included in the trials. Likewise, DR1, DR11, DR16, DR17, DN5-2-3 and Jyoti Prasad were received from Vanarasi, UP, India. In April 2002 rice varieties such as Gautam, Richharia, Saroj, Dhan Laxmi and Prabhat were received from RAU, Pusa during 2001. BRRI DHAN-36 was collected from Bangladesh during 2002. Sugaha Local was collected from farmer's field of Motihari, East Champaran, Bihar, India. Chaite-2 and Ghaiya-2 showed excellent performance in winter season. Some of them were evaluated in 3 sites and results are discussed here.

MATERIALS AND METHODS

Seeds were soaked in water for 24 hrs and kept in incubation for 48 hrs. For seed treatment Bavistin @ 2.5 g/l of water was mixed before soaking the seeds. The pre-germinated seed were seeded on puddle soil. For weed management in the seedbed Butachlor was applied @ 2 l/ha. Fertilizer was applied @ 1:1:0.5 N:P:K for 1000 m² area. Water level was maintained as the seedling height increased and removal of dew from the tip of the seedlings

was done every morning to escape from cold injury. Fertilizer was applied @ 120:60:40 N:P:K kg/ha in the field of Belwa. Half of the N was applied as top dressing in 3 splits. Whereas at Fatepur fertilizers were applied @ 80 kg N, 40 kg P₂O₅ and 30 kg K₂O/ha. Random planting was done in both sites. Transplanting was done on 20 February at Belwa. For weed management Butachlor was applied @ 3 l/ha and other plant protection and water management were carried out as per the need of the crop. A Farmer Field Day was celebrated on adhoc basis through the financial support of Rice Wheat Consortium, CYMMYT, Nepal. This field day helped as participatory varietal selection of boro rice for the coming season. Farmers' preferred varieties are Saroj, Gautam, Richharia, Dhan Laxmi, BRRI DHAN 36, DR1, DR11, DR16, DN 5-2-3, Ghaiya2, Chite2, Jaya, Parwanipur Masuli, NR10285-15 and Khumal 11. From quality point of view Saroj, DR1 and DN5-2-3, Khumal 11 for Chiura (beaten rice) and Parwanipur Masuli for grain and straw were. On farm evaluation of boro rice varieties was done in collaboration with New Zealand ODA Project/CYMMIT, Nepal and ARS, Ranighat, Birgunj.

RESULTS AND DISCUSSION

Four varieties of boro rice were tested at Belwa, Parsa (Table 1). BG 1442 and Jaya produced higher grain yield. This level of productivity is quite higher than the productivity of boro rice in neighboring countries, Bangladesh (1.46 t/ha) and India (3.5 t/ha) (Singh 2003). Similarly at Fatepur, Bara Gautam and Jaya produced highest yield. In 2002/03, boro rice varieties Prabhat, Gautam, Dhan Laxmi and Richharia were evaluated at Biruwaguthi, Parsa and Gautam gave 4241, 2266 kg/ha. Hence, Gautam, Prabhat and Dhan Laxmi can be grown as boro rice. Some farmers expressed that boro rice would replace wheat due to low cost of cultivation and more yield. Farmers have kept the seeds for next season and some are exchanging the seeds from farmers to farmers. Seed multiplication of promising boro rice varieties is launched by RARS, Parwanipur at Biruwaguthi and Fatepur in 2 ha. Varieties grown are DR1, DR11, DN52-3, Joyti Prasad, Khumal-11 and Saroj.

Farmers of Biruwaguthi, Parsa had perceived boro rice as an important commodity for the following reasons:

- Farmers have less competition receiving water for cultivation of boro rice compared to Chaite rice.
- Farmers can save straw for cattle from boro rice that would have been lost during Chaite rice harvest due to excess rainfall.
- Farmers do not face labour scarcity problem during boro rice harvest while they face the same due to synchrony in Chaite rice harvest and normal rice planting.
- Farmers are compelled to pay high labor charges because of shortage of labor during Chaite rice harvest.
- Sufficient turn over time is available where boro rice is grown, but very less time is left between Chaite and normal rice.
- Fresh rice has high market value for Chiura (beaten rice).
- Breeding material for hills would have two generations in a year and thus would save half of the required time for variety release.
- Boro rice would help to solve unemployment, income generation, poverty alleviation, sustainable food security and ultimately helps enhance livelihood of the targeted people.

Table 1. Yield performance of boro rice varieties at Belwa, Parsa and Fatepur, Bara in 2001/02

Belwa		Fatepur	
Variety	Yield, kg/ha	Variety	Yield, kg/ha
BG-1442	5543	Gautam	3210
Saroj	4435	Jaya	3210
Gautam	4435	BRRIDHAN 36	3120
Jaya	5543	Sugaha (Local)	1980

Table 2. Yield of boro rice varieties in farmers' field at Biruwaguthi, 2002/03†

Farmer	Variety	Yield, kg/ha
Khaharu D Chaudhary	Gautam	4241
	Prabhat	3343
Ram R Chaudhary	Dhan Laxmi	3185
	Richharia	2266

† Fertilizer dose, 120:60:40 N:P:K kg/ha.

CONCLUSION

Rice cultivars like Gautam, Prabhat and Dhan Laxmi could be recommended as boro rice for Central Tarai of Nepal. Boro rice training is needed to the concerned farmers at all locations.

ACKNOWLEDGEMENTS

We would like to give special thank to Dr. Peter Hobbs, CYMMIT, Nepal for giving idea to start work on boro rice eight year ago. We fail to find words for expressing our profound sense of gratitude to Mr R Mishra, Parwanipur for providing materials and giving valuable suggestions during the experimentation and S Bista, ABD Khumal for making availability of hill rice seeds. Special thanks are to Dr R Thakur, ICAR, India, Dr JN Ray and UP Singh, UP India for making availability of five boro rice varieties. Thanks are due to Dr SB Mishra for making availability of a hand out of collaborative training course on boro rice production technology. Help received from Mr J Ghimire, Mr M Karki, Mr R Yadav, Mr D Shrestha, Mr Prabhat Sah, Mr Ram Sogarath Sah is highly acknowledged. Special thanks are to Mr HM Thakur and R Mandal for computer typing, analysis and graphics.

REFERENCE

Singh UP. 2003. *Boro rice: An opportunity for intensification*. Addressing resource conservation issues in rice-wheat systems of South Asia. March 2003. Pp.136-140.

Appropriate Plant Spacing for Cauliflower Intercropping under Maize

Purushottam P Khatiwada

Agriculture Research Station, Pakhribas

ABSTRACT

This investigation was carried out to identify appropriate combination of plant population of maize and cauliflower for intercropping in potato + maize cropping system. The experiment was carried out at Sinduwa Sub-station, Dhankuta during 1998 to 2000. Three spacings for both of the crops were tested and cauliflower was transplanted after the harvest of potato. Maize grain yield was significantly ($P < 0.001$) higher (2.66 t/ha) in closer (100- × 25-cm) spacing. Similarly, closer spacing (45- × 30-cm) of cauliflower also yielded significantly ($P < 0.01$) higher (5.08 t/ha) curd yield than that of 60 × 45-cm (3.87 t/ha). A bivariate analysis of both crops showed that increasing plants population either of cauliflower or maize gave the higher yield. Falling apart of the non-confidence region of 26,666 maize with 74,074 cauliflower plants/ha with 40,000 maize with 74074 cauliflower plants/ha (higher maize yield) and 20,000 maize with 74,074 cauliflower plants/ha (higher cauliflower yield) demonstrate that 26,666 maize population with 74,074 cauliflower population/ha was the more appropriate mix to get balance yield of cauliflower and maize.

Key words: Cauliflower, intercropping, maize, plant spacing

INTRODUCTION

Potato+maize, - a traditional system, covers about 63% of the total cultivated land of high altitudes (1700 - 2200 m) of the Eastern Nepal (Chand 1997). Potato and maize both are the staple food crops of the high hills and play significant contribution to the food security and diversity to farming households. Willey (1979) mentioned that the intercropping is more productive and efficient due to higher combined yield than that of sole cropping. Besides the higher production per unit area and food security by the system, potato serves as cash generating crop and maize stovers are important for animals because of scarcity of fodder in the high altitudes during the dry season (February - May). Hill farming system is characterised as complex farming system along with subsistence in nature, where on-farm cash generation is considered to be the most difficult task. Increase in population and low land holding have exerted further pressure to farm household to increase the productivity per unit area and time. Of the many avenues of on-farm income generation, growing vegetables around the road access areas seems to be one of the viable approaches. However, cultivation of vegetables in the hills is not a straightforward due to long distance to big markets and geophysical conditions. Distance markets increase transportation charge resulting high cost of the products at the time of deliver. Growing vegetables in the off-season for Tarai markets can overcome the relative disadvantage from the big markets due to distance. In the high hills, maize takes about seven months to mature and do not have irrigation facility at all in Nepal. Intercropping high value vegetable crops under maize in summer season utilize time as well as fetch the off-season prices in markets.

Experience has shown that the recommended technology in isolation without considering the existing farming systems do not help to resource poor farmers due to their marginality and limited land holdings. Small farmers cannot take risk to grow high value crops in sole cultivation despite knowing the fact that vegetable crops cultivation is a feasible and lucrative business. In this scenario, incorporation of cauliflower, one of the most high value crops in the existing cropping pattern without replacing any food crops will have immense value to

raise the farm income of all categories of farmers. By visualising this fact, Agriculture Research Station Pakhribas (PAC) has initiated a preliminary study of vegetables intercropping with maize and found that peas, cabbage and cauliflower can be intercropped or relayed under potato + maize cropping pattern (PAC 1991). Further experimentation has revealed that intercropping cauliflower under maize after harvest of potato will be an approach to expand cauliflower production season along with the net return of Rs 73,720.0 (US\$ 1084) per hectare (Khatiwada 1997). In the context of paucity of technologies for off-season cauliflower production (Khatiwada et al 1998), depth studies on intercropping technology should be pivotal. KC (1989) argued that technology suitable for sole cropping may not be suitable for the intercropping situation because of extra competition for light, moisture, nutrient and space. Hence, this study was carried out to develop an appropriate plant population of cauliflower as under storied crop and maize as upper storied crop for the optimization of available resources in intercropping situation.

MATERIALS AND METHODS

The field experiment was conducted at high altitude Sub-station of PAC, Sindhuwa in an altitude of 2200 m. The experiment was designed in 3×3 factorial arrangement, where three different plant spacing of cauliflower (60- $\times$ 45-cm, 45- $\times$ 45-cm and 45- $\times$ 30-cm) and three plant spacing of maize (100- $\times$ 25-cm, 150- $\times$ 25-cm and 200- $\times$ 25-cm) were allocated. The experiment was planned in a randomized complete block design with four replications. After ploughing, the land was again dug out by spade to make the fine tilth. Just before planting, 33 tons of compost and 30 kg each of nitrogen and phosphorus per hectare were applied in the field. Hale, a highly popular red type potato variety was planted in the experiment. Whole tubers were planted in the first week of February in a distance of 50 cm between rows and 25 cm between plants. Ganesh-1 - a newly released variety of maize for the high hills was shown during the first fortnight of March. Maize plants were thinned to one/hill after a month of emergence. The manual weeding of potato and maize field was done in last week of April.

Seeds of cauliflower variety Kibo Giant was sown in a nursery in last week of May. Uthane M-45 (Mancozeb) at a rate of 2.0 g of water was sprayed once in the nursery to prevent the seedling from damping off.

Potato was harvested in the last week of June. Remaining 30 kg N/ha was top-dressed to maize. N:P:K at the rate of 60:100:60 kg/ha were applied in the plots as a basal dose for cauliflower. Similarly, the plots were also treated with Malathion dust 5% at a rate of 20 kg/ha in cauliflower plots. Cauliflower seedlings were transplanted under maize on the first week of July. Despite the use of Malathion, the problem of cutworms was severe in the experimental field. As a result of that, three gap fillings were done to maintain the appropriate plant population to provide the equal competition. After final gap filling, soil drenching was carried out by Chloropyrphus at a rate of 2.5 ml/l. Gap filled after 15 days of first transplanting were omitted from the observations. Metacid at a rate of 2 ml were sprayed after crop establishment. After 30 and 60 days of transplanting, cauliflower seedlings were top-dressed by urea at the rate of 30 kg N/ha. During the whole growing season of spray of Blitox at a rate of 2.5 ml/l and 3 sprays of Indofil 2 g/l were performed. Weeding was done in about a month interval. The harvesting of cauliflower was spread between first week of October and first second week of December. Maize was harvested in the last week of October. The data were analysed using Genstat 3.23 software.

RESULTS AND DISCUSSION

Potato yield and other characters

An early and highly preferred potato variety, Hale, yielded an average yield of 9.40 t/ha. There was no any definite trend of attack of late blight in different treatments. Late blight was first recorded in the first week of May and completely (100%) infected by the end of June. The yield of Hale (9.4 t/ha) was lower than that of the highest yielding potato variety (15.7 t/ha of CPI-575015) under potato + system in 1990 (PAC 1991). The high yielding potato varieties have the longer life. But early maturing potato variety is needed for intercropping cauliflower under maize after potato harvest. The late transplanted cauliflower could not fetch off-season price in Tarai markets. Hence, despite having poor yield, the variety Hale was selected. Despite the low yield, farmers have been using this variety due to great consumer preferences. As a result of that the sale price is always higher

by Rs 2.00 per kg.

Maize yield and other characters

Maize, the upper storied crop was harvested at the last week of October. The grain yield was calculated at 15% moisture content. Analysis of variance of grain yield revealed that the yield difference between different plant populations was significant ($P > 0.001$). The yield ranged from 1.47 to 2.75 t/ha in the intercropped situation (Table 1). There was a significant effect of increasing plant populations in the grain yield production.

Table 1. Single component analysis of maize grain and cauliflower curd yields from intercropping study conducted at Sindhuwa

Maize population	Grain yield, t/ha	Cauliflower population	Curd yield, t/ha
40,000 plants/ha	2.75	37,037 plants/ha	3.87
26,666 plants/ha	1.94	49,382 plants/ha	4.42
20,000 plants/ha	1.47	74,074 plants/ha	5.08
F test	***		**
SED	0.121		0.349
CV, %	20.3		19.5

***, Significant at 0.1% level. **, Significant at 1% level. SED, Standard error of differences.

The maize variety Ganesh-1 was released for high altitude areas for sole and intercropping situation. Under potato + maize system, the variety yielded 3.48 t/ha (average of five sites) in 1993 (Tiwari et al undated). In the recommended plant population (40,000/ha) for intercropping, 2.75 t/ha was recorded from the experiment. This result has proved that intercropping cauliflower under maize has some adverse effect on maize. It is natural to get proportional decrease in grain yield along with plant population.

Cauliflower yield

Cauliflower was under storied crop under maize, which was transplanted after harvest of potato. Analysis of variance of cauliflower curd yield showed that the yield was significantly ($P < 0.01$) different among treatments. The curd yield was varied from 3.87 t/ha to 5.02 t/ha (Table 1). The closest spacing produced the significantly highest yield. The cauliflower yield obtained from this experiment is quite low. However, the yield obtained from the system is a bonus crop to farmers. In the case of squash intercropped under maize, about 5 times yield reduction has been reported (Sullivan 2001).

Crop mixture

Land equivalent ratio (LER) and bivariate analysis are the two most commonly used approaches for intercropping data analysis. This experiment was initially planned to analyse the data by using bivariate analysis, as this method does not demand the data from the sole plots. The bivariate analysis of maize and cauliflower yield revealed that there were highly significant effects among treatments (Table 2).

Table 2. Maize and cauliflower curd yield from intercropping experiment conducted at Sindhuwa (bivariate analysis of the component crops)

Treatment	Maize yield, t/ha	Cauliflower yield, t/ha
A. 40,000 maize with 37,037 cauliflower plants/ha	2.73	3.49
B. 40,000 maize with 49,382 cauliflower plants/ha	2.78	4.04
C. 40,000 maize with 74,074 cauliflower plants/ha	2.73	4.75
D. 26,666 maize with 37,037 cauliflower plants/ha	1.93	3.75
E. 26,666 maize with 49,382 cauliflower plants/ha	1.85	4.22
F. 26,666 maize with 74,074 cauliflower plants/ha	2.0	5.08
G. 20,000 maize with 37,037 cauliflower plants/ha	1.55	4.38
H. 20,000 maize with 49,382 cauliflower plants/ha	1.39	5.01
I. 20,000 maize with 74,074 cauliflower plants/ha	1.48	5.42
Bivariate F statistics for treatment (16 and 46 df)	Highly significant	
Radius of non-significance region (2 and 24 df)	1.304	

The grain and curd yield presented in the Table 2 are the treatment mean obtained from the experiment. The result from intercropping is more precisely elucidated by a bivariate graph. (Figure 1)

The result of component crop analysis demonstrated that plant population is the crucial factor than that of interactive effect of two crops. Plant population of maize or cauliflower can be increased or decreased as per the priority of the crop. Perusal of the available literature suggest that very few studies (KC 1989, PAC 1991) have been conducted on intercropping of non-leguminous vegetables with cereals. Comparable yield of maize from the experiment showed that the additional crop, cauliflower, has given avenue to increase farm income without disturbing the traditional potato + maize system. Initially Khatiwada (1997) reported that intercropping cauliflower under maize is a very lucrative intervention to the hill farmers residing along the road corridor of north-south feeder roads. KC (1989) found 69% yield advantage from intercropping vegetables with sweet corn without any significant yield reduction of vegetable.

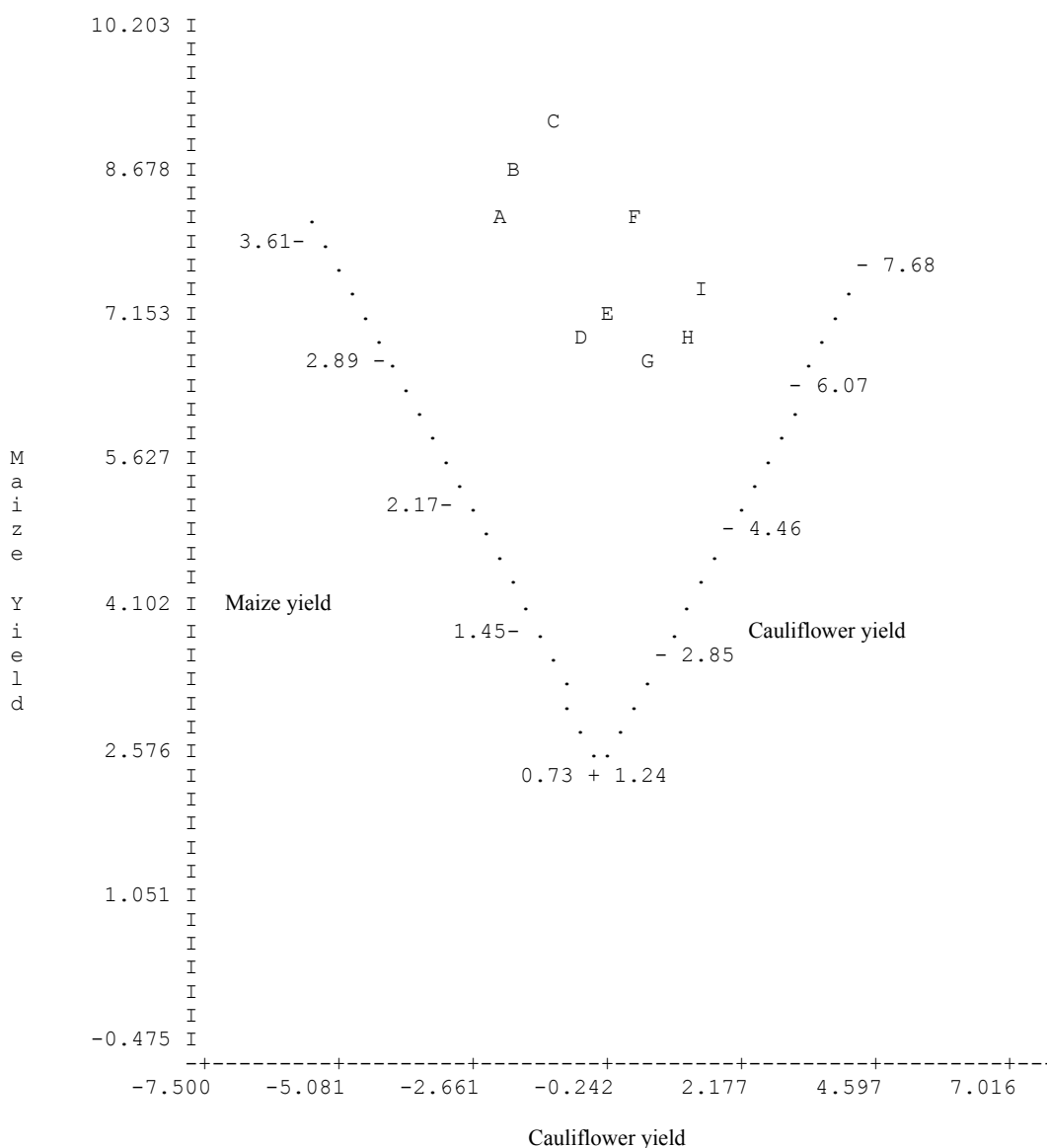


Figure 1. Diagrammatic representation of the yield of maize and cauliflower in intercropped situation using bivariate analysis. The circles represent the non-significant region. The alphabets in the graph represent the treatment combination as mentioned in Table 2.

The Figure 1 clearly showed that increasing plants population either of cauliflower or maize give the higher yield. The radius of non-confidence region of treatments C, F and I fell apart. It clearly shows that F is the balance treatment for the intercropping cauliflower under maize. If someone is more inclined towards

cauliflower I (higher cauliflower yield) is the best combination and C (higher maize yield) is the best for maize.

Other associate traits of cauliflower

Curd size index, plant height, plant spreading and leaf size were not affected by the different plant populations of cauliflower and maize. Similarly, the interactive effect of different plant spacing of maize and cauliflower was not significant in all aforementioned traits. Regarding the upper ground biomass production, there was significant effect on cauliflower spacing and maize spacing on the total biomass production of cauliflower. However, there was not any interactive effect. As in the curd yield, the closest spacing produced the highest (12.75 t/ha) biomass and the lowest (9.32 t/ha) was from the widest spacing.

The experiment has proved that 150- × 25-cm maize spacing and 45- × 30-cm of cauliflower spacing is the best combination for intercropping situation in the high hills of Eastern Nepal. Both maize and cauliflower are shallow rooted crops and brassicas are the heavy feeder. Therefore, care should be taken for proper nutrients management. To fetch off-season price by cauliflower, early maturing potato variety should be planted. If potato yield cannot be compromised, it would be worth investigating short duration hybrid varieties of cauliflower.

ACKNOLEDGEMENTS

I would like to express my sincere gratitude to Hill Agriculture Research Project of DFID for the financial support to carry out this experiment. Professional helps extended by Dr TP Tiwari, Dr DB Subba, DP Dhakal and S Piya are highly acknowledged. Many thanks go to JB Basnet, PB Paudel, BP Chaudhary and JL Mandal for their field level helps.

REFERENCES

- Chand SP. 1997. Effect of time of planting of traditional potato varieties on yield of intercropped potato and maize in the hills of Nepal. *PhD Thesis*. Wye College, University of London, UK.
- KC Sharan. 1989. The potential of intercropping maize and vegetables. *MSc Thesis*. The University of East Anglia, UK.
- Khaliwada PP, AJ Ghimire and MP Thapa. 1998. Effect of planting dates and plant spacing on late season (March - May) cauliflower production. *PAC Working Paper No. 230*. Pakhribas Agricultural Centre, Dhankuta.
- Khaliwada PP. 1997. Intercropping cauliflower under maize: An approach to extend the cauliflower production season for subsistence farmers. *Kasetsart J. (Nat. Sci.)* 32(5):72-80.
- PAC. 1991. *Annual report 1990-1991*. Pakhribas Agricultural Centre, Dhankuta, Nepal.
- Sullivan P. 2001. *Intercropping principles and practices agronomy system guide*. Appropriate Technology Transfer for Rural Areas, Arkansas, USA.
- Tiwari TP, BD Gurung and MM Palikhe. Undated. *Proposal for release of Ganesh-1 maize derived from Pool-9A*. A proposal submitted to Variety Releasing committee. Pakhribas Agricultural Centre, Dhankuta.
- Willey RW. 1997. *Intercropping: Its importance and research need*. Part 1. Competition and yield advantages. *Field Crops Abstracts*, Commonwealth Bureau of Pasture and field crops 32:1-10.

Assessment of Factors Responsible for Yield Decline in Toria

Tara B Ghimire

National Oilseed Research Program Nawalpur, Sarlahi

ABSTRACT

In order to assess the factors responsible for yield decline in toria (*Brassica rapa* syn. *Brassica campestris* var. *toria*), field survey was carried out at Bardiya and Dang in 1999 and Chitwan and Bara in 2000 and field trials were conducted at National Oilseed Research Program (NORP), Nawalpur Sarlahi during 1997/98-1999/2000. Seed yield decline in toria has been realized and felt throughout the toria growing areas of the kingdom. Low or no use of fertilizer and manures, declining inherent soil fertility, non-adoption of plant protection measures, use of local cultivars, lack of irrigation facility and weeds were identified as the major factors responsible for toria yield decline at farmers' field. Pollinators (honey bees) and chemical fertilizers (NPK) were the two main constraints responsible for toria yield decline at National Oilseed Research Program Nawalpur, Sarlahi, which reduced the seed yield by 46.53% and 29.48% respectively. Full package of practice increased the toria seed yield and net return by 95.48 and 27%, respectively compared to farmer's practices. Honeybees were helpful in seed setting and oil production in toria.

Key word: Fertilizer, pollinator, toria, yield decline

INTRODUCTION

Toria (*Brassica rapa* syn. *Brassica campestris* L. var. *toria* Duth. and Full.) is the most important oilseed crop of Nepal. The productivity of toria has been realized to decline since last several years. Intensive cropping, depletion of organic matter and low microbial activity, coarse texture soils, moderate to strong acidic soil reaction, low cation exchange capacity (CEC) and high leaching losses during monsoon season are the soil related constraints in declining the maize-toria productivity in Chitwan and neighboring districts (Shrivastava et al 2001). Deficiency of major plant nutrients, viz., N, P and K were the most important yield limiting factors in existing rapeseed cultivation in western hills (Budhathoki and Subedi 1995). Fertilizer alone proved its superiority to other agronomic input in mustard seed production. Improper fertility management is one of the reasons for low productivity of rapeseed and mustard. The importance of NPK fertilizer in this crop is well recognized (Singh and Verma 1993). Boron is less available to plant when N is limiting in soil (Munankarmy and Tuladhar 1999). Boron is considered an important in pollen tube elongation in fertilization process. This element is limited in most of the Chitwan soils. Low productivity of rapeseed and mustard is due to use of susceptible cultivars to various diseases and low quality seed (Shreshtha et al 1998). Among the diseases, alternaria blight (*Alternaria brassicae* (Berk.) Sacc.) is the major problem (Shreshtha and Shreshtha 1992 cited from Shreshtha et al 1998). The quantitative loss in seed yield due to alternaria blight has been estimated to be 35-46% (Chaudhary 1999). Mustard aphid (*Lipaphis erysimi* Kaltb.) among the insect pest is the most destructive and serious pests causing 20-35% yield loss in toria (Ray 1996). In certain situations a parasitic weed, *Orobancha*, causes considerable damage to the crop. Small acreage under improved varieties, non adoption of improved package of practices and the cultivation of rapeseed mustard on marginal and sub marginal land under poor package of plant protection practices are the some of the other factors associated in low productivity. Agronomically, delay sowing, poor plant stand, lack of optimum fertilization schedule, poor irrigation facilities, inadequate weed control and vagaries of nature often accentuate the difficulties in production of rapeseed mustard and at times, severely affect the realization of even their existing yield potential (Kumar and Singh 1989). This study was under taken to assess the major factor responsible for toria yield decline in major toria growing districts of Nepal and to quantify the yield loss caused by each factor in terai conditions.

MATERIALS AND METHODS

Rapid rural appraisals (RRA) were conducted at Bardiya (Taratal and Khairapur) and Dang (Manpur- Majgai and Bankatti) in 1999 and Chitwan (Prembasti and Gunjnagar) and Bara (Nijgarh) district in 2000 crop season (podding stage) to assess the major factors/constraints responsible for yield decline in toria. A semi- structured questionnaire was prepared and key informants (farmers) were interviewed regarding the cultivation practices, input use, yield level, marketing system and consumption pattern and farmers perception in toria yield decline. Toria fields of interviewed farmers were visited for the observation of diseases, insects and weeds. The soil samples were collected from observed toria field from vacant space between the toria plants and analyzed for pH, OM, total N, phosphorus, potassium content at Soil Science Division, Khumaltar.

A field experiment was conducted in randomized complete block design with 3 replications at NORP, Nawalpur Sarlahi (144 masl) during crop season of 1997/98-1999/2000 to assess the major yield limiting factors responsible for toria yield decline. Eleven treatments combinations were as follows (1) Full package of practices (POP) -Recommended fertilizer (60:40:20 kg N:P:K/ha), sulphur application @ 20 kg/ha through gypsum, boron and zinc @ 500 ppm foliar spray at flower initiation stage (30 days after sowing), fungicide and insecticide spray to control alternaria blight and aphid, pollinators (honey bees) management, hand weeding, line sowing; (2) Farmers' practices (FP)- No NPK, S, B, and Zn; no plant protection, broadcasting seed and no weeding; (3) POP- NPK; (4) POP-S; (5) POP-B; (6) POP-Zn; (7) POP-Fungicide; (8) POP-Insecticide; (9) POP-Pollinators; (10) POP- Hand weeding; (11) POP- Line sowing. Treatments were evaluated in minus one technique in rainfed upland under maize based system. FYM @ 20 t/ha was applied in all treatments before planting of toria crop in second and third year of experimentations. Treatments were repeated in the same plot in all the years. The plot size was 4- × 4-m. The sowing was done in second fortnight of October in 1997 and 1998 and 1st of November in 1999. The rainfall received during crop season was 95.5 mm, 46.4 mm and nil during 1997, 1998 and 1999, respectively. The weather condition during reproductive stage of toria in 1997/98 was unfavorable (cloudy). The toria variety Pragati was planted in all years of experimentations. Days to maturity, yield attributing characters and seed yield were recorded. Seed oil content was analyzed using Soxhlet apparatus at Food Research Unit, Khumaltar. The composite soil sample before conducting experiment and treatment wise soil samples after completion of experiment were taken and analyzed for pH, OM, N, P, and K content. The year wise yield and yield attributes were analysed using MSTAT-C software.

RESULTS AND DISCUSSION

Rapid rural appraisal (RRA)

RRA conducted in the two crop seasons of 1999 and 2000 revealed that yield declining trend was alarming in Chitwan compared to Bardiya, Dang and Bara districts (Table 1). During seventies the yield level of toria was up to 10-12 qtl/ha with tall plant, thick stem and profuse branching in Chitwan. In nineties toria yield went down to 3-4 qtl/ha and in some years when bad weather experienced, yield even lowered down to 0.5- 1 qtl/ha. Similarly, yields of summer crops in toria based system was also declining in the surveyed districts. The average productivity of maize, sesame and chilly was 1920, 150 and 3125 kg/ha respectively.

Table 1. Yield trend of toria (qtl/ha) in selected districts of Nepal

District	1970	1980	1990	1999/2000
Bardiya	10-12	8-9	6-7	2-3
Dang	8-10	6-7	4-5	3-4
Chitwan	10-12	6-9	3-4	1-2
Bara	10-12	9-10	8-9	6-7

Productivity of toria was not declining so severely in Bara. Crop-livestock farming system in Nijgarh area was complementary in crop production in general and toria in particular. Plenty use of FYM in toria crop sustained the productivity of toria crop. Farmers' perception regarding toria yield declining problem is summarized in Table 2. Most of the farmers were aware of yield decline problem in toria. Of the interviewed farmers, 40% expressed weather change (prolong cloudy weather) during toria growing season was the sole cause of yield decline in toria. The bad weather encourages diseases and insect pressure. Remaining 60% farmers expressed combine effects of low or no use of organic and inorganic fertilizers, poor tillage practice, no irrigation facility, declining native soil fertility, aphid attack, etc.

Table 2. Farmers' perception regarding toria yield declining problem

Factors affecting in toria yield decline	Per cent of farmers responding
Low or no use of organic and inorganic fertilizer	60
Weather change in reproductive stage	40
Lack of irrigation	60
Aphids infestation	60
Poor tillage practices	20
Decline native soil fertility	60
Open grazing in winter is reduced or stop	6
Mechanization disturb the soil	6

Responses are more than the size of sample because there was more than one response.

RRA conducted in 1999-2000 revealed that 83% of toria was under bariland condition with maize- toria system and 67% toria was under rainfed conditions. 60% toria cultivation was under mixed cropping system with lentil, field pea and barley. About 67% of toria was grown without chemical fertilizer. Rest 33% toria was under minimum fertilizer use (12:12:0 kg N:P:K/ha). Most of the farmers used FYM in summer crops only. Only 50% of the farmers used FYM @ 5 t/ha in toria crop. Almost all farmers grew local variety and used their own seed every year in higher rate. They did not treat the seed against seed and soil born diseases. The planting time in mid western development region was slightly early but in central development region it was comparatively late (Table 3).

Table 3. Indigenous toria cultivation practices and yield level in selected district of Nepal

District	Cropping system	Environment	Planting time	Variety use	Seed rate, kg/ha	FYM use, t/ha	Fertilizer (NPK, kg/ha)	Sowing method	Yield level, kg/ha
Bardia	Maize-toria Chilly – toria+lentil	Rainfed	1-15 Oct	Local	10	5 (maize)	0:0:0	Broadcast	300-400
		Partial irrigated (Boring)	15-30 Oct	Local	3+6 (lentil)	10 (toria)	0:0:0	Broadcast	150-200
Dang	Maize-toria+pea Maize-toria+barley	Partial irrigation	End Sept	Local	45	5 (maize)	0:0:0	Broadcast	800-900
		Rainfed	1-15 Oct	Local	15	5 (maize)	9:23:0	Broadcast	250-300
Chitwan	Maize-toria	Rainfed	15-30 Oct	Local	25	2 (maize) + 5 (toria)	0:0:0	Broadcast	100-200
	Sesame-toria	Rainfed	25-30 Oct	Local	14	2 (toria) Poultry litter	25:17:0	Broadcast	100-200
	Rice-toria	Rainfed	1-15 Nov	Local	30	2 (toria) Poultry litter	39:28:0	Broadcast	300-400
Bara	Rice-toria+lentil	Rainfed	15-30 Oct	Local	12+23 kg lentil	15 (toria)	20:25:0	Broadcast	700+800 kg lentil
Mean					17	6	12:12		338-371

Aphid (*Lipaphis erisimi*) was more problematic pest in Chitwan. Late planting of toria in rice field was much more affected by this pest. Farmers were not aware of losses caused by aphid and did not spray their crop with insecticide. Some of them tried, but did not spray appropriate insecticide. Insecticide like monocrotophous was used in some field, which is harmful to honey bees. Mustard saw fly (*Athalia lugens proxima*) was more serious in Bardiya district. Among the diseases alternaria blight (*Alternaria brassicae*) was quite common in all the surveyed districts and Sclerotinia rot (*Sclerotinia brassicae*) was more prevalent in Bardiya, Dang and Chitwan districts at reproductive stage. No control measures had been adopted for these diseases and this caused considerable loss in yield and quality of seed. Out of toria field surveyed, severity of diseases was minimum in Bara (Nijgarh). Dominant weed species recorded in toria field were wild onion, *Orobancha aegyptica*, *Vicia sativa*, *Chenopodium album* and *Anagalis arvensis* in Bardiya; *Orobancha aegyptica*, *Chenopodium album* and *Vicia sativa* in Dang; *Cynodon dactylon*, *Chenopodium album* and *Fumaria parviflora* in Chitwan and *Orobancha aegyptica* and *Cirsium arvense* in Bara districts.

Marketing of oilseed was not problem in survey district. 33% of surveyed farmers dispatched their produce immediately after threshing and cleaning in near by market. 17% of them grew toria for their home consumption only. Remaining 50% of them sold from their home itself. The average consumption of oils in the survey districts was 7.217 liter/capita/annum (3.4-12 l/capita/annum), which is around 20 g/capita/day. The availability of edible oils in the rural area of Nepal was just half against 14 kg as recommendation made by Indian Council

of Medical Research. The oil cake after extraction was either used as animal feed or left in mill as crushing charges.

Chemical properties of soils of different districts are presented in Table 4. The most of the soils of toria growing districts was found acidic in reaction, low in organic matter, low to medium in total nitrogen, high in phosphorus and medium to high in potassium content. The soils reaction was unsuitable for rapeseed mustard cultivation as these crops require neutral to alkaline soils for their proper growth and development.

Table 4. Chemical properties of soils in different districts

District	pH	Rating	OM, %	Rating	N, %	Rating	P, kg/ha	Rating	K, kg/ha	Rating
Bardiya	6.1	Neutral	1.41	Low	0.08	Low	186	High	632	High
Dang	5.5	Acidic	1.88	Low	0.124	Mid	125	High	542	High
Chitwan	4.2	Acidic	1.61	Low	0.130	Mid	122	High	266	Mid
Sarlahi	5.8	Acidic	2.01	Low	0.140	Mid	443	High	475	High

Field trial

Significant seed yield reduction from 692 kg to 370 kg/ha was recorded when pollinator was omitted from POP in toria crop. The 46.53% seed yield reduction was recorded in absence of pollinators (honey bees) compared to POP. Pratap (1999) reported that cross-pollination by honeybees in rapeseed mustard increases seed and quality and oil content of seed. A loss of Rs 5100/ha was recorded due to omission of honey bees (Table 6). Next important production factor was chemical fertilizer, omission of this from POP reduced 29.48% seed yield. A decrease of 85.11% in net return was recorded due to omission of only NPK fertilizers from recommended packages. This is due to reduced number of siliqua/plot, number of seeds/siliqua, 1000-seed weight compared to POP. However, omission of chemical fertilizers (NPK) increased the oil content. Ghimire and Awasthi (1999) reported reduction in oil content with the increase in nitrogen levels in rapeseed.

Table 5. Effect of different treatments on yield attributes, seed yield and oil content of toria (3 year-mean)

Treatment	Days to maturity	Plant height, cm	Branches /plant, n	Siliqua/Plant, n	Seeds/Siliqua, n	1000-seed weight, g	Seed yield, kg/ha	% yield decrease over POP	Seed oil content, %
Full package	85	76	4	61	14	3.3	692	-	41.42
Farmers practice	81	77	2	31	13	2.7	354	48.84	40.73
POP-Fertilizer	84	73	4	52	12	2.9	488	29.48	42.8
POP-Sulphur	82	84	4	59	14	2.6	668	3.47	42.16
POP-Boron	85	80	4	67	14	3.0	657	5.06	40.90
POP-Zinc	86	81	4	59	14	2.7	704	+1.7	40.58
POP-Disease control	83	85	4	69	13	2.8	618	10.69	38.29
POP-Insect control	86	81	4	67	13	2.9	662	4.34	39.19
POP-Pollinators	92	99	7	71	11	3.4	370	46.53	36.53
POP-weeding	84	77	4	57	14	3.1	590	14.74	39.31
POP-Line sowing	86	82	3	52	14	2.9	611	11.7	37.89
F test	**	**	**	**	ns	ns	**		
Mean	85	81	4	58.7	13.1	2.93	583		
CV, %	3.5	8.81	30.6	25.5	12.6	20.7	28.3		
LSD (0.05)	2.2	12.2	0.86	11.1	-	-	124		

The year wise seed yield of toria is presented in Table 6. The mean seed yield in 2nd and 3rd year significantly increased compared to first year. This is due to heavy manuring/composting in second and third years and favorable weather. FYM/compost, which usually consists of all nutrients needed for plant growth could alleviate the secondary and micro nutrient deficiency problems. Manure application increased both soil boron availability and plant boron concentration and that this increase was more pronounced for the sandy soil (Moustaoui and Zerari 1998). The response of sulphur, boron and zinc on toria seed yield was not observed at experimental field. The seed yield of toria in third year of experiment was found increasing with the omission of sulphur from POP because excess application of gypsum reduced the availability of boron, which might cause the decrease in seed yield of toria. Amin et al (1994) reported similar results in mustard. Omission of Zn from POP increased the mean seed yield of toria. Higher dose of zinc (10 kg/ha) had a depressive effect on the grain yield of rapeseed (Mohammad et al 1999). A decrease in seed yield by 10.69% was recorded when disease control was omitted from POP. This was due to infection of alternaria blight (*Alternaria brassicae* Berk) in the treatment where disease control measure was not adopted. Similarly, a decrease in seed yield by 4.34% was recorded when insects control measures were omitted from POP. This was due to infestation of mustard aphid (*Lipaphis erysioni* Kalt) in the treatment where plant protection measure was not adopted. The yield loss due to insects and

diseases was low in uncontrolled treatment because of timely planting of toria, which might escape severe diseases and insect attack. Toria crop planted during the last week of September to first week of October would help to escape infection of major diseases or arrest the growth of the disease to reach at the economic threshold level (Sharma 1997). Weeding was most important cultural practices. Omission of weeding from POP decreased 14.74% toria yield. Broadcast method of sowing reduced seed yield of toria by 11.7% compared to line sowing method. Broadcast sowing, disease and insect, weed reduces the oil content compare to POP. Subbaiah and Mittra (1996) reported foliar application of Zn and B @ 500 ppm increased seed yield and oil content in mustard. Farmers' practices (FP) resulted 48.84% lower yield compared to POP due to poor branching, less number of siliquae and low 1000-seed weight (Table 5). Poor yield of toria crop is attributed to lack of management factors like fertilizer application, weeding, line sowing, diseases and insect control. Singh et al (1992) reported that complete package of practices significantly out yielded rest of the treatment and farmers' practices recorded the lowest yield.

Table 6. Seed yield (kg/ha) and net return (Rs/ha) affected by different treatments in toria at NORP Nawalpur

Treatment	1998	1999	2000	Mean, kg/ha	Net return, Rs/ha
Full package	474	644	960	692	2350
Farmers' practices	234	189	640	354(48.84)	1850
POP-Fertilizer	297	517	650	488(29.48)	350
POP-Sulphur	406	559	1038	668(3.47)	2250
POP-Boron	398	675	898	657(5.06)	2250
POP-Zinc	550	585	975	704(+1.7)	2950
POP-Disease control	382	600	871	618(10.69)	1500
POP-Insect control	456	611	920	662(4.34)	2350
POP-Pollinators	385	447	279	370(46.53)	-5100
POP-Weeding	419	469	881	590(14.74)	700
POP-Line sowing	558	613	662	611(11.7)	1225
F test	ns	**	*	**	
Mean	415	537	798	583	
CV, %	27.16	16.87	30.37	28.31	
LSD (0.05)	-	155	413	124	

Figures in parenthesis are percent yield reduction compared to full package of practices.

CONCLUSION

Low or no use of fertilizer and manures, pollination problem, non adoption of plant protection measure, use of local cultivars, declining inherent soil fertility and pH level, lack of irrigation facilities and weeds were the main factors responsible for toria yield decline in Nepal. Soil fertility improvement through heavy manuring (20 t/ha), crop residue incorporation (maize/sesame/sunflower stover), liming, timely planting and weeding, use of 50% recommended chemical fertilizers, 2 spray of Mancozeb (2 g/l) + Thiodan (1.5 ml/l) at 45 and 60 days after sowing and 3-5 colonies of honey bees/ha for pollination are very important for sustaining toria productivity in Nepal.

REFERENCES

- Amin MD, F Islam and MM Haque. 1994. Effect of sulphur in different varieties of mustard in old Himalayan Piedmond plain soil. *Bangladesh J. Ag. Res.* 19(1):80-84.
- Budhathoki CK and KD Subedi. 1995. Depth of planting and yield constraints study on rapeseed, 1993/94. *LARC Working paper* No. 95/21. Lumle Agricultural Research Center, Kaski, Nepal.
- Chaudhary RN. 1999. Evaluation of fungicides in the management of *Altenaria* blight diseases of rapeseed-mustard. *Nepal J. Ag. Res.* 3:72-77.
- Ghimire TB and KR Awasthi. 1999. Studies on methods of sowing and nitrogen requirement of sarson (*Brassica campestris*). *Nepal J. Ag. Res.* 3:82-88.
- Kumar A and RP Singh. 1989. Agronomic investigations on rapeseed and mustard at Pantnagar. In: *Oil Crops: Proceedings of the three meeting held at Pantnagar and Hyderabad, India, 4-17 January 1989*. Pp. 35-42.
- Moustauoi D and N Zerrari. 1998. Effect of manure supply on the behavior of boron availability and absorption by sunflower. *Agroclimica* (Italy) 42 (3-4): 95-103.
- Mohammad W, SM Shah, H Nawaz and MM Iqbal. 1999. *Pakistan J. Soil Sci.* (Pakistan) 16(1-2):111-114.
- Munankarmy RC and JK Tuladhar. 1999. Response of wheat to boron application in Sipaghat soil. *Nepal J. Ag. Res.* 3:36-41.
- Pratap U. 1999. *Pollination management of mountain crops through beekeeping: Trainers' Resource Book*. ICIMOD.

- Ray SP. 1996. Screening of *Brassica* germplasm against mustard aphids. **In:** *Proceedings of the National Winter and Summer crops (Oilseeds)* workshop held at RARS Bhairahawa, 12-15 September, 1996. NARC/ORP, Nawalpur, Sarlahi. Pp. 59-62.
- Sharma BP. 1997. Effect of sowing time on incidence and severity of major diseases of rapeseed mustard. *Nepal J. Ag. Res.* 1:43-48.
- Shreshtha SK, L Munk and SB Mathur. 1998. Occurrence and distribution of *Alternaria species* in seeds of rapeseed-mustard in Nepal. *Nepal J. Ag. Res.* 2:69-74.
- Shrivastava SP, DD Neupane and DP Sherchand. 2001. Long term fertility trial on maize-toria rotation at NMRP Rampur farmland. In: *Proceedings of Maize Symposium: Sustainable Maize Production Systems for Nepal* from 3-5 December, 2001, Kathamandu, Nepal. Pp. 200-204.
- Singh AK, HM Sharma and RP Sharma. 1992. Contribution of various inputs in rape (*Brassica napus*) field of North Bihar. *Indian J. Agron.* 37(4):849-850.
- Singh NB and KK Verma. 1993. Agronomic inputs for higher productivity of mustard (*Brassica juncea*) in Rapti diara of eastern Uttar Pradesh. *Indian J. Agron.* 38(3):414-416.
- Subbaiah G and BN Mittra. 1996. Effect of foliar spray of micronutrients on yield and oil content of Indian mustard (*Brassica juncea*). *Indian J. Agron.* 41(1):95-97.

Cultivation of Medicinal and Aromatic Plants in Nepal: An Overview

Tanka P Barakoti

Agricultural Research Station, Pakhribas, PO Box 29 Dharan, Dhankuta

ABSTRACT

Nepal is rich in medicinal and aromatic plants (MAPs), prevalent from Tarai plain (60 m) to the Himalayan region (5000 masl). Of the 1624 species identified with medicinal and aromatic properties, some have good source for income and health care. Above 80% crude herbs are exported to India, China and other countries. MAPs contribute about 5% GDP and annual earning from the export exceeds 10 million dollars. Increasing interest in plant origin medicines led rising demand of herbal products throughout the world. However some of the high value MAPs are endangered and extinct in the natural habitats resulting in declined export. Diverse geographical and climatic conditions are congenial for growing various MAPs in Nepal. Socio-economic and market conditions also reveal tremendous opportunities to increase production and export. Farmers are interested to cultivate MAPs for income generation and improve livelihood. Collectors, porters, processors, traders and exporters may also be benefited. However, the cultivation technologies not well understood. Studies needed to identify the existing cultivation practices, constraints and opportunities for the production of MAPs. Review of past works and field study found that depletion of MAPs was mainly due to unscientific and over-harvesting. Some species banned were illegally traded. The study identified lack of research and development policies and programs for domestication, cultivation and sustainable harvesting practices. Available technologies for few species identified however technologies required for propagation and cultivation of most MAPs are lacking. A number of suggestions and recommendations made by many researchers and development workers from the governmental, I/NGOs and private organizations are incorporated. Emphasis was given to increase production and export of potential MAPs by developing and application of technologies for commercial cultivation. Initiation taken by some organizations in cultivation and research are also highlighted in the paper.

Key words: Medicinal, aromatic, plants, cultivation, Nepal

INTRODUCTION

The Himalayan country, Nepal is rich in unique flora and fauna. Due to diverse geographical and climatic conditions, it harbors 3 per cent of the world's bio- diversity. Among the genetic resources, 6076 taxa of flowering plants (belonging to 216 families and 1534 genera) have been identified from Tarai plain (60 masl) to the high Himalayas (Shrestha et al 2000). The highest altitude recorded for the endemic flora (*Logotis nepalensis*) is at 5,800 m (Lacoul and Pant 2000). The database of Nepal's medicinal and aromatic plants (MAPs) or "Jadibuti" (in Nepali) encompasses over 1624 species (Shrestha et al 2000) and distributed throughout the country. Most of the species are used as Ayurvedic, Homeopathic and Tibetan systems since time immemorial. Shrestha et al (2000) reported that about 85% residents in the rural areas depend on traditional herbal drugs, and according to Adhikari (1998) and Bhattarai (1994), herbal medicines and essential oils have been receiving increased interest all over the world.

The MAPs as one of the major natural resources of Nepal has been contributing a lot to the national economy. Above 100 crude MAPs are annually exported to the foreign countries in different continents. According to Edwards (1993), annual earning from the export of non-timber forest products exceeds 10 million dollars, however Department of Forest (FY 2000/01) reported 9,678,660 kg of herbal products sold on NRs44,162,733. Shrestha et al (1994) mentioned that medicinal plants are diverted wealth of Nepal. These plants grow in the natural forest and marginal grasslands, from where rural poor collect them and sell to the traders locally or in the district/regional markets. The processors or drug manufacturers purchase and utilize these products. Domestic use is limited, major fraction is exported to India and other foreign countries (Lacoul and Pant 2000). Indian

traders and companies are the main buyers (about 80%). At present, herbal products contribute in the GDP above 4% out of 15% from forest resources. The future of MAPs seems brighter than timber to generate national revenue. The MAPs have good prospect to reduce rural poverty and support development if the production and export could be increased and sustained. These products would be one of the potential trading commodities of Nepal for World Trade Organization (WTO).

Sustainable management of natural resources and increase productivity of valuable plants to raise the livelihood of rural people is one of the objectives of Agricultural Perspective Plan (APP) of Nepal. The main target of the Government during the 9th and on-going 10th Development Plan is poverty alleviation. One of the ways to achieve this purpose will be the proper utilisation and exploitation of high value medicinal plants. Role of MAPs to support this national goal might have recognized by the Government.

Depletion and extinction of valuable MAPs is undergoing in the natural habitats due to lack of conservation practices. Bhattarai (1994) identified some important species such as Jatamansi, Chiraito, Kutki, Panchaunle, Satuwa, Padamchal, Yarshagumba, etc. supposed to be endangered. Need to increase their production, export and income has been realised by many researchers and development workers. Production can be increased through commercial cultivation, regeneration and sustainable harvesting. But due attention is not paid to domestication and cultivation nor the conservation. Personal communications with many stakeholders and farmers by the author from 1998 to date identified that farmers are interested to cultivate MAPs in their private land and community forests as income generation activity. Unfortunately appropriate propagation techniques and cultivation practices are not known to the farmers and concerning stakeholders.

Commercial cultivation of MAPs seems important from different points of view. It shall support conservation of the endangered MAPs in situ resulting in bio-diversity conservation. It shall help utilization of marginal and unproductive lands, soil conservation and environment protection. Similarly, it may create additional employment and income resulting in the livelihood improvement of the rural communities. However literature on the domestication as well as commercial cultivation of MAPs is limited, and not found in compiled form easily accessible for the wider users.

Therefore the present study has been carried out to identify the farming practice of MAPs for generating local income. This paper highlights the status of MAPs, their economic importance, attempts made by researchers and institutions for domestication and commercial cultivation, constraints and opportunities and valuable suggestions for promotion. The main objective was to identify overall situation and potential of commercial cultivation, to compile available cultivation technologies.

MATERIALS AND METHODS

The available literatures were the main source of review to overview the scenario of MAPs and their cultivation in Nepal. For this purpose, desk study of various literatures: journals, proceedings, books, reports and other materials were consulted in the libraries (ARS Pakhribas, NARC Khumaltar, FRSD Babarmahal, DPR Thapathali, HPPCL Koteswar, Dabur Nepal Tinkune, etc). Along with the findings, general information, personal communication with various stakeholders and farmers, experiences of the author are incorporated in the paper. Some plantation fields were also visited and observed.

RESULTS AND DISCUSSION

Classification of Nepal's medicinal plants

The data-base of MAPs in Nepal has been compiled (Shrestha et al 2000). According to botanical classification, most species (1515) fall under angiosperms group. Ferns, fungi, lichens, liverworts and gymnosperms are limited (Table 1). These plants come under different headings and sub-headings. MAPs belong to agricultural crops and weeds also. Amatya (2000) reported that distribution pattern of MAPs is higher (55%) in temperate zone followed by 31% in tropical and sub-tropical zones, and 14% in alpine region.

Table 1. Synopsis of the medicinal and aromatic plants of Nepal

Plant groups	Families	Genera	Species
Fungi	9	9	9
Lichens	4	8	18
Liverworts/mosses	4	5	6
Ferns and allies	20	36	58
Gymnosperms	8	12	18
Angiosperms	173	868	1515
Monocot	23	132	197
Dicot	150	736	1318

Source: *Proceedings of Nepal-Japan Joint Symposium 2000.*

Among the agricultural crops, there are above 100 species under spices, vegetables, fruits, ornamentals, oilseeds and pulses (Subedi 2000). Aside the cultivated crops, 82 species of weeds have been identified with medicinal properties (Rajbhandari et al 2000). Likewise, Vaidya et al (2000) reported that out of 361 species of orchids, 53 species possess medicinal value. Among the ferns, 29 species out of 383 species (Tuladhar 2000) and 16 fungal species, especially the mushrooms (Manandhar and Adhikari 2000) have medicinal properties. Based on the availability in the natural habitat, the MAPs are classified under vulnerable, rare, threatened, endangered, extinct, etc.

Domestication of medicinal plants

First realization for the domestication of medicinal plants was 1960s with the establishment of the Department of Medicinal Plants. However domestication could not gear up. Some of the high value species were supposed to be endangered due to early, unscientific and over-harvesting. According to Bhattarai (1994) these are: Sweet flag (*Acorus calamus*), Wild asparagus (*Asparagus racemosus*), Yarshagumba (*Cordyceps sinensis*), Orchid (*Dactylorhiza hatagierae*), Satuwa (*Paris polyphylla*), Kakuli (*Fritillaria cirrhosa*), Jatamansi (*Nardostachys sp*), Kutki (*Picrorhiza kurroa*), Chiraito (*Swertia chirata*), Laghupatra (*Podophyllum hexandrum*), Padamchal (*Rheum emodi*), Majitho (*Rubia manjith*), Sarpagandha (*Rauwolfia serpentina*). There are other important herbs like Bikh (*Aconitum spicatum*), Pakhanved (*Bergenia ciliata*), Foxgloves (*Digitaria sp*), Dhasingre (*Gaultheria fragrantissima*), Panchaunle (*Orchis latifolia*), Sugandhawal (*Valeriana jatamansi*), which need to conserve in situ. Unfortunately the endangered and highly valuable exportable native species such as Jatamansi, Kutki, Panchaunle are not yet domesticated (Shrestha et al 1995).

With the aim of conserving Yarshagumba and Guchhichyau, the Government has increased their royalty rate, although illegal trade and smuggling has been observed. So neither royalty could be collected nor these mushrooms conserved. Similarly some MAPs have been banned to collect, transport, and or to export without processing. But the policy did not work as desired. Singh (1999) reported that ban increases illegal and indiscriminate collection leading to loss of species rather than conservation. The word "conservation" is very much popular in forestry like "cultivation" in agriculture. Perhaps there is no word of "cultivation" in forestry terminology. Instead of conservation, the term sustainable harvesting may give meaning. Shrestha et al (1994), Bashyal et al (1995) have emphasized on the need of appropriate national policy for the conservation of MAPs by public sector through domestication.

Medicinal plants in global trade

Some medicinal plants of Nepal as mentioned below have high value and global demand. However in personal communication Das (2003) opined that we so far are unable to produce and trade none of the species in large and commercial scale.

1. <i>Andrographis paniculata</i> (Kalmegh)	9. <i>Glycyrrhiza glabra</i> (Jethimadhu)
2. <i>Asparagus racemosus</i> (Kurilo)	10. <i>Mentha species</i> (Pudina)
3. <i>Carica papaya</i> (Mewa, Papita)	11. <i>Mucuna species</i> (Kawach)
4. <i>Cassia species</i> (Tapre & other)	12. <i>Rauwolfia serpentina</i> (Sarpagandha)
5. <i>Catharanthus roseus</i> (Sadabahar)	13. <i>Sapindus mucorossi</i> (Rittha)
6. <i>Centella asiatica</i> (Ghodtapre)	14. <i>Strychnos nuxvomica</i> (Kuchila)
7. <i>Curcuma longa</i> (Kalo Haledo)	15. <i>Swertia species</i> (Chiraito)
8. <i>Datura species</i> (Dhaturo)	16. <i>Withania somnifera</i> (Ashwagandha)

Source: B. DAS (SION) 2003.

Cultivation of medicinal plants

Need of scientific study and cultivation of medicinal plants in Nepal was felt for the first time in early 1960's (Shrestha et al 1994). As a result, the then Department of Medicinal Plants under the Ministry of Forest and Soil Conservation (MoFSC) was founded aiming to conduct research and development of MAPs. However cultivation of MAPs practically started after 1986. The need of commercial cultivation for sustaining production, export and income was felt by several researchers (Aryal 1993, Maharjan 1994, Shrestha et al 1994, Bashyal et al 1995, Singh 1998, Tiwari 1999, Bhattarai 2000, Barakoti 2001). The authors also highlighted the importance of research for commercialization and industrialization. Research is needed to identify better techniques or methods for the improvement of varieties and qualities of wild MAPs, best time of planting and harvesting etc. Cultivation of agro-crops having medicinal values, such as sesame, horse-gram, ginger, garlic, coriander, radish, bitter gourd, amaranth, bamboo, banana, mango, cardamom etc. is well known.

In Nepal, due attention is not paid to cultivation of medicinal plants, except few aromatic plants. However Bashyal et al (1995) reported that no noteworthy research findings have been published so far on commercial cultivation practices. One of its reasons is lack of commitment, research plan and programs. Aside the technical know-how, lack of regeneration techniques and conservation practices are other aspects. To overcome the problems application of modern technology for cultivation of the required medicinal plants (Pimpirkar and Haque 2000) would be useful. Shrestha et al (1994) suggested that instead of talking a lot on over-harvesting, and lack of conservation practices, commercial cultivation in situ should be increased so that the rural people will be continuously benefited. Cultivation and sustainable use of medicinal plants for livelihood is a collective concern of local communities, entrepreneurs and Govt. institutions.

Little information on cultivation of MAPs is due to limited research carried out in this area. Few work on germplasm collection and evaluation, propagation and cultivation of few MAPs have been initiated by some departments and companies under the Ministry of Forest and Soil Conservation, Universities (Tribhuvan, Mahendra Sanskrit, Purbanchal, Pokhara), Nepal Agricultural Research Council. But the effort seems very limited and not efficient as required (Lacoul and Pant 2000). Research on the cultivation aspect should be equally considered so as to sustain the productivity. Tiwari (1999) reported that cultivation and domestication is the only way for sustainable utilization of MAPs. The importance of commercial cultivation of MAPs has been expected (Shrestha et al 1994) in additional income generation, conservation of the endangered MAPs, use of marginal and unproductive lands and development of processing system for value addition.

Some government and private organizations have attempted cultivation of MAPs. Their attempts could be noted as following.

Cultivation initiated by the department of plant resources

The Department of Plant Resources (DPR), previously known as the Department of Medicinal Plants has been involved in different activities of MAPs since 1960. Collection of plant samples and analysis for chemical composition and others were done for many species. It has produced some extension materials regarding cultivation of some MAPs: *A. belladonna*, *R. serpentina*, *V. jatamansi*, *C. glaucescens* etc. DPR has established herbal nurseries at 9 locations in the country and extended branch offices in 7 districts. It has also developed tissue culture technology for plant propagation.

Cultivation practiced by the herbs production and processing company limited (HPPCL)

Established in 1981, as a parastatal under the MoFSC, HPPCL has become a pioneer producer/exporter of essential oils as well as medicinal herbs/extract from Nepal. It has introduced farming, processing and sustainable collection of MAPs in its farms, private lands and community forests (Maharjan 2000). Since 1986 it has been involved in cultivation of MAPs, which are grown at commercial scale. These are:

Annual crops

Mentha
French basil
Matricaria/chamomile

Perennial crops

Palmarosa
Citronella
Lemon grass

The other aromatic plants cultivated are Japanese mint and wild marigold. The company has focused on the cultivation of mainly aromatic (essential oil extracting) plants in its herbal farms. The HPPCL has so far domesticated/cultivated 10 MAPs (Amatya 2000, Shrestha et al 1994).

Atropa belladonna, *Chrysanthemum cinerariaefolium*, *Cymbopogon winterianus*,

C. flexuosus,
Mentha arvensis,
Valeriane jatamansi

C. martinii,
Rauwolfia serpentina,

Cinnamomum glaucescens
Tagetes glandulifera

Cultivation and processing are being done in the following farms of the company located in the eastern, central, mid and far-western Terai of Nepal. Palmarosa, citronella and lemongrass have been extensively cultivated, (each in more than 50 ha).

Tamagadhi farm
Tarahara farm
CFUG program

Bara district
Sunsari district
Udayapur district

Belbari farm
Tikapur farm

Morang district
Kailali district

HPPCL has been assisting local communities through training on sustainable collection, cultivation, processing and marketing in 25 districts (Maharjan 2000). It has been processing Dhasingre, Jatamansi, Sunpati, Dhupi, Lichen, Timur, Bojho, Sugandhakokila collected from forest and marginal *Bari* land. In addition, the company has started cultivation of MAPs in the field of Mahendra Sanskrit University in Dang and Purwanchal University in Morang district in relatively larger areas.

Cultivation practiced by Dabur Nepal

Dabur Nepal Private Limited (DNPL) is intensively involved in medicinal plants particularly after the establishment of a sophisticated nursery at Banepa, (near Kathmandu) in 1998. It is producing and supplying seedlings/saplings to farmers/NGOs/institutions. It aims to provide technical and extension supports, buy back guarantee and contract production of desired plants (Primpikar and Haque 2000). The DNPL's priority medicinal plants for different altitudes are as following.

High altitude (Working area: Marpha, Manang, Gunchha, Khawa)

1. <i>Taxus baccata</i>	2. <i>Anacyclus pyrethrum</i>
3. <i>Saussurea lappa</i>	4. <i>Picrorrhiza kurroa</i>
5. <i>Swertia chirayita</i>	6. <i>Nardostachys jatamansi</i>
7. <i>Rheum emodi</i>	

Mid altitude (Kakani, Nagarkot, Jumla, Dang)

1. <i>Asparagus racemosus</i>	2. <i>Hypericum perforatum</i>
3. <i>Crocus sativus</i>	4. <i>Valeriana wallichii</i>

Low altitude (Birganj, Tandi, Besishahar)

1. <i>Carthamus tinctorius</i>	2. <i>Withania somnifera</i>
3. <i>Silybum marianum</i>	4. <i>Mentha arvensis</i>
5. <i>Zanthoxylum armatum</i>	6. <i>Piper longum</i>
7. <i>Piper peepuloids</i>	8. <i>Emblia officinalis</i>

Medicinal plants planted through DNPL up to 2000 are:

1. Saffron	200,000 plants	2. <i>S. lappa</i>	196,000 plants
3. <i>Taxus</i> sp.	185,000 „	4. <i>A. pyrethrum</i>	171,000 „
5. Chiraito	110,000 „	6. Amala	105,000 „
7. Sugandhawal	32,000 „	8. Padamchal	17,000 „
9. Pipla	16,000 „	10. Kutki	4,000 „
11. Others	180,000 „	Total	12,16,000 plants

Source: Proceedings of Nepal-Japan Joint Symposium.

A total of more than 100 ha have been used for the cultivation of medicinal plants. After 1990s different herbs trading and manufacturing private companies have been registered and run in the country. However, only a few companies are involved in cultivation. For instance Shambhala Herbal and Aromatic Industry has started cultivation of *S. lappa*, *P. aureus*, *V. officinalis* and *Aquilegia sp* in the hills and *Sida cordifolia* in the Tarai.

Existing cultivation technologies and practices

A. Existing propagation and cultivation practices of essential oil species

SN	Oil species	Propagation techniques	Cultivation practices
1	Lemon grass	Through seed in nursery. Time: May-June in	Planting time: Rainy season (June-July). Spacing: 50
2	Palmarosa and	well prepared with compost and raised bed. Seed	x 50 cm. FYM rate: 10t/ha. Weeding: 2-3 times
3	Citronella	rate: 2kg/ ha, sown at 15-20 cm mixing into	starting from 1 month after transplanting with
	<i>Cymbopogon</i>	wood ash. Seed germinates at 1 wk. Seedling	earthing-up. Irrigation: After planting, then as per
	(exotic) species	will be ready after 3-4 weeks for transplanting at	need/ water source. Harvesting: First cutting at 4-5
		15 cm high. Through slips directly. Slips are	months after planting. Then 2.5-3 months interval
		separated from the plantation. Leaves and few	upto 4-6 years (Palmarosa).
		roots are cut and transplanted immediately	Yield: 10-15 t/ha 1 st year, 25-30 t/ha in subsequent
		during monsoon period.	years.
4	Mentha	Through sucker. Time: February.	Planting time: March-April. Spacing: 45 x 60 cm.
	(Pudina)	Healthy plant suckers or roots having 2-3 nodes	FYM rate: 15-20 t/ha. Weeding: 1-2 month interval as
		and 5-7 cm long are separated and immediately	per need with earthing-up. Irrigation: Necessary,
	<i>Mentha</i>	transplanted in the nursery. Planting materials	immediately after transplanting, then as per need.
	<i>arvensis</i>	will be ready within 1-2 month.	Harvesting: First cutting at 3.5-4 months in June
			when the plants start flowering. Second cutting in
			Aug-Sep. Yield: 14 t/ha from 2 cuttings.
5	Basil (Babari)	Through seed in nursery. Time: March April. In	Planting time: April-June. Spacing: 50 x 25 cm. FYM
	Tulsi jati	well-prepared compost applied raised bed, which	rate: 10-15t/ha. Weeding: 1-2 month interval as per
		is watered/moistened before seeding. Seed rate:	need with earthing up. Irrigation: After transplanting
	<i>Ocimum</i>	1.5 kg/ha, sown at 15-20 cm, not covered with	as per need, but land should be drained. Harvesting:
	<i>basilicum</i>	soil. Seed germinates at 7-10 days and will be	First cutting at 2-2.5 months after flowering then at 1-
		ready for transplanting at 20-25 days when	2 month. Leave few stems for regrowth. Second year-
		seedlings will attain 15 cm high.	new planting is necessary. Yield:
6	Matricaria	Through seed in nursery. Time: March-April	Planting time: October-November. Spacing: 50 x 20
	(Tare phool)	Seed rate: 0.5kg/ha, Other methods: as for basil.	cm, FYM rate: 10 t/ha. Weeding: 2-3 times/year as
		Seed is sown mixing with ash at 1:30 ratio.	per need. Irrigation: as per need, land should be
	<i>Matricaria</i>		drained. Harvesting: After full flowering, small twigs
	<i>chammomile</i>		with fruits harvested. 2 nd and 3 rd plucking at 15-20
			days interval up to April. Yield:
			Planting time: June-July (Hill). Tarai: October.
7	Tagetes	Through seed in nursery. Time: May-June (Hill).	Spacing: 45-60x30 cm. FYM rate: 10 t/ha. Weeding:
	(Sayapatri)	Seed rate: 2 kg/ha, sown in raised/prepared bed	2-3 times as per need. Irrigation: As per need but
		at 30cm row after moistening the soil. Seeds are	should not be waterlogged. Harvesting: (Hill) Oct-
	<i>Tagetes</i>	mixed into sand or ash or soil at 1:20.	Nov. (Tarai): March-April, at full flowering, plants
	<i>glandulifera</i>	Germination:	with leaves are cut and dried in shade. Yield: 8.5 t/ha.
		appears at 1 week, seedlings will be ready when	2 harvests may be taken.
		become 10-15 cm high. Tarai - Sep.-October.	
		Spacing: 45 cm	
8	Tejpat,	Through seed in nursery. Time: April-May. Seed	Planting time: June-July, shading for 1 year seedling.
	Dalchini	starts germinate after 30-45 days, seedlings	Spacing: 2 x 3 m, 800 plants/ha. FYM, weeding and
		become ready for transplanting at 10-12 months.	irrigation not mentioned. Harvesting: Leaf can be
	<i>Cinnamomum</i>	Through cutting in February-March. Small	harvested at 8 years after planting.
	<i>tamala</i>	branches cut at 10-15 cm and the cuttings are	Bark or Dalchini can be harvested after 3 years (from
		planted in the bed or poly bag with soil and sand.	cutting) and at 5 years (from seedlings). Yield: Leaf
		After regular irrigation, roots initiate after 50-60	(dry)- 20 t/ha,
		days. Through coppicing from the cut surface.	Bark- 10 t/ha.
9	Sugandha-	Through seed in nursery. Time: January. Seed	Planting time: June-July. Spacing: 7 x 7 m (pit 30x30
	kokila	collected in Sep.-Oct. soaked for 24 hrs. prior	cm). FYM and soil mixed equally and filled the pits
		seeding. Provide shade to prevent from frost.	and transplanted. Weeding: around the plant at early
	<i>Cinnamomum</i>	Germination starts after 4-5 weeks, transplant	stage of weeds. Pruning: lower branches after 3 years.
	<i>glaucescens</i>	after 1 month in poly-tube, where forest soil and	Irrigate if there is dry. Harvesting: after 6-7 years.
		sand (2:1) or soil: compost: sand put in 3:2:1	Fruits bore in July start to mature in Oct.- November.
		ratio. Seedlings may be ready for transplanting	Ripe fruits collected, fruit coat removed and dried on
		after 6 months.	Sun. Yield: 50 kg fruits/plant.
10	Timmur	Through seed in nursery. Time: Oct-Nov. Seed	Planting time: June-July. Spacing: 3 x 3 m (pit 30x30
		rate: 0.5 kg/ha. Seeds are soaked for 24 hrs.	cm). FYM rate: Equal quantity mixed with soil and
	<i>Zanthoxylum</i>	sown in well prepared bed, covered with mulch	filled the pit (1 doko= 10 pits). Weeding: 2-3
	<i>armatum</i>	and irrigated. After germination dwarf shade	times/year as per need. Irrigation: not practiced.
		made. Weeding : as per need.	Water logging is prohibited. Fruiting starts 3 years
		Through cutting: Dec.-Jan. Mature branch cut at	after planting. Harvesting: Fruits are collected placing

SN	Oil species	Propagation techniques	Cultivation practices
		15 cm, cuttings are planted in the poly-bag filled with fertile soil and compost. Shade is given to prevent from frost. Budding starts in March-April from cuttings and saplings will be ready after 3-4 months.	plastic sheet under the plant, the branches are shackled with stick. Yield: 2 kg seed/plant.
11	Pipla <i>Piper longum</i>	NA	Planting time: June-July. Spacing: 1.5 x 1.5 m on raised bed of 15cm Land preparation: Apply decomposed FYM and lime. Fruiting: Second year. Harvesting: After 1.5 year upto 3 years. Then replanted. For root purpose 10-30 years can be harvested. Yield: Seed- 500 kg/ha, stem/root- 500 kg/ha.
12	Bojho <i>Acorus calamus</i>	Through rhizome. Time: March-April. The rhizome with bud cut into pieces. Those are transplanted into the friable sand mixed soil at 30 cm.	Planting time: March-April. Spacing: 30 x 30 cm. Land: Fertile but swampy. Harvesting: 1 year after planting during April-May. Rhizomes are uprooted leaving few parts inside the soil. Yield: 2 t/ha.
13	Sugandhawal <i>Valeriana wallichii/jatamansi</i>	Through seed in nursery. Time: March-April. Seed is mixed with sand at 1:5 and broadcast on the prepared bed. Watering is done timely. Through slips- separated and transplanted in the bed.	Planting time: June-July. Spacing 50 x 25 cm. Weeding as per need.

B. Propagation and cultivation techniques of some medicinal plants

SN	Oil species	Propagation techniques	Cultivation practices
1	Alainchi Cardamom <i>Ammomum subulatum</i>	Through seed: in nursery. Through rhizome. Propagated according to recommended techniques of Cardamom Development Centre.	Transplanted as per identified general method. Cultivation practices are also identified and followed in the field by the farmers.
2	Chiraito <i>Swertia chirayita</i>	Through seed in nursery and broadcasting in terrace riser. Time: April-May. Technology identified by ARS Pakhribas. Bed raised 10 cm with forest soil, sand and compost @1:1:1 ratio. Upper part filled with sieved substrate. Seed is mixed with sand at 1:50 and broadcast on the well-levellled surface. Malathain 5% dust @ 2 g/m ² is applied against insect pests. Mulching is done with thatch or straw. Roofing is made to protect from rain and hail. Regular watering and uprooting weeds is necessary. Seed starts to germinate after 2-3 weeks and will take up to 2 months. Seedlings can be transplanted into poly-bag after 2-3 months.	Planting time: June-July. Spacing: 50 x 25 cm. FYM: 15-20 t/ha first year & 15-20 t/ha second year. Land preparation: as per for maize. Weeding: 4-6 times/year as per need. Irrigation: During Oct.- April as per need and facility. Harvesting: the plant gives rise to shoot in second year and matures during Oct.- Nov. second or third year. Whole plant is uprooted, dried and made small bundles. Yield: 1-3 t/ha depending on growth and stands. The cultivation technologies were recently identified/developed by ARS Pakhribas.
3	Kurilo, Satawari <i>Asparagus racemosus</i>	Through seed: in nursery. Time: April. Seeds are sown in a well prepared bed at 10 cm row.	Planting time: Rainy season. Spacing: 60 x 40 cm. Harvesting: after 1.5 years.
4	Amala <i>Embllica officinalis</i>	Through seed in nursery. Time: March In the prepared bed, seed is sown at 10-15 cm. Seedlings are transplanted into poly bag after 3 months. Shade is provided to prevent from frost. Through cutting: 15-20 cm long cuttings from branches are transplanted in the bed and saplings prepared. Through coppicing	Planting time: Rainy season (June-July). Spacing: 5 x 2.5 m. (800 plants/ha). FYM rate: 5 t/ha. Harvesting: Fruits can be harvested after 2-3 years from cutting and after 4-5 years from seedling tree. Yield: dry fruit 3.5 t/ha. Coppices grow faster, become stronger and flower/fruit earlier.
5	Samayo <i>Valeriana jatamasi/wallichii</i>	Through seed in the nursery. Research for domestication carried out in Mid-western region (Dailekh, Jumla, Humla) by Dabur Nepal and NGo since 1999. Performance was good but further research needs to develop its cultivation technologies.	Planting time: June-July. Transplanting, manuring, weeding, other intercultural operations and package of cultivation practices should be further confirmed.

SN	Oil species	Propagation techniques	Cultivation practices
6	Loth Sallo <i>Taxus buccata</i>	Through roots and stem cuttings in the nursery. Cutting time: Jan-Feb. One years old pencil size 15cm cuttings are grown in media. Dabur Nepal has tried to domesticate since 1999 in Dolakha, Sindhupalchok and later in Jumla and Humla.	Planting time: Both rainy and winter season. Spacing: 50-60 cm. NPK: 67: 28: 55 Kg/ ha. Pit size: 30x30cm. Land preparation through ploughing. Expected yield: 50 g dry matter/ plant after 6 years. As the research is just started in limited locations, cultivation technologies should be developed by further research.
7	Sarpagandha <i>Rauwolfia serpentina</i>	HPPCL has initiated its cultivation in its herbal farm Sunsari and other districts previously. As it is banned no further development of cultivation practices continued.	
8	Kuth <i>Saussurea lappa</i>	Through seed: in the nursery. Through root cutting: Propagation techniques were recently tested by Dabur Nepal for its domesticating.	Planting time: Jun-Jul. Spacing: 60x60cm. Harvesting time: Oct-Nov. The root of Kuth can be harvested after third year. Harvest before seed mature.
9	Padamchal <i>Rheum emodi</i>	Through seed in the nursery. Dabur Nepal has successfully propagated seedlings in the Green house condition at Banepa. Seed collection in Feb-Mar.	Planting time: Rainy season. Spacing: 60x60 cm. Harvesting: Roots can be harvested after third year of transplanting. The cultivation practices are to be identified and confirmed.
10	Saffron, Keshar	Cultivated in Europe and also in India. Its flower is expensive (Rs. 45000/kg). Cultivation practiced in Jumla since 1998. There is lack of farmer's interest.	Cultivation practices are to be tested and developed.
11	Atis	Through seed or through rhizome: in the nursery. Time: May. Seed germinates after 2 months. Domestication practice was just started since 2002.	Planting time: Rhizome- Baishak, Seedling-Saun. Spacing: 30x30cm. Manure: 0.5 kg /m ² . Harvesting: First harvest can be taken after 3 years.
12	Akkarkara	Propagation: through seed. Its propagation and cultivation started from 2000.	Planting: Direct sowing in the prepared land. Spacing: 15x45cm. Manure: 0.5 kg/m ² . Harvesting: second year of planting.
13	Rudrakshya <i>Elaeocarpus sphaericus</i>	Through cutting in nursery. Time: February. 1 year old finger size branch with 3 buds planted in polybag of 4x7" filled with forest soil, sand and compost @2:2:1after watering. Bed is prepared with gravel in bottom then forest soil. Shade provided. Budding starts at 20-30 days. Mother plants are prepared in the stool bed for cutting source. Hard and semi-hard woods are successful. Through layering Air layering is done on 1-2 year old branch. Mixed manure, soil and lichen are covered where bark removed. Then plastic covered air tightly.	Planting time : June-July. Pitting: 45-90x90cm. Spacing: 5x5 m. FYM: About 20 Kg/year in April. Weeding: First year-3 times (Aug, Dec, Apr). 2 nd year-2 times (Sep, Apr.). Mulching: with straw or Shyaula after weeding. Irrigation: if necessary and available. Pruning: Apical and lower branches are cut for spreading tree and getting more seed yield. Protection given from birds, rodents and others. Harvesting: Starts to flower after 4-5 years. Mature between Sep to Jan. Pluck mature fruits with the help of bamboo Tosro. Yield: up to 300 Kg/ tree, gives up to 50-60 years.

Economic benefit from medicinal plants

In Nepal, agriculture plays a vital role in the economic and social life of the rural people and agriculture contributes above 40% of the GDP. Together with agriculture, forestry sector is also important (Amatya 2000). Medicinal and aromatic plants are playing important role in generating income of the rural people. Every year 10,000 to 15,000 m. tons of about 100 species plant products are harvested. The annual value of these products contributes above 4% to the national GDP (Edward 1996). Nepalese herbal products are exported to Asian (India, Japan, Korea, Pakistan, Sir Lanka, Malaysia, Singapore etc), European (Germany, France, Italy, UK, Spain etc), and some American and African countries. The rural collectors, porters, traders and middlemen have been benefited from the business of MAPs. Herbal trade is one of the oldest businesses in Nepal, however the economic importance of MAPs has been recently appreciated. But the country is not able to industrialize the MAPs. The export of some medicinal plants from Nepal started to decline. Over-harvesting is a sign of big market for export. But attempts for managing their sustainable production should be made consequently.

On the other hand, production and export of essential oils and extracts from different aromatic plants have been noticeably increased during the last few years. The price of the essential oils ranged from Rs400 to 1200 or more per kg. An example of royalty and local income generated from MAPs is presented for 1990 to 1998 (Table 2).

Table 2. Royalty and local income generated from MAPs for 1990/91 to 1997/98

Fiscal Year	Quantity collected, t	Royalty, Rs '000	Market value, '000	Avg. Annual income/family
1990/91	3448	3,490	35,500	2822
1991/92	6217	7,400	75,800	6052
1992/93	3372	5,650	65,600	5216
1993/94	5779	11,330	134,300	10492
1994/95	5680	11,258	154,100	12007
1995/96	3233	11,011	80,825	6250
1996/97	4130	17,825	120,390	9246
1997/98	5084	25,484	152,520	20000?

Source: Raw data of the Department of Forest

No. of families involved in collection of MAPs is 12400 to 13020, except in 1997/98 (22626).

Average price of traded MAPs is from NRs 20 (farm gate price) to NRs 75 (exporter's price).

Royalty value paid in 2054/55 (1997/98),

Total product species = 80.

Eastern Region - NRs 2896042,

Central Region - NRs 2088668

Western Region - NRs 3175719,

Mid- western Region - NRs. 9475613

Far western Region - NRs 2808622

Total values - NRs 20444664

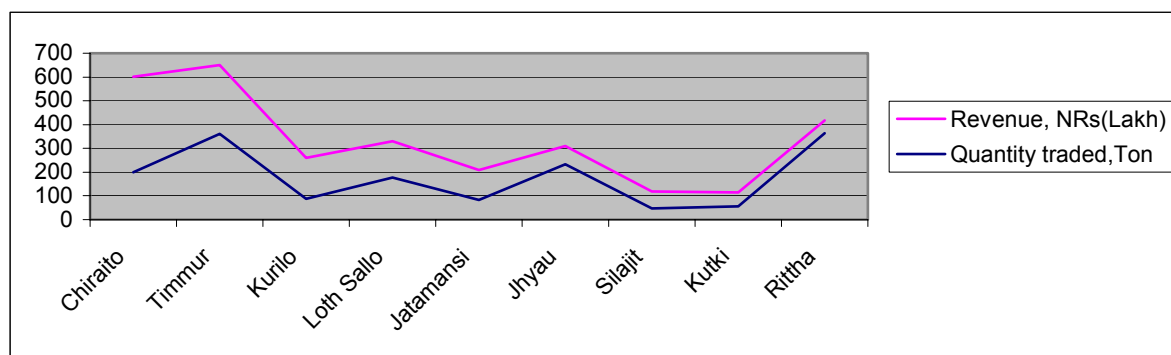


Figure 1. Top 9 MAPs traded from Nepal.

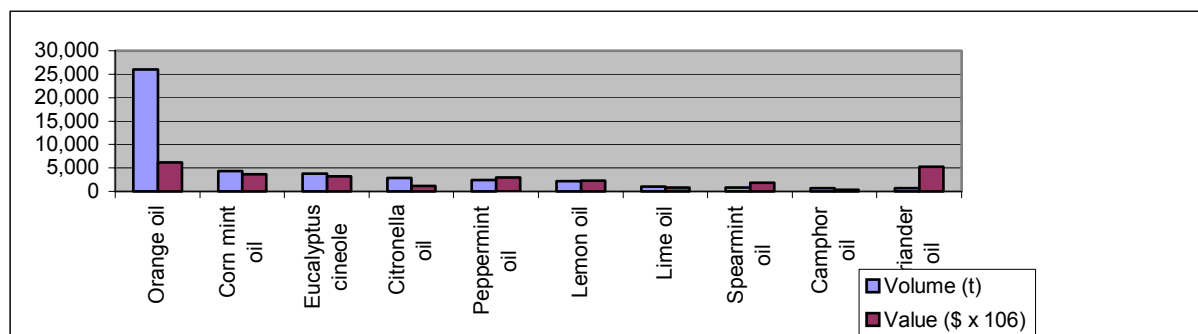


Figure 2. Major essential oils in global market.

Commercially cultivated and processed plants in Nepal

SN	Botanical name	Product
1	Cymbopogan flexuosus (DC) Stapf.	Lemongrass oil
2	C. martinii Stapf.	Palmarosa oil
3	C. winterianus Jowitt	Citronella oil
4	Matricaria chamomilla L.	Chamomile oil

SN	Botanical name	Product
5	<i>Ocimum basilicum</i> L.	Basil oil
6	<i>Tagetes glandulifera</i> (Mill.)	Blake Tagetes oil
7	<i>Vetiveria Zizanioides</i> (Lin)	Nash vetiver oil
8	<i>Zingiber officinale</i> Rose	Zingier oil
9	<i>Mentha arvensis</i> L.	Mentha

Constraints and opportunities

Implementation of Forestry Master Plan has been started by His Majesty's Government of Nepal since 1990 with major focus on community forest and MAPs development programs (Maharjan 2000). National policy formulated but sound planning for cultivation and overall development of MAPs was lacking. Due to unclear and unstable policies, the entrepreneurs might feel that the government shall impose rules and regulations that may bring catastrophe in their production (Amatya 2000).

Various researchers in forestry as well as agriculture both Nepalese and foreign scientists, planners, private entrepreneurs and stakeholders have expressed their views and experiences on constraints and opportunities of MAPs cultivation in Nepal. While going through the literature, particularly after 1990s, the following views in general have been identified.

Constraints

- Lack of government higher authorized co-ordinating body.
- Lack of planning on domestication and commercial cultivation.
- Lack of technical know-how and extension materials.
- Lack of suitable technologies for propagation and cultivation.
- Non-availability of planting materials at required time and quantity.
- Lack of funds with farmers for sapling and cultivation.
- Problem of accessibility due to remote hills and mountains.
- Lack of organization for production, collection and supply.
- Lack of market information, its knowledge and linkage.
- Lack of research and development policies and program.
- Lack of coordination among R & D institutions.
- Lack of post-harvest techniques and processing facilities.

Opportunities

The hills and mountain areas covering more than 80% territory in Nepal are the main source of medicinal plants in Nepal. This region is potential for growing different herbs. Most people living in these areas are also poor and marginal. Medical plant products will be a good source of income to them. Similarly most of the essential oil species grow in the Tarai and low hills. Promotion of MAPs through cultivation on private and marginal wasteland would be the best way for conserving endangered species as well as raising the rural income. The following points are identified as opportunities for the cultivation of MAPs in Nepal.

- Agro-climatic conditions are favorable for the cultivation of a number of important MAPs in Nepal.
- The medicinal herbs are cost effective to grow, to utilise the marginal/unproductive land.
- There is ample scope of cultivating MAPs in the agro-forestry system both in on-farm and off-farm conditions (Amatya 2000).
- Local cultivation and processing of medicinal plants will support not only rural income, but also employment opportunity for subsistence farmers.
- Valuable modern drugs of Ayurvedic and allopathic systems are developed from the plant sources.
- Farmers particularly in the hills and mountains are interested to cultivate Jadibuti or MAPs in the private land and community forests.
- Nepalese people are familiar with many medicinal plants and so these are socially acceptable.

RECOMMENDATION

It was identified that research scientists, planners as well as development workers have made a number of suggestions and recommendations for conservation, commercial production, sustainable utilization, and industrialization of the Himalayan medicinal plant resources. Some of them are:

- Development of suitable propagation technologies is an urgent need for the domestication of economically important and endangered medicinal plants.
- Sustainable harvesting and regeneration techniques for medicinal plants should be identified and adapted.
- Research and development works are necessary for improving quality and production of medicinal plants.
- Cultivable MAPs should be prioritised and studied the natural conditions (soil, climate, aspect, altitude etc.).
- Medicinal and aromatic plants should be included in the income generation activities of the community forestry.
- Farmers involved in production should be trained to cultivate medicinal and aromatic plants in their land and community forest.
- Conduct research and extension programs, training and technology/information dissemination, networking and collaboration.
- R & D should emphasize on the development of appropriate agro-technologies for propagation and cultivation of medicinal plants and disseminated through extension channels.
- Market opportunity, economic benefit and government policy should be examined before starting commercial cultivation of any medicinal plant.
- Domestic and foreign markets need to be examined, marketing channel developed.
- Back-buy guarantee of cultivated species needed from concerning agencies.
- Research should back up for and focus on the overall promotion and development of MAPs.
- There should be close links between research, extension and training.
- Involvement of public and private sectors in the production and processing of MAPs should be encouraged.
- Use of herbal medicines in the communities should be promoted through their incorporation in health delivery system.
- Species banned to collect and use are to be reviewed to bring cultivation and utilization
- The current royalty system needs to revise in favour of commercial cultivation and export. The royalty should be reviewed timely and fixed on the basis of market value.
- Political intervention in the business/export of medicinal products/raw materials should be removed.

REFERENCES

- Adhikari S. 1998. *Health care by local herbal resources* (Sthaniya Jadibutidwara Swasthya Rakshya-in Nepali). Mahendra Sanskrit University, Dang, Nepal.
- Amatya KR. 2000. *Utilization of Himalayan medicinal plant resources: Status, problems and prospects*.
- Amatya SM. 2000. Agro-forestry models and its potential of combining MAPs in Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- ARSP. 2000. Development of cultivation practices for Chiraito. **In:** *Annual report 2057-058 (2000/01)*. Agricultural Research Station Pakhribas (ARSP), Nepal Agricultural Research Council, Pakhribas, Dhankuta, Nepal.
- Aryal M. 1993. Diverted wealth: The trade in Himalayan herbs. *HIMAL* (Himalayan Magazine). Jan/Feb 9:18-7.
- Barakoti TP. 2000. Germination of Chiraito (*Swertia chirayita*) seeds tested through various methods under different conditions in the eastern hills of Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Bashyal BP, NK Bhattarai and J Pradhan. 1995. Role of research and development in commercial utilization of NTFPs: Medicinal and aromatic plants. *Proceedings of National Seminar on NTFPs*, Kathmandu, Nepal.
- Bhattarai DR. 2000. Utilization, industrialization and commercialization of Himalayan medicinal resources. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Bhattarai NK. 1994. Some endangered medicinal plants of Nepal. **In:** *Cultivation and utilization of medicinal plants*. Council of Scientific and Industrial Research, Jammu-Tawi, India.
- CSIR. 1985. *The wealth of India: A dictionary of Indian materials and industrial products* (revised edition). Council of Scientific and Industrial Research, New Delhi, India.
- Daniggelis EK. 1996. *Swertia chirayita* can supplement rural income in Nepal. *Banko Janakari* 6(2).

- Edwards DM. 1993. The marketing of non-timber forest products from the Himalays, the trade between east Nepal and India. *RDFN*, Paper 15b.
- Lacoul R. and RS Pant. 2000. An overview: Medicinal and aromatic plants of Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Maharjan MR. 1994. Chiraito cultivation in community forestry. *Project Report No. 8* NUKCFP, Dhankuta, Nepal.
- Manandhar V and MK Adhikari. 2000. Some higher fungi with medicinal value from Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Pimprikar GD and M Haque. 2000. Plant for life: An attempt to develop a sustainable source of medicinal plants in Himalayas. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Rajbhandari KK, R Joshi and S Dahal. 2000. Medicinal weeds of Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Regmi, S, S Bista and M Casey. 2000. Conservation and sustainable use of high value medicinal and aromatic plants in Jumla district of Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Shakya MK and CN Kanel. 1998. *Chiraito research and development activities in Nepal: Problems and prospects*. Pakhribas Agriculture Centre (PAC), Dhankuta, Nepal.
- Shrestha GL, RB Joshi, G Amatya and VM Sthapit. 1994. Domestication and commercial cultivation of medicinal and aromatic plants (MAPs) in Nepal. *Proceedings of National Seminar on NTFPs*, Kathmandu, Nepal.
- Shrestha KK, NN Tiwari and S Ghimire. 2000. MAPDON- Medicinal and aromatic plant database of Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Singh LM. 1999. Medicinal plants of Nepal: An overview. **In:** *Proceedings on wild relatives of cultivated plants in Nepal*. Kathmandu, Green Energy Mission/Nepal. Pp.15-18.
- Subedi LP. 2000. Medicinal plants of agricultural importance in Himalayan region. *Proceedings on Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Tiwari NN. 1999. Wild relatives of cultivated medicinal and aromatic plants in Nepal. **In:** *Proceedings on wild relatives of cultivated plants in Nepal*. Kathmandu, Green Energy Mission/Nepal. Pp.141-148.
- Tuladhar DY. 2000. Medicinal ferns of Nepal. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.
- Vaidya B, M Shrestha and N Joshee. 2000. Report on Nepalese orchid species with medicinal properties. *Proceedings of Nepal-Japan Joint Symposium*, Kathmandu, Nepal.

Annex 1. List of medicinal plants commonly found and traded from Nepal

SN	Botanical name	Local name	Plant type	Use of part	Tentative price, Rs/kg	Growing altitude, m
1	Acacia consinna	Sikakai	Tree, climber	Fruit	35	200-1200
2	Aconitum bisma	Bikhma	Herb	Root		3000-4800
3	Aconitum heterophyllum	Atis	Herb	Root	350	3600-4900
4	Aconitum spicatum	Bikh	Herb	Root		3300-4300
5	Acorus calamus	Bojho	Herb	Root	45	500-2200
6	Allium wallichii	Ban Lusun	Herb	Root		2800-4300
7	Ammomum subulatum	Alainchi	Herb	Fruit	350	1000-2000
8	Asparagus racemosus	Kurilo, Satavari	Herb	Root	170	600-2100
9	Bergenia ciliata, ligulata	Pakhanved	Herb	Root	20	1800-4300
10	Cinnamomum glaucescens	Sugandhakokila	Tree	Fruit		200-1200
11	Cinnamomum tamala/ jeylanicum	Tejpat & Dalchini	Tree, shrub	Leaf, bark	60	450-2100
12	Cordyceps sinensis	Yarsha gumba	Mush-room	Whole plant		3000-5000
13	Dactylorhiza hatagirea	Panchaunle	Herb	Whole plant		2800-4000
14	Delphinium denudatum	Nirbasi	Herb	Root		1500-2700
15	Dioscorea deltoidea	Vyakur	Climber	Root		450-3100
16	Elaeocarpus ganitrus/aphaericus	Rudrakshya	Tree	Fruit		800-1500
17	Embllica officinalis	Amala	Tree	Fruit	70	200-1200
18	Entada phaseoloides	Pangro	Climber	Fruit		300-1400
19	Ephedra gerardinia	Somlata	Herb	Root		2400-5000
20	Gaultheria fragrantissima	Dhasingray	Shrub	Leaf		1500-2700
21	Juniperos comunis	Dhup	Shrub	Bark		1800-4600
22	Lycopodium clavalum	Nagbeli	Herb	Root, fruit		1500-3500
23	Morchella conica	Guchhichyau	Herb	Mush-room	5500	2500-3500
24	Nardostachys grandiflora	Jatamansi	Herb	Rhizome	150	3600-4800
25	Paris polyphylla	Satuwa	Herb	Leaf, root	125	2000-3000
26	Parmelia spp.	Jhyau	Lichen	Root		1000-3500
27	Picrorhiza kurroa	Kutki	Herb	Seed		3300-4300
28	Piper longum	Pipla	Climber	Fruit		200-1500
29	Pistacia integerima	Kakrsingi	Herb	Gull	160	1000-3000
30	Rauwolfia serpentina	Sarpagandha	Herb	Root		0-1200
31	Rheum australe	Amalbed	Herb	Stem, leaf	150	3000-4200
32	Rheum emodi	Padamchal		Root	50	3000-4000
33	Rhododendron anthopogan	Soonpati		Whole plant		3000-4800
34	Rubia cordifolia	Majitho	Shrub	Stem, root	45	1200-2700
35	Sapindus mukorossi	Rittha	Tree, shrub	Fruit	25	0-1500
36	Silajitum?organic exudate	Silajit	Exud.	Exud.	210	3000-5000
37	Swertia chirayita	Chiraito	Herb	Whole plant	250	1500-3500
38	Taxus baccata	Talis patra	Tree	Leaf		2100-3400
39	Terminalia ballerica	Barro	Tree	Fruit		500-1500
40	Terminalia chebula	Harro	Tree	Fruit		0-1500
41	Valeriana jatamansi/ wallichii	Sugandhwal	Herb	Seed, Root	90	2500-3600
42	Zanthoxylum armatum	Timmur	Shrub	Fruit	125	1100-2500

Effect of Enriched CO₂ on Rice under Open Top Chamber Condition at Khumaltar

Kishore Sherchan, Suchit Shrestha and Alok Sharma

Agriculture Environment Unit, NARC, Khumaltar, Lalitpur

ABSTRACT

During panicle initiation and flowering stages, CO₂ enriched plot had the highest leaf area index (LAI) in the first year. Minimum temperature was slightly higher in CO₂ enriched plot. CO₂ enriched plot had 15% and ambient plot had only 10% increase in grain yield as compare to the field. The CO₂ enriched plot had almost higher straw yield than others. It was about 30 to 37% higher than field plot. Number of tillers per square meter was highest in CO₂ enriched plot followed by ambient and field plot. Plant height and panicle length were both higher in CO₂ enriched plot. CO₂ enriched plot had lesser N, P and K content in grain, straw and root. However, organic carbon (OC) content in root was more than 100% as compare to the field plot. C:N ratio were also higher except in the grain. Higher grain yield in CO₂ enriched plot was due to higher number of tillers per square meter, seeds per panicle and panicle length.

Key words: Enriched CO₂, open top chamber, rice yield

INTRODUCTION

Increasing the CO₂ concentration in the atmosphere generally increases the growth rates of plants and the harvestable yields. A question that has rarely been considered in this regard, however, has to do with the effects of atmospheric CO₂ enrichment on crop yield of the plant. Response of CO₂ varies in C₃ and C₄ crops. C₃ crops like rice, wheat, barley, potato grow under unsaturated CO₂ concentration due to active photorespiration loss whereas C₄ crops like maize, sorghum, sugarcane grow under saturated CO₂ concentration. The photorespiration loss in C₄ crops is minimum.

Prior to the industrial revolution, the CO₂ concentration in the air was probably somewhere in the range of 260 to 290 ppm (Bolin 1986). Today, the CO₂ content of the air is nearly 360 ppm, or 25% greater, largely due to burning of anthropogenic activities. CO₂ concentration is predicted to be double before the era of the next century (NAS 1979). Abrol et al (1992) studied on the effect of increased CO₂ on various phenological stages and found that 1°C linear rise in global temperature will depress grain yield of wheat by 8-10% through decline in grain number by 5.5% and 1000-grain weight by 3%.

The major work on CO₂ enrichment studies on various crops and other living plants had been conducted in USA. Some works had also been carried out at IARI, New Delhi. Some scientists conducted study on the effect of enriched CO₂ on various crops (Hunsacker et al 1996, Idso et al 1987, Kimball 1983). Open fields might respond less than green house or indoor or closed conditions. High value crops of economic importance dominated the data to the humanity. The analysis showed that yield probably increased by an average of 33% with a doubling of CO₂ concentration.

Upreti (1999) studied extensively the effect of enriched CO₂ on *Brassica* sp. and their wide crosses. CO₂ significantly increased the rate of photosynthesis, carbon content of leaves, stem and the roots and significantly enhanced the C:N ratio in leaves, stem and roots. The increased CO₂ also enhanced relative water content and reduced transpiration in the leaves allowing to grow under water stress condition (Rabha and Upreti 1998, Upreti and Rabha 1999).

Patterson and Flint (1980), Carlson and Bazzaz (1980) indicated that the growth of C_4 crops to increased CO_2 is likely to be about one fourth that of C_3 crops. Among food crops about three fourth belong to C_3 species such as rice, wheat, barley, pulses and oilseed crops.

There is also an accepted hypothesis that CO_2 increase will also influence the increase in the temperature, which will ultimately demand for more transpiration loss. Hunsacker et al (1996) studied wheat under wet irrigation and dry irrigation, which gave varied evapotranspiration (ET) rate. Under wet irrigation, ET was less and 5% higher than the control (ambient condition). Water use efficiency was also higher in both the wet and dry irrigation conditions. Idso et al (1989) suggested that inconclusive results were obtained in determining the effect of enriched CO_2 on the root: shoot ration of cotton and soybean but in root crops like radish and carrot, enriched CO_2 increased root: shoot ratio by about a third.

This study offers a great variety of scopes such as exposure to the status of global warming on agriculture production and food provision, exposure of South Asian Region scientists, policy makers and government officials regarding the effects of rising atmospheric CO_2 on various aspects of agricultural productivity and biogenic emissions, familiarization of the use of Open Top Chamber (OTC) facility for examining the effect of elevated CO_2 on crops and generate database for crop and climatic model. Objectives of this study are to study the effect of enriched CO_2 on the growth and understand interactions between elevated CO_2 concentration, temperature and other environmental factors on rice crop.

MATERIALS AND METHODS

The research for CO_2 enrichment technology was carried out in the identical OTC designed by IARI, New Delhi India (Upriety 1998) at Khumaltar. Two OTCs were used for CO_2 enrichment treatment (580 ppm CO_2), one OTC as an ambient (350 ppm CO_2) and an open field of the same area. The surface area of the chamber is 7.1 m^2 . Gross area cultivated was only 4.71 m^2 . In the CO_2 enriched chambers, gas passes through copper pipes connected to manifold. The gas circulates inside the chamber through a black polythene pipe of 6 inches diameter and mixed with air using a blower, which spreads it uniformly through small holes surrounding the chamber. The amount of CO_2 concentration enriched in the OTC was 230 ppm higher than that of the atmosphere (350 ppm CO_2). The Maximum-minimum thermometer and dry wet bulb thermometer were installed in the chambers.



Figure 1. Open top chamber.



Figure 2. CO_2 manifold.

Chianung-242 rice variety was selected for the experiment. It was transplanted in 20- × 15-cm spacing in 4.71 m^2 area. In both the years, chemical fertilizer at the rate of 100:40:20 kg/ha (N:P:K) was applied and two topdressings were done through urea. In the first year, 10 t/ha farmyard manure (FYM) was also applied in all the plots. Thirty-seven days old seedlings were transplanted on 21 May in both the years (2001 and 2002). After 74 days (in 2001) and 79 days (in 2002) rice was harvested from the plots. Soil samples were taken from the plots at different times and routine analysis was done (Table 1).

CO₂ gas was released in the chamber during sunny hours at the rate of 0.38 kg/hr/chamber. In 2001, the gas was released from 3 July to 27 September (99 days) and the total hour was 802. Similarly in 2002, it was released from 4 July to 11 October (116 days) and the total hour was 606.

Table 1. Soil analysis for N, P, K, OM and pH in different time periods

Treatment	Total N, %	Available P ₂ O ₅ , kg/ha	Exchangeable K ₂ O, kg/ha	OM [†] , %	pH
Bench mark/before planting (2001)					
Field (composite sample)	0.05	432	343	2.14	4.2
During standing plants (2001)					
CO ₂ enrichment	0.10	377	285	2.01	4.5
Ambient	0.09	483	301	2.01	4.6
Field	0.12	457	360	2.14	5.7
Prior to 2002 rice experiment					
CO ₂ enrichment	0.16	565	278	2.55	
Ambient	0.16	475	209	2.67	
Field	0.21	371	209	2.81	

[†] OM, Organic matter.

RESULTS AND DISCUSSION

Phenology

Different physiological growth stages were observed during the experiment (Table 2). There is no significance in these parameters. However, panicle initiation period was about two days earlier in CO₂ enriched plots as compare to open field plot.

Table 2. Physiological stages (days after seeding in the nursery bed) of rice variety

Plot	Transplanting	Panicle initiation	Flowering	Heading	Milking stage	Physiological maturity	Harvesting
Year 2001							
CO ₂ Enriched	37	40	64	66	80	100	111
Ambient	37	40	62	63	79	100	111
Field	37	42	64	67	80	102	111
Year 2002							
CO ₂ Enriched	37	43	71	73	84	104	116
Ambient	37	45	68	70	83	102	116
Field	37	45	70	72	84	103	116

Soil analysis

There has been increase in the content of N, P and OM. The addition of FYM as well as the inorganic fertilizer should have contributed to this.

Plant analysis

Only straw samples were analyzed in the year 2001. However, grain, straw and root samples were analyzed in the soil laboratory for nitrogen, phosphorous, potassium and organic carbon in the year 2002 (Table 3).

There was no significance between the treatments. But, N, P, K and organic carbon (OC) were lower in CO₂ enriched plot than others. This was expected due to the dilution factor of the plant nutrients associated with yield. C:N ratio however increased in the enriched plot followed by the ambient in 2002. N content of straw was significantly higher in the 2001 than in 2002 but OC content was slightly less affecting C:N ratio being further reduced in 2001.

A plant nutrient in grain samples also showed no significance among the treatments. It was however lower in CO₂ enriched plot. This was again expected due to the dilution factor associated with the increased grain yield. C:N ratio was also less than the field probably for the same reason.

In root samples N, P and K level was similar as in straw and grain. But, OC was highest in CO₂ enriched plot by more than 100%. Carbon translocation to the root was a significant observation when the plant is enriched with CO₂. C:N ratio thus increased significantly.

Table 3. Plant parts (straw, grain and root) analyzed for N, P, K and OC of rice variety
A. Straw in 2001 and 2002

	N, %		P, %		K, %		OC, %		C:N	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
CO ₂ enrichment	2.08	1.06	1.64	1.01	1.96	2.26	14.94	19.77	7.18	18.65
Ambient	3.07	1.23	1.38	1.29	1.82	3.21	17.65	20.48	5.75	16.65
Field	3.32	1.78	1.75	1.14	2.21	3.95	17.65	21.95	5.32	12.33

B. Grain and root in 2002

	N, %		P, %		K, %		OC, %		C:N	
	Grain	Root	Grain	Root	Grain	Root	Grain	Root	Grain	Root
CO ₂ enrichment	1.47	0.94	0.51	0.30	0.62	0.39	5.82	36.06	3.96	38.36
Ambient	1.80	1.14	0.74	0.37	0.51	0.73	5.26	14.94	2.92	13.10
Field	1.47	2.04	0.54	0.78	0.56	1.07	6.38	14.19	4.34	6.96

Leaf area index (LAI)

Leaf area index was measured in both the years at different intervals (Figure 3). In the first year the LAI was measured on 34, 48 and 63 days after transplanting, however, during the second year it was measured on 41 and 68 days only. In both the years there had been progressive growth in the LAI. The LAI was highest during panicle initiation and flowering stages of the first year in the CO₂ enriched plot whereas ambient plot had little higher LAI value than in the CO₂ enriched plot in the second year.

Temperature

Maximum and minimum temperatures during standing crop in the micro plot are shown in Figure 4. Gradual fall in temperature were observed during the later stage of growth more sharply in the second year. This would obviously increase the maturity period.

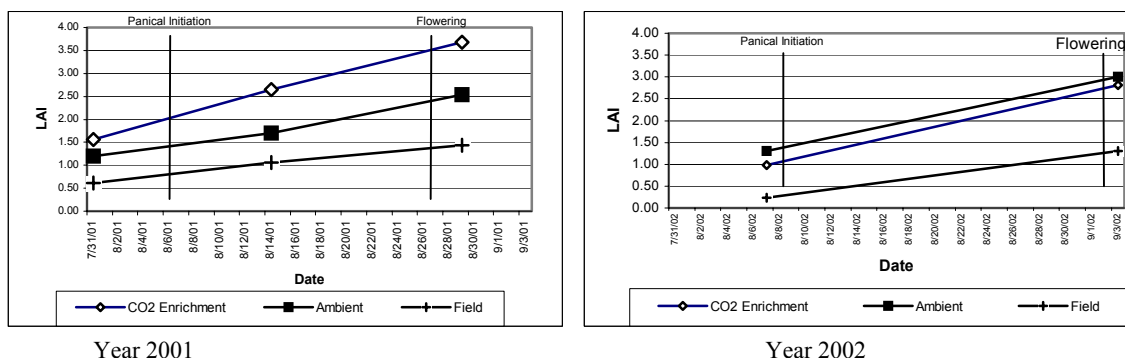


Figure 3. Leaf area index (LAI) during different growth stages of rice variety.

Maximum temperature is highest in ambient plot followed by CO₂ enriched and field plots in both the years. The temperature did not really match the expectation as reported by the others. The higher record in ambient was realized an experimental error in both the years. Because the 6" black polythene pipe for air circulation to blow up the CO₂ gas was not replicated in the ambient resulting in the higher temperature. The design has now been corrected following the third year hoping to verify the effect of CO₂ enrichment.

Minimum temperature is found slightly higher in CO₂ enriched plot in the both the years. The first year was significantly higher (Figure 4). However, there was no significant difference between ambient and field plots except in some days. In the second year, minimum temperature continued to lower towards the maturity stage. This observation was occurred because CO₂ gas as well as air circulation was interrupted during night when the minimum temperature is recorded. The CO₂ however is presumed to be accumulated more in the enriched plot, which could raise the night temperature.

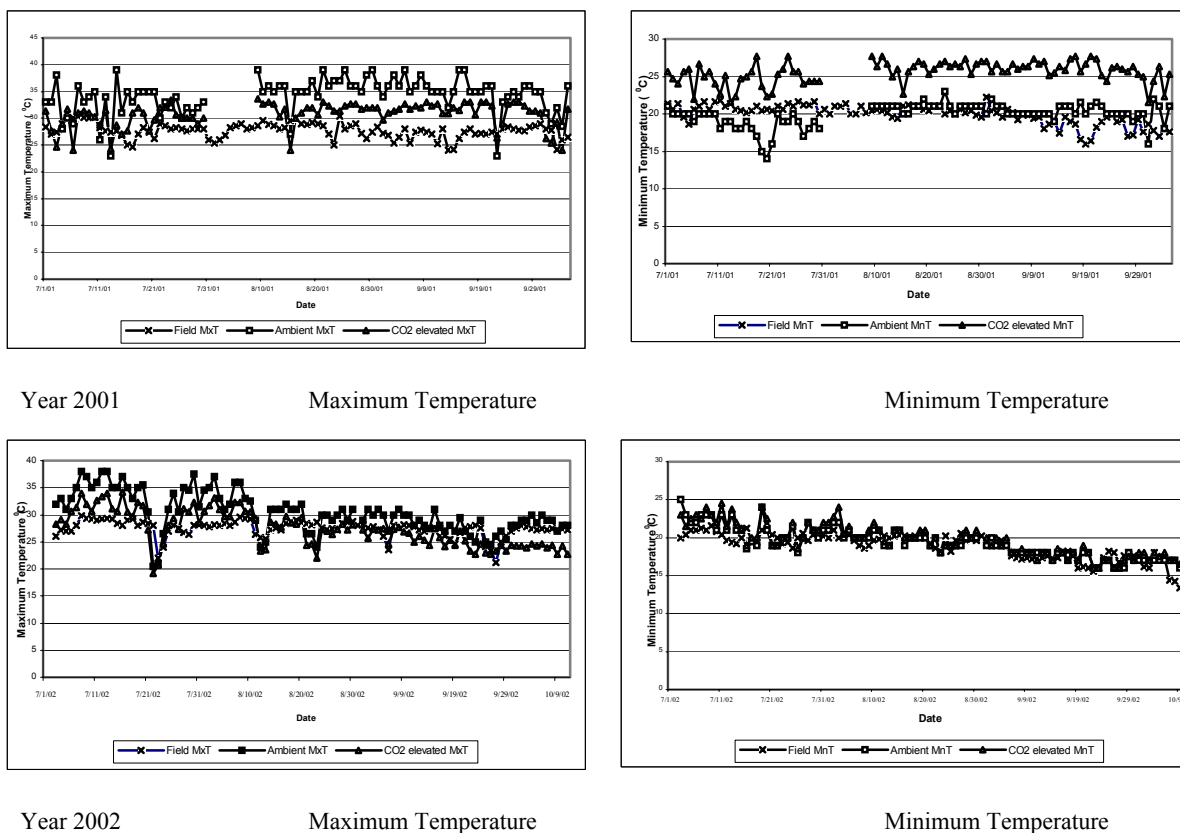


Figure 4. Maximum and minimum temperature during rice growing season (2001 and 2002).

Yield

In the first year CO₂ enriched plot has extremely highest yield (Table 4). This may be due to bias management practice. However, this will be verified in the following years experimentation. The bias attitude of this kind especially in the ambient and field plot could be due to newer soil management, which could then be corrected in the following years through continued cropping. Because, the yield level of the CO₂ enriched plot was almost at par with the second year. And there was a significant difference between treatments in grain yield. In the second year, CO₂ enriched plot has 15% and ambient plot has only 10% increase in grain yield as compare to the field.

Straw yield was significant. The CO₂ enriched plot had almost higher yield than other. It was 37% higher in the first year and 30% higher in the second than the field. Whereas ambient plot had only about 4% increase in the first year and less in the second year.

Root quantity seemed significant in both the years, the first year showed negative trend as compare to the second year. The sampling of root system was not properly set resulting in the negative trend from the CO₂ enriched plots. But, in the second year there was increase by 28.5 and 13.2% in CO₂ enriched and ambient plots respectively from the field plot.

Table 4. Grain, straw and root yield (kg/ha) of rice variety

A. Grain yield, kg/ha at 14% moisture

Plot	2001	% change from field	2002	% change from field
CO ₂ enriched	10857	70.0	11966	15.8
Ambient	6860	7.4	11392	10.2
Field	6386	0.0	10334	0.0
Mean	8035		11231	
SD	2456.0		827.88	
CV, %	30.6		7.4	
t test	5.7		23.5	
P	0.030		0.002	

B. Straw yield, kg/ha (oven dry)

Plot	2001	% change from field	2002	% change from field
CO ₂ enriched	10867	37.0	14465	30.4
Ambient	8253	4.0	10329	-6.9
Field	7934	0.0	11096	0.0
Mean	9018		11964	
SD	1609.2		2200.2	
CV, %	17.8		18.4	
t test	9.7		9.4	
P	0.010		0.011	

C. Root wt, kg/ha (oven dry)

Plot	2001	% change from field	2002	% change from field
CO ₂ enriched	826	-0.1	1426	28.5
Ambient	758	-8.3	1257	13.2
Field	827	0.0	1110	0.0
Mean	804		1264	
SD	39.6		158.1	
CV, %	4.9		12.5	
t-test	35.2		13.9	
P	< 0.001		0.005	

Agronomic parameters

Number of tillers per square meter was highest in CO₂ enriched plot followed by ambient and field plots in both the years (Table 5). Number of seeds per panicle was still higher in the CO₂ plot. Plant height and panicle length were both higher in CO₂ enriched plot. However, there is variation in the ambient plot during second year.

There is no significance in filled and unfilled grains. The variation is larger. CO₂ enriched plot has lesser grain weight than other.

Table 5. Agronomical parameters of rice variety

A.

Plot	No. of tillers/m ²		No. of seeds/panicle		Plant height, cm		Panicle length, cm	
	2001	2002	2001	2002	2001	2002	2001	2002
CO ₂ enriched	411	390	127	123	90	119	21	22
Ambient	253	361	105	132	85	125	20	23
Field	238	305	116	102	85	102	20	19

B.

Plot	Filled grains (in 1000 grains)		Unfilled grains (in 1000 grains)		1000-grain wt, g at 14% moisture	
	2001	2002	2001	2002	2001	2002
CO ₂ enriched	845	808	156	192	19	26
Ambient	932	772	68	228	22	27
Field	928	861	72	139	22	28

CONCLUSION

CO₂ enriched plot has lesser N, P and K content in grain, straw and root. However, OC content in root was more than 100% as compare to the field plot. C:N ratio were higher in the enriched plots in straw and root but not in grain. Lower values of LAI were observed in ambient and open field conditions. Higher value of LAI and plant height reflects the higher straw yield. Maximum and minimum temperatures were higher in ambient and CO₂ enriched plots respectively. In the CO₂ enriched plot grain, straw and root yields were 15, 30 to 37 and 28.2% higher than field plot. Higher grain yield in CO₂ enriched plot was due to higher number of tillers per square meter, seeds per panicle and panicle length, however, thousand-grain weight seemed lesser.

ACKNOWLEDGEMENTS

National Physical Laboratory, New Delhi is acknowledged for making a partner of the research. Special thanks to Dr AP Mitra, Dr DC Uprety and Mr SC Garg for their help. Directors of Nepal Agricultural Research Council are also thanked for providing us administrative support. Nepal Bottlers Pvt Ltd is duly acknowledged for providing us carbon dioxide gas, without which this research would not have been conducted.

REFERENCES

- Abrol YP, DC Uprety and A Sharma. 1992. First Agri. Sci. Congress (invited paper). Pp.63-70.
- Bolin B. 1986. How much CO₂ will remain in the atmosphere? The greenhouse effect, climate change and ecosystems (B Bolin, BR Doos, J Jager and RA Warric, eds). Wiley, New York.
- Carlson RW and FA Bazzaz. 1980. The effects of elevated CO₂ concentrations on growth, photosynthesis, transpiration and water use efficiency of plants. Pp.609-612.
- Hunsacker DJ, BA Kimball, PJ Pinter, RL LaMorte and GW Wall. 1996. Carbon dioxide enrichment and irrigation effects on wheat evapotranspiration and water use efficiency. *Transactions of the American Society of Agricultural Engineers*. 39:1345-1355.
- Idso SB, BA Kimball, MG Anderson and JR Mavney. 1987. Effects of atmospheric CO₂ enrichment on plant growth: the interactive role of air temperature. *Agric. Ecosys. Environ.* 20:1-10.
- Idso SB, SG Allen, MG Anderson and BA Kimball. 1989. Atmospheric CO₂ enrichment enhances survival of azolla at high temperatures. *Environmental and Experimental Botany* 29(3):337-341.
- Kimball BA. 1983. *Carbon dioxide and agricultural yield: An assemblage and analysis of 770 prior observations*. US Water Cons. Lab., Phoenix, AZ. 71p.
- NAS. 1979. *Carbon dioxide and climate: A scientific assessment*. National Academy of Science. National Academy Press, Washington DC. 22p.
- Patterson DT and EP Flint. 1980. Potential effects of global atmospheric CO₂ enrichment on the growth and competitiveness of C₃ and C₄ weed and crop plants. *Weed Sci.* 28:71-75.
- Rabha BK and DC Uprety. 1998. Effect of elevated CO₂ and moisture stress on *Brassica juncea*. *Photosynthetica* 35(4):597-602.
- Uprety DC. 1998. Carbon dioxide enrichment technology: open top chamber: a new tool for global climate research. *J. Scientific and Industrial Research* 57:226-270.
- Uprety DC and BK Rabha. 1999. Effect of elevated CO₂ and moisture stress on the carbon and nitrogen contents in *Brassica juncea*. *Biologia Plantarum* 42(1):133-136.
- Uprety DC. 1999. Physiological and biochemical responses of *Brassica juncea* to the interaction of elevated CO₂ and moisture stress at different stages of plant growth. In: *Rising atmospheric CO₂ and crop response*. Global Change Series, IARI, New Delhi, India. Pp.22-31.

Effect of Sprout Manipulation of Diffused Light Stored Seed Potatoes on Subsequent Field Growth and Tuber Yield at Lumle

BK Dhital¹ and SJ Wilcockson²

¹ Sustainable Soil Management Programme (SSM-P), Bakhundol, Lalitpur, PO Box 688, Nepal,
<psusmp@wlink.com.np>

² Dept. of Agriculture, University of Newcastle, Newcastle upon Tyne NE1 7RU, UK,
<s.j.wilcockson@ncl.ac.uk>

ABSTRACT

Yield potential of sound tubers from diffused light storage (DLS) was reduced to a large extent than cold-stored seed because of advanced physiological ageing of the seed potatoes. An experiment was conducted to investigate the effect of sprout manipulation of DLS seed potatoes (a practical way of manipulating physiological age) on their subsequent tuber yields at Lumle Agriculture Research Centre (1675 m), Nepal during 1998 and 1999. The results revealed a large effect of genotype and sprout manipulation treatments and their interactions on the subsequent tuber yield of potato. Seed tubers planted with original sprouts intact gave the lowest tuber yields (22.2 t/ha) and highest tuber yield was given by seed tubers de-sprouted at planting (28.1 t/ha). Seed potatoes de-sprouted at planting and re-sprouted for a month produced similar tuber yields. However, there was an interaction between genotype and sprout manipulation practice. Genotypes with a long dormancy period, slow rate of sprout growth and long maturity period such as NPI/T-0012 and Gumda Local were not affected by sprout manipulation. Whereas the effect was large in genotypes with a short or medium dormancy period, fast sprout growth and short maturity such as Kufri Jyoti, Sikha Local and CIP-379693.110.

Key words: Sprout Manipulation, diffused light stored, seed potatoes, field growth

INTRODUCTION

Tuber yield of potato is determined by genotype, environment, seed and crop management. Choice of appropriate genotype and use of seed, which is of good quality physiologically as well as pathologically does not usually increase costs of production yet can have major effects on tuber yield. An important component of seed quality is physiological age, a parameter that is used to quantify or describe the vigour or potential for growth of a seed potato. Vigour can be defined as the potential of a tuber to produce sprouts and plants under favourable conditions (van der Zaag and van Loon 1987). The physiological age is the stage of development of a seed tuber at any given time from initial dormancy until incubation, a condition that is modified by for example, increasing chronological age (Kawakami 1952 as quoted by van der Zaag and van Loon 1987). Incubation is the stage of forming 'little potato' in the stolon of the mother tuber. The number of day-degrees experienced by the seed tubers after the onset of sprouting has generally been accepted as a practical way of measuring physiological age and quantified on the basis of accumulated day-degrees ($>4^{\circ}\text{C}$) starting from the time of appearance of sprouts ≥ 3 mm (Allen and O'Brien 1986, Allen et al 1992).

Research on the physiological age of seed potatoes and its effect on sprout and subsequent field growth and tuber yield started as early as the 1950s and continues. Most investigations have been conducted in temperate regions using storage temperatures of 4 to 12°C . In these environments, there is some evidence that de-sprouting removes the effect of physiological ageing and the ageing process recommences with the onset of re-sprouting. On the basis of this principle, the age of seed tubers de-sprouted at planting should be of about the same age as tubers from low temperature ($<4^{\circ}\text{C}$) storage and give similar yields (O'Brien and Allen 1981 as quoted by

O'Brien and Allen 1984). Furthermore, Allen et al (1992) stressed that seed planted without sprouts after several de-sproutings and seed stocks stored at <4°C produced similar growth patterns and yields.

Seed potato storage conditions are different in the tropics and sub-tropics and the practice of diffused light storage (DLS) at ambient temperatures has been adopted after the development and promotion of this technique during the 1980s (Rhoades and Booth 1983, Booth et al 1983, Rhoades 1988). However, the concept of physiological age developed from experience in the temperate region may not be entirely applicable or readily extrapolated to the DLS of the tropics and sub-tropics. Here, daily mean temperature of DLS often exceeds 18°C, so the seed tubers can be physiologically very old at planting. Productivity of such seed potatoes is often substantially reduced compared to seed potatoes of more optimum, younger age. Accumulated day-degrees (>4°C) from the time of appearance of sprouts to planting often exceeds 2000 in the tropical and sub-tropical mid-lands (<1500 m). In the temperate region, the figure is about half the value and usually less than 1000, which is considered to be appropriate to aim for in commercial practice (O'Brien et al 1983, 1986).

The extent to which sprout manipulation ie de-sprouting at planting or de-sprouting followed by re-sprouting, either removes or modifies the age of DLS stored seed which has been achieved before de-sprouting and its effect on crop growth and yield potential is not well known. Some workers clearly indicated the over ageing problem of DLS stored seed potatoes in the tropics and sub-tropics (Benz and Fahem 1988, Lewis 1992, Dhital et al 1997). However, systematic research was lacking to quantify the relationship between accumulated day-degrees and physiological ageing of DLS stored seed potatoes and the possibility of managing the ageing effect. Hence, the objectives of this study were to (i) estimate the accumulated thermal time of seed potatoes and their sprouts stored in the mid hill environment and (ii) investigate the possibility of reversing the ageing effects of DLS seed potatoes by de-sprouting at or prior to planting.

MATERIALS AND METHODS

The experiment was conducted at Lumle Agriculture Research Centre (LARC, 1675 m) in the spring seasons of 1998 and 1999. Seed potatoes for the first cycle were produced in the spring season of 1997 and tubers produced from the first cycle experiment were used for the second cycle experiment. Seed potato storage in DLS was a separate experiment and all data related to ageing of seed potatoes were recorded in the store.

Storage and production environments

The spring and summer seasons are warm and late autumn and winter are cold. The storage experiment was conducted in a purpose-built Diffused Light Store (DLS) at LARC. The summary of temperature records of the DLS at LARC during seed potato storage period is given in Table 1.

Table 1. Monthly average temperatures (°C) and RH (%) of potato store at LARC (mean of 1997 and 1998)

Month	Max	Min	Mean	RH, %
June	22.8	17.8	20.3	92
July	22.2	18.3	20.3	94
August	21.8	18.1	20.0	96
September	21.6	16.8	19.2	93
October	19.3	12.6	16.0	85
November	16.7	9.8	13.3	83
December	14.0	6.2	10.1	83
January	12.5	4.5	8.5	83
Mean	18.9	13.0	15.9	88

The potato growing environments of 1998 and 1999 were quite different at LARC. 1999 was drier than 1998. February, March and April 1999 were much warmer and drier than the same period of 1998 (Table 2).

Representative soil samples were collected three times from the trial plots, once before planting the seed crop, second, before planting the first cycle experiment and the third after the harvest of the first cycle experiment. The samples collected were analysed for N, P₂O₅, K₂O, organic matter and pH at LARC soil laboratory.

The experiment was conducted under rainfed condition with rice followed by potato cropping pattern. The soil of the experimental plots was slightly acidic (pH ranging from 5.3 to 5.4). In general, N content was low which ranged

from 0.16 to 0.29%. P₂O₅ (60 to 130 ppm) and K₂O (0.23 to 0.30 me/100g soil) were medium and the experimental plots were rich in organic matter content (4.7 to 5.0%). Soil texture of the experimental plots was sandy loam.

Table 2. Monthly average meteorological records of potato growing periods of first and second cycle experiments at LARC

Month	First cycle expt (Feb to Jun 1998)					Second cycle expt (Feb to Jun 1999)				
	Air temp °C		Total rainfall, mm	RH, %	Sun Shine, hrs	Air temp °C		Total rainfall, mm	RH, %	Sun Shine, hrs
	Max	Min				Max	Min			
Feb	15.5	6.9	46.3	78	7.0	19.2	10.4	24.5	57	8.0
March	16.9	8.5	169.0	74	6.0	21.8	11.2	0.0	55	9.2
April	21.4	13.0	327.6	68	7.4	25.5	16.2	17.8	53	8.5
May	22.9	16.0	286.7	84	6.3	22.9	15.1	546.7	87	5.7
June	24.3	18.5	794.4	84	NR	23.9	17.0	1166.6	88	5.8
Mean	20.2	12.6	1624.0	78	6.7	22.6	14.0	1755.6	68	7.4

Total sunshine hours per day

Genotypes and source seed

Five genotypes, viz Sikha Local, Gumda Local, NPI/T-0012, CIP-379693.110 and Kufri Jyoti were used. Initial stocks for multiplication were collected from different sources. Seed potatoes of three genotypes namely, Sikha Local, Gumda Local and NPI/T-0012 were collected from the high hills (2250 m) during late Sept and early Oct 1996. These were stored in DLS at LARC until their planting. Seed tubers of CIP-379693.110 were received from National Potato Research Programme (NPRP), Nepal in 1993 and were maintained at LARC. Similarly, pre-basic seed of Kufri Jyoti, which was received from NPRP in 1994 and multiplied twice at LARC, was used. Sikha Local and Gumda Local are the oldest, most popular and widely grown genotypes in the hills of Nepal. Kufri Jyoti is the oldest improved genotype. The general agronomic characteristics of these genotypes are given in Table 3.

Table 3. General agronomic characteristics of the genotypes used in the experiment

Genotype	Dormancy period	Apical dominance	Foliage coverage	Crop maturity	Tuber size	Yield
Sikha Local	Medium	Low	Medium	Medium	Small (4)	Low
Gumda Local	Long	Low	Very large	Late	Very small (3)	Low to medium
NPI/T-0012	Long	Very high	Large	Late	Very large (8)	High
CIP-379693.110	Medium	Very high	Medium	Early	Medium large (8)	Medium
Kufri Jyoti	Medium	Very low	Small	Early	Medium large (6)	Medium

Numbers in parentheses are based on Dutch scoring scale (CPRD-DLO 1994). Nine and three are for very large and very small tubers respectively.

Accumulated thermal time of seed potatoes over storage period

Accumulated thermal time of seed potatoes over the storage period was recorded for the seed tubers with intact sprouts. Ageing started earlier in 1998 than in 1997 and ageing rate was also faster in 1998. Varietal difference was also prominent in the ageing process. Sikha Local and CIP-379693.110 started ageing quickly in DLS. NPI/T-0012 aged very slowly and Gumda Local and Kufri Jyoti were intermediate (Table 4). Total accumulated thermal time of seed potatoes of different treatments (as a result of combinations of genotypes and sprouting treatments) at planting was also studied in the storage experiment.

Table 4. Thermal time (day-degrees) of seed potatoes accumulated over a storage period under DLS at LARC in 1997 and 1998

Genotype	Aug		Sep		Oct		Nov		Dec		Jan	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Sikha Local	0	463	149	928	478	1342	733	1681	886	1904	1001	2069
Gumda Local	0	0	130	372	459	786	714	1125	867	1348	982	1513
NPI/T-0012	0	0	0	0	127	401	352	740	505	963	620	1128
CIP-379693.110	98	324	545	789	874	1203	1129	1542	1282	1765	1397	1930
Kufri Jyoti	0	93	313	558	642	972	897	1311	1050	1534	1165	1699

Experimental design

The design was $5 \times 2 \times 3$ factorial incomplete blocks with partially balanced lattice. The treatments were replicated three times. The first factor was genotype, the second was seed potato storage method (diffused light storage and dark storage) and the third factor was sprout manipulation. The three levels of sprout manipulation were (i) planting re-sprouted seed, seed potatoes were de-sprouted at 25-30 d before planting and were kept under diffused light for re-sprouting until planting, (ii) planting de-sprouted seed, seed potatoes were de-sprouted completely at one to three dries before planting and (iii) planting seed tubers with original (intact) sprouts, seed tubers with original sprouts intact were planted. Although there were two storage method ie DLS and dark, the dark storage treatment has been omitted. Therefore, only five levels of genotypes and three levels of sprout manipulations were used making a treatment combination of $5 \times 3 = 15$. Plots of 2.4- $\times$ 2.5-m or four rows and 10 plants per row (40 plants per plot or 66667 plants per ha) were used. Inter plot gap was not given and there were no discard rows.

Cultural practices

Soil and seed treatment

Seed tubers were dipped in 0.25% Dithane M-45 (Mancozeb) solution for 10 minutes and air-dried before planting. This was done to protect the seed tubers from external fungal diseases. Soil was treated with Malathion dust (5% ai) at 30 kg/ha to protect the seed tubers from soil insects particularly, red ants (*Dorylus* sp) and cut worms (*Agrotis* sp). This was applied along the furrows at a depth of 6 to 10 cm.

Manuring and planting

Furrows were made in a well-prepared, flat plot. Chemical fertilisers 100:100:60 kg N:P₂O₅:K₂O/ha through urea, diammonium phosphate and muriate of potash and farm yard manure, 20 t/ha were applied in furrows and were thinly covered with soil. Seed potatoes were placed in these furrows and covered with about 6-10 cm soil. Planting was done on 1 Feb in both years. Seed tubers of 20 - 60 g were used at a spacing of 60- $\times$ 25-cm, giving a seed rate of 2-3 t/ha. Genotypes with larger tuber size such as NPI/T-0012, CIP-379693.110 and Kufri Jyoti had slightly higher seed rates than genotypes with smaller tubers such as Sikha Local and Gumda Local.

Crop protection from hailstorm

Occurrence of hailstorms is a common problem during April and May in the western mid hills of Nepal. The experimental plots were covered with small mesh wire netting by fixing a roof at a height of about 1.25 m.

Cultural operations

Earthing-up was done at 15-20 d after emergence (DAE) of each treatment and it took about two weeks to complete the operation. The potato is usually a rainfed crop in the mid to high hills of Nepal. The crop was irrigated six times at weekly intervals starting from 15 March in 1999. Although the irrigation was frequent, the water supplied was not sufficient for optimum crop growth because of limited water availability.

The Krilaxyl 72WP (Metalaxyl 8% and Mancozeb 64%) 0.2% was applied five times in 1998 and only once in 1999 to protect the crop from late blight (*Phytophthora infestans*). Rogor 30EC (0.15% solution, 1.5 ml/l of water) was applied at 10 to 12 day intervals starting from full emergence to protect crops from aphids (*Myzus persicae*), thrips (*Frankliniella* sp) and mites (*Polyphagotarsonemus latus*).

Plant measurements

Emergence progression was recorded (counted as the number of plants per plot) at 15, 20, 25, 30, 35, 40, 45, 50 and 60 days after planting (DAP). Days to 80% plant emergence were interplotted from the data recorded at various DAP. Percent crop cover was recorded at 50, 70, 90 and 110 DAP with the aid of a quadrant having 50 squares each having 50 cm². One measurement per plot was made in exactly the same place every time.

Plant height (length of the longest stem from soil surface to the terminal leaf base) was recorded at maturity and number of main stems and tubers (>10 g) per plant were recorded after harvest of the crop. Plant stand per plot was counted at harvest and is presented in numbers per hectare. Crop duration (ie days from planting to maturity) was recorded and the crop was harvested after the full maturity of individual treatments. Crops were considered to be mature when more than 50% of leaves had senesced. Total tuber yields were recorded excluding very small tubers (<10 g).

Data analysis

All quantitative data recorded were statistically analysed. General Linear Model (GLM) in the GENSTAT-5 (Release 3.2.2) was used to analyse most of the data sets. Fitted or predicted means from the model were computed where GLM was performed. General Analysis of Variance (ANOVA) was performed in cases where data sets were balanced. SEDs were used to determine the differences between means of the treatments.

RESULTS

Emergence

Rate of emergence was influenced by year, genotype and sprouting treatment. Emergence was slightly faster in 1999 than in 1998, but there was no effect of year on final emergence. NPI/T-0012 emerged late and was the last to attain 80% emergence. All other genotypes were similar (Table 5). Emergence was very much affected by sprouting treatment. As expected, it was earlier in seed tubers planted with intact sprouts and latest in the case of seed tubers de-sprouted at planting. Re-sprouted seed showed an intermediate response (Table 5). However, per cent final emergence was more than 98% and statistically similar for all treatments. Seed tubers planted with intact sprouts attained 80% plant emergence at 21 to 23 d except NPI/T-0012, which took 32 d (Table 5). With de-sprouted seed, it took 32 to 34 d except for NPI/T-0012, which took 41 d. Re-sprouted seed was intermediate.

Table 5. Effect of sprout manipulation and genotype on days to 80% plant emergence (mean of 1998 and 1999)

Genotype	Re-sprouted	De-sprouted	Intact sprout	Mean
Sikha Local	31	34	23	32
Gumda Local	28	32	21	29
NPI/T-0012	37	41	32	38
CIP-379693.110	26	33	21	29
Kufri Jyoti	28	33	22	30
Mean	30	35	24	32

Tuber initiation

There was a clear effect of year, genotype and seed type (sprout manipulation treatment) on the number of days to tuber initiation after 80% plant emergence. Tuber initiation was six days earlier in 1999 than 1998 (16 cf 22 d). Sikha Local and CIP-379693.110 were earliest to initiate tubers and NPI/T-0012 the latest. Gumda Local was similar to NPI/T-0012 and Kufri Jyoti similar to CIP-379693.110 (Table 6). Seed tubers planted with intact sprouts initiated tubers earlier than seed tubers de-sprouted at planting. CS seed behaved similarly to DLS seed de-sprouted at planting.

Table 6. Effect of year, genotype and seed tuber storage method or seed tuber type on number of days to tuber initiation (after 80% plant emergence)

Genotype	DLS seed						CS seed			Mean
	Intact sprouts			De-sprouted						
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
Sikha Local	18	11	14	18	11	14	17	14	15	14
Gumda Local	23	12	17	25	23	24	27	20	23	21
NPI/T-0012	22	17	20	25	29	27	25	31	28	25
CIP-379693.110	19	10	14	23	14	18	21	11	16	16
Kufri Jyoti	18	15	16	25	13	19	22	15	18	18
Mean	20	13	16	23	18	20	22	18	21	19

The tubers were considered to be initiated when 80% of the main stems form the tuberous swelling twice the diameter of the subtending stolon.

Plant height

Year had a significant effect on plant height. Plants were taller in 1998 than in 1999 (54 cf 48 cm). Gumda Local and NPI/T-0012 were tallest and Kufri Jyoti was the shortest genotype. Plants produced by seed tubers with intact sprouts were shortest and longest in the case of seed tubers de-sprouted at planting. The plant height was intermediate in the case of re-sprouted seed potatoes (Table 7).

There was a strong interaction between genotype and sprout manipulation. The effect of de-sprouting was much greater in Sikha Local and CIP-379693.110 and much smaller in NPI/T-0012 and Gumda Local. There was an

intermediate effect in Kufri Jyoti (Table 7). For example, de-sprouted seed of Sikha Local produced plants, which were 217% taller than seed tubers with original sprouts. The difference between re-sprouted seed and seed tubers de-sprouted at planting was also significant for Sikha Local and CIP-379693.110. The other three genotypes produced plants of similar height with re-sprouted and de-sprouted tubers (Table 7).

Table 7. Effect of sprout manipulation of DLS stored seed and genotype on plant height (cm) (mean of 1998 and 1999)

Genotype (G)	Sprout manipulation (SM)			Mean
	Re-sprouted	De-sprouted	Intact sprout	
Sikha Local	42	57	18	39
Gumda Local	95	95	59	83
NPI/T-0012	84	89	70	81
CIP-379693.110	32	52	20	34
Kufri Jyoti	17	22	11	17
Mean	54	63	36	51
CV, % = 19.9	SEd (Year) = 2.13 (P>0.05)		SEd (G) = 3.37 (P<0.001)	SEd
SM) 2.61 (P<0.001)	SEd (Y × SM)=3.69 (P>0.05)		SEd (G × SM) = 5.04	
(P = 0.003)	SEd (Y × G × SM) = 8.26 (P>0.05)			

Days to crop maturity

NPI/T-0012 and Gumda Local were the latest to mature and Kufri Jyoti and CIP-379693.110 were the earliest. Sikha Local was intermediate (Table 8). As expected, seed tubers planted with sprouts intact and seed tubers de-sprouted at planting were earliest and latest, respectively. Crops grown from re-sprouted seed tubers had an intermediate response (Table 8).

Table 8. Effect of sprout manipulation of DLS stored seed and genotype on days to crop maturity (mean of 1998 and 1999)

Genotype (G)	Sprout manipulation (SM)			Mean
	Re-sprouted	De-sprouted	Intact sprout	
Sikha Local	122	131	112	122
Gumda Local	134	135	122	130
NPI/T-0012	134	135	129	133
CIP-379693.110	117	125	104	115
Kufri Jyoti	112	117	103	111
Mean	124	129	114	123
CV, % = 3.3, SEd (Year)=0.85 (P>0.05), SEd (G)=1.34 (P<0.001), SEd (SM)=1.04 (P<0.001), SEd (Y × SM) = 1.47 (P<0.001), SEd (G × SM)=2.33 (P=0.003), SEd (Y × G × SM) = 3.29 (P>0.05)				

Interactions between genotype and sprout manipulation and year and sprout manipulation were significant. The effect of de-sprouting was largest in CIP-379693.110 followed by Kufri Jyoti and Sikha Local, and the least in case of NPI/T-0012 (Table 8). The difference between re-sprouted and seed tubers de-sprouted at planting was also significant for Sikha Local and CIP-379693.110, but not significant for NPI/T-0012, Gumda Local and Kufri Jyoti.

Interaction effect between year and sprout manipulation was mainly due to the similar maturity period of re-sprouted seed and seed tubers de-sprouted at planting in 1998 but earlier maturity of re-sprouted seed compared with seed tubers de-sprouted at planting in 1999. Seed tubers planted with intact sprouts matured much earlier in 1999 than in 1998.

Plant stand at harvest

Plant stand at harvest was slightly higher in 1998 than in 1999 (66408 cf 65704/ha). Overall plant stands of all treatments were very good and the effects of genotype, sprout manipulation and their interaction effects were not significant.

Number of stems per plant

Slightly more stems were produced in 1998 than in 1999 (3.0 cf 2.6/plant). NPI/T-0012 and CIP-379693.110 had the lowest number of stems, Sikha Local and Gumda Local the highest and Kufri Jyoti was intermediate (Table 9). Seed tubers planted with intact sprouts had fewest stems (1.8). Re-sprouted seed (3.2) and seed tubers de-

sprouted at planting (3.5) both produced statistically similar numbers of stems/plant. Seed tubers de-sprouted at planting produced approximately twice the number of stems of seed tubers planted with intact sprouts (3.5 cf 1.8/plant).

Table 9. Effect of sprout manipulation of DLS stored seed and genotype on number of stems/plant (mean of 1998 and 1999)

Genotype (G)	Sprout manipulation (SM)			Mean
	Re-sprouted	De-sprouted	Intact sprout	
Sikha Local	3.9	4.6	2.2	3.5
Gumda Local	4.0	3.7	1.8	3.2
NPI/T-0012	2.4	2.5	1.5	2.2
CIP-379693.110	2.8	3.6	1.2	2.5
Kufri Jyoti	2.9	3.0	2.3	2.7
Mean	3.2	3.5	1.8	2.8
CV, % = 17.6, SEd (Year) = 0.10 (P=0.002), SEd (G) = 0.17 (P<0.001), SEd (SM) = 0.13 (P<0.001), SEd (Y × SM) = 0.18 (P>0.05), SEd (G × SM) = 0.29 (P<0.001), SEd (Y × G × SM) = 1.74 (P>0.05)				

There was a significant interaction between genotype and sprout manipulation. All genotypes produced more stems from seed tubers de-sprouted at planting than from seed planted with intact sprouts, but the effect varied among genotypes. The effect was highest in CIP-379693.110, seed tubers de-sprouted at planting produced 200% more stems than intact sprouts (3.6 cf 1.2). It was 122% and 109% greater in Gumda Local and Sikha Local, respectively. The effect was the least in case of Kufri Jyoti followed by NPI/T-0012 (Table 9).

Number of tubers per plant

Slightly more tubers per plant were produced in 1998 than in 1999 (14.6 c.f. 11.9/plant). Gumda Local produced the most tubers/plant (20.9) closely followed by Sikha Local. The other three genotypes produced between 8 and 10 tubers/plant (Table 10). Seed tubers with intact sprouts produced fewest tubers (11.3/plant) and re-sprouted seed and seed tubers de-sprouted at planting produced similar numbers of tubers.

Table 10. Effect of sprout manipulation of DLS stored seed and genotype on number of tubers/plant (mean of 1998 and 1999)

Genotype (G)	Sprout manipulation (SM)			Mean
	Re-sprouted	De-sprouted	Intact sprout	
Sikha Local	18.9	22.5	13.4	18.3
Gumda Local	22.3	22.6	17.7	20.9
NPI/T-0012	9.6	9.3	9.3	9.4
CIP-379693.110	9.4	10.1	9.3	9.6
Kufri Jyoti	9.6	8.0	7.0	8.2
Mean	14.0	14.5	11.3	13.3
CV, % = 17.1, SEd (Year) = 0.48 (P<0.001), SEd (G) = 0.76 (P<0.001), SEd (SM) = 0.58 (P<0.001); SEd (Y × SM) = 0.83 (P>0.05), SEd (G × SM) = 1.31 (P<0.001), SEd (Y × G × SM) = 1.85 (P>0.05)				

There was no effect of sprout manipulation on tubers per plant in NPI/T-0012, CIP-379693.110 and Kufri Jyoti. Sikha Local was affected the most: seed tubers de-sprouted at planting produced 68% more tubers per plant than the seed tubers planted with original sprouts intact (Table 13). The number of tubers produced by re-sprouted seed and seed tubers de-sprouted at planting was also different. Gumda Local produced least tubers from seed tubers planted with original sprouts intact. The number of tubers produced by re-sprouted seed and seed tubers de-sprouted at planting were similar (Table 10).

Total tuber yield

The total tuber yield was affected by year, genotype and sprout manipulation treatment. Yields were 44% higher in 1998 than in 1999 (30.7 cf 21.3 t/ha). The highest tuber yield (33.8 t/ha) was produced by NPI/T-0012 and the lowest (20.6 t/ha) by Kufri Jyoti (Table 11). Similarly, the lowest tuber yield was produced by seed tubers with

original sprouts intact, which had the highest number of accumulated day-degrees and were the oldest physiologically (Table 11). Tuber yields of seed tubers de-sprouted at planting (0 ADD) and re-sprouted before planting (90 ADD) were similar. Seed tubers de-sprouted at planting and re-sprouted before planting produced 26.6% and 19.4% higher tuber yield, respectively, compared to seed tubers planted with intact sprouts. The tuber yield of seed tubers de-sprouted at planting had higher or comparable yields to CS seed (116 ADD) (Table 11).

Table 11. Total tuber yield (t/ha) of potato genotypes as affected by accumulated day-degrees experienced by source seed potatoes as a result of sprout manipulation (mean of 1998-1999)

Genotype	DLS stored seed			CS seed	Mean
	De-sprouted	Re-sprouted	Intact sprouted		
Sikha Local	30.3 (0)	22.7 (93)	17.0 (1535)	21.2 (120)	23.3
Gumda Local	26.7 (0)	29.4 (93)	25.1 (1247)	26.6 (120)	27.1
NPI/T-0012	34.0 (0)	36.5 (75)	30.7 (889)	28.4 (100)	33.8
CIP-379693.110	26.4 (0)	22.8 (93)	21.0 (1663)	24.6 (120)	23.4
Kufri Jyoti	23.3 (0)	21.3 (93)	17.2 (1431)	21.8 (120)	20.6
Mean	28.1 (0)	26.5 (90)	22.2 (1353)	24.5 (116)	25.6

CV, % = 14.4, SEd (G) = 1.23 (P<0.001), SEd (SM) = 0.95 (P<0.001), SEd (G × SM) = 2.13 (P=0.005)

Values given in parentheses are accumulated day-degrees, >4 °C experienced by the seed after onset of sprout growth (measured as the appearance of a 3 mm long sprout).

Interactions between genotype and sprout manipulation, and year and sprout manipulation were significant. A significant interaction (P=0.005) between genotype and sprouting treatment revealed two major trends. These were: (i) increase in tuber yield due to de-sprouting at planting or one month before planting which could be due to fewer accumulated day-degrees. This was the case for four genotypes out of five. The effect of sprouting treatment was greatest in Sikha Local followed by Kufri Jyoti and CIP-379693.110 where de-sprouted seed produced 78.2%, 35.5% and 25.7% higher yields respectively than seed tubers with intact sprouts. The effect was least in the case of NPI/T-0012 (Table 11). (ii) no effect of de-sprouting treatment (and hence accumulated day-degrees) on tuber yields in cultivar Gumda Local; seed tubers with 1247 ADD (seed tubers with intact sprouts) and 0 ADD (de-sprouted at planting) yielded similarly. However, even in the case of Gumda Local, re-sprouted seed produced 17% higher yield than seed tubers planted with intact sprouts (29.4 cf 25.1 t/ha) (Table 11). This difference was not quite significant at 1% level but it might be an indication of ageing of seed potatoes even in the case of Gumda Local.

DISCUSSION

Effects of seed tubers' age on emergence

It was obvious to have an effect of sprout manipulation treatments on days to emergence. This is because physiologically old seed usually emerges sooner than younger ones. This has been reported by several workers (O'Brien and Allen 1984, O'Brien et al 1986, Allen and O'Brien 1986, van der Zaag and van Loon 1987, Benz and Fahem 1988, Dhital et al 1997) and was further confirmed by this study. Emergence of physiologically very old seed can be delayed and it can be very erratic. However, this was not the case as the total emergence was not affected by sprouting treatments and overall there was an excellent emergence in all treatments. De-sprouting delayed the emergence but did not affect the total or final emergence. This gives an opportunity to de-sprout the DLS stored seed potatoes where necessary.

Tuber initiation

Tuber initiation is an important developmental stage of potatoes. With the initiation of the tubers, the elongation of the shoot axis is usually retarded. That means, early initiation of tubers when plants are small retards further growth in stem lengths and production of new leaves. Physiologically old seed initiate tubers earlier when plants are smaller than seed with young or optimum age (Toosey 1963, Fischnich and Krug 1963). Therefore, it was not surprising to have an earlier tuber initiation in seed potatoes planted with original sprouts intact than de-sprouted at planting. Very early initiation of tubers and the consequent short duration of crop growth in the case of physiologically old seed can be a major drawback, particularly where available growing period in the field is more than 110d. This applies to seed potatoes stored in DLS in low to mid hills (1000 to 1800 m) and that are

planted with original sprouts intact. Clearly, it is important to consider the potentially beneficial effects of de-sprouting such seed potatoes before planting.

Vigour of crop growth

As facilities for leaf area measurement were not available, % canopy cover at different dates and plant height (stem length) at maturity were used as indicators of crop vigour. Crops grown from seed tubers with original sprouts suffered more than re-sprouted seed, as early crop growth was more advanced. The effect was least in the case of seed tubers de-sprouted at planting. Genotype also had an effect in avoiding the drought period. Genotypes with a long maturity period such as NPI/T-0012 and Gumda Local were less affected than genotypes with a short maturity period such as Kufri Jyoti and CIP-379693.110. Sikha Local, being an intermediate genotype was in between. However, the effect of de-sprouting was largest in Sikha Local. This planted with original sprouts behaved like early maturing genotypes such as Kufri Jyoti, but behaved as a late maturing genotype like NPI/T-0012 when seed tubers were de-sprouted at planting. Crop growth of late maturing treatments was retarded less than early maturing ones. Fast canopy development started in late maturing treatments when rainfall resumed following drought, but early maturing treatments had already begun to senescence. Thus, seed tubers de-sprouted at planting exhibited a good drought avoidance mechanism allowing excellent re-growth of the crop. Drought in the hills of Nepal (particularly at <2000 m) is common during March to early May coupled with high day temperature. As a result, planting seed tubers with original sprouts may be detrimental in most of the cases where the crop is grown in rainfed conditions. However, this also depends on genotype; affecting more for early maturing genotypes.

It has long been known that physiologically old seed tubers produce shorter plants than seed tubers with optimum or younger age (Fischnich and Krug 1963, Toosey 1963, Iritani 1968). In this study, seed tubers de-sprouted at planting tended to produce taller plants than seed tubers with intact sprouts at all locations. This is in agreement with van der Zaag and van Loon (1987) who reported that physiologically old seed produced shorter plants than seed tubers of optimum age. This indicates that de-sprouting of DLS seed potatoes remove or minimise the ageing effect of seed potatoes. Though not measured, field observations suggested that there were many more leaves per plant and somewhat larger leaflet sizes in crops grown from seed tubers de-sprouted at planting compared to crops grown from seed with original sprouts intact. Seed tubers de-sprouted at planting tended to be of a more indeterminate type compared to the seed potatoes planted with their original sprouts intact.

Crop maturity

Seed tubers de-sprouted at planting had a slightly longer crop maturity period than seed tubers planted with original sprouts. This might have been because of less advanced growth and delayed emergence of de-sprouted seed tubers. These are characteristics of physiologically young seed potatoes. There was an overwhelming effect of year on crop maturity. Wet and cool growing conditions of 1998 slowed down crop senescence resulting in slightly longer crop duration than in 1999.

Number of stems and tubers per plant

Seed tubers de-sprouted at planting produced 94% more stems than those planted with original sprouts intact. Seed tubers de-sprouted at planting produced 28% more tubers per plant than seed tubers planted with original sprouts. Several authors reported a reduced number of tubers per plant from physiologically old seed compared with seed tubers of optimum age (O'Brien et al 1986, Severian et al 1986). This is in an agreement with our findings.

Total tuber yield

The effects sprout manipulation on tuber yield were similar to those reported from the temperate zone. Accumulated thermal time of seed potatoes with original sprouts intact ranged from 620 day-degrees (NPI/T-0012) to 1396 day-degrees (CIP-379693.110) in 1997 and 1128 day-degrees (NPI/T-0012) to 2069 day-degrees (Sikha Local) in 1998 (Table 4). Re-growth of sprouts after de-sprouting was not a problem, which could be due to less exhausted seed tubers. Generally, de-sprouting did not affect the number of seed tubers, which emerged, although it delayed emergence by 9-12d. Seed tubers de-sprouted at planting produced more vigorous plants, more stems and tubers per plant and a larger canopy which remained photosynthetically active for a longer period than the seed tubers planted with their original sprouts. These effects might have accounted for higher tuber yields of seed tubers de-sprouted at, or prior planting.

To a large extent, results of our experiment supported the hypothesis that de-sprouting reverses the physiological age and rejuvenates seed tubers. However, interactions between year, genotype and sprouting treatment indicated that de-sprouting might not be necessary for genotypes with a long dormancy period, good storability and long maturity period such as Gumda Local and NPI/T-0012 in a good growing season. Previous studies on the effects of sprout manipulation of DLS stored seed potatoes on subsequent tuber yield at LARC (Dhital et al 1997) generally agreed with the findings of this study. However, findings of CIP at Huancayo (3200 m) in Peru contrast with this result. This could be because of the much cooler environment of Huancayo than at LARC. Findings of Benz and Fahem (1988) from Tunisia also agree with our results.

The results showed that physiological ageing during DLS varied greatly among genotypes. There were large differences in total accumulated day-degrees at the end of storage for different genotypes. This was attributed mainly to differences in dormancy period and crop maturity period, both of which are also closely associated. Genotypes behave differently in their subsequent performance in response to accumulated thermal time. It is expected that accumulation of higher thermal time than optimum is detrimental to tuber yield. However, it is important to note from the results that different genotypes have different optimum levels of accumulated thermal times for optimum tuber yields. Consequently, the necessity for and/or possibility of altering the accumulated thermal time of seed potatoes by de-sprouting was dependent mainly upon amount of thermal time which had been accumulated previously and the genotype. Apparently genotypes have a certain threshold of thermal time beyond which de-sprouting at, or prior planting can reverse the physiological ageing of seed potatoes. This results in higher tuber yields than seed potatoes, which have not been de-sprouted. Below this limit, it is not necessary to reverse the age by de-sprouting as seed potatoes are still in the optimum age range.

CONCLUSION

Sprout manipulation particularly de-sprouting at, or prior planting of DLS stored seed potatoes was very important for most of the genotypes. Effects were evident on emergence progression, number of stems and tubers per plant, plant height, percent crop cover and days to crop maturity. Seed tubers de-sprouted at planting emerged and tuberised later. They gave taller plants, greater canopy cover for a longer duration, more stems and tubers per plant and took slightly longer to mature than seed tubers planted with original sprouts intact. Performance of seed tubers re-sprouted for a month was similar to those de-sprouted at planting.

The reduced yields of DLS seed when planted with original sprouts intact could have hindered the adoption of the technology. Clearly, the evidence that crop performance and tuber yield may be enhanced by de-sprouting DLS seed may stimulate uptake of this method of seed storage. However, it is essential to stress that the effect is very much dependent upon the genotype and accumulated thermal time of seed potatoes at planting. The findings of the current studies are not sufficiently adequate to describe the relationship more specifically due to the limitations of field experimentation. Future studies, under controlled environment conditions, which simulate tropical conditions is suggested for more specific quantification of the relationship between accumulated thermal time, genotype, growing environment and sprout manipulation practices.

ACKNOWLEDGEMENTS

This study was part of PhD studies of the main author and financial support was provided by Department for International Development (DFID) of the British Government. Our thanks also go to HP Paudel (Lumle Agriculture Research Centre) for his sincere assistance in carrying out the experiment.

REFERENCES

- Allen EJ and PJ O'Brien. 1986. The practical significance of accumulated day-degrees as a measure of physiological age of seed potato tubers. *Field Crops Research* 14:141-151.
- Allen EJ, PJ O'Brien and D Firman. 1992. Seed tuber production and management. **In:** *The potato crop: The scientific basis for improvement* (PM Harris, ed). Chapman and Hall, London. Pp.247-291.
- Benz JS and M Fahem. 1988. Effects of storage conditions on field performance of potato seed in Tunisia. *Potato Research* 31:37-41.
- Booth RH, RL Shaw and A Tupac Yupanqui. 1983. Use of natural diffused light for the storage of seed tubers. **In:** *Research for the Potato in the Year 2000* (WJ Hooker, ed). International Potato Centre, Lima, Peru. Pp.65-66.

- Dhital BK and SR Ghimire. 1999. Effect of sprout manipulation practices of diffused light stored seed potatoes on growth and tuber yield in the hills of Nepal. *Nepal Agriculture Research Journal* 3(1):14-18.
- Fischnich O and H Krug. 1963. Environmental factors influencing sprout growth and subsequent plant development in the field. **In:** *The growth of the potato*. (JD Ivins and FL Milthorpe, eds). Butterworth, London. Pp.72-78.
- Iritani WM. 1968. Factors affecting physiological ageing (degeneration) of potato tubers used as seed. *American Potato Journal*, 45:111-116.
- Lewis HT. 1992. *Storability potential of the potato (Solanum spp) in the lowland tropics*. PhD Thesis. University of Reading, UK.
- O'Brien PJ, EJ Allen, JN Bean, RL Griffith, SA Jones and JL Jones. 1983. Accumulated day degrees as a measure of physiological age and the relationship with growth and yield in early potato varieties. *Journal of Agricultural Science*, Cambridge. 101:613-631.
- O'Brien SA and EJ Allen. 1984. Some effects of de-sprouting on growth and yields of contrasting varieties. *Abstracts of the 9th Triennial Conference of the European Association for Potato Research*, Interlaken, Switzerland. Pp.303-304.
- O'Brien PJ, JL Jones, EL Allen and GSM Raouf. 1986. Effects of physiological age of seed tubers on seed yield and re-growth of progeny tubers in potatoes. *Journal of Agricultural Science*, Cambridge. 107:307-327.
- Rhoades RE and RH Booth. 1983. Acceptance of diffused light potato seed storage technology in developing countries. **In:** *Research for the Potato in the Year 2000* (WJ Hooker, ed). International Potato Centre, Lima, Peru. Pp.160-161.
- Rhoades RE. 1988. Post-harvest technology development: Lessons from farms and villages. **In:** *Proceedings of a workshop on potato post-harvest technology* held at Kunming China on 25-26 June 1988. CIP and APA. Pp.114-126.
- Severian P, F Devinc and P van der Zaag. 1986. Seed potato (*Solanum tuberosum*) storage methods and field production in New Caledonia. *Tropical Agriculture* 96:52-56.
- Toosey RD. 1963. The influence of sprout development at planting on subsequent growth and yield. **In:** *The growth of the potato*. (JD Ivins and FL Milthorpe, eds). Butterworth, London. Pp.79-94.
- Van der Zaag DE and CD van Loon. 1987. Effect of physiological age on growth vigour of seed potatoes of two cultivars. 5. Review of literature and integration of some experimental results. *Potato Research* 30:451-472.

Effect of Time of Grafting and Budding on Trifoliate Rootstocks for Mandarin Orange Saplings Production

Ishwori P Gautam, Deep N Sah and Bhogendra Khatri

Regional Agriculture Research Station, Lumle, Kaski

ABSTRACT

An experiment was conducted in factorial randomized complete block design (RCBD) at RARS, Lumle (1400 masl) during 1999/2000. Ten scions grafted/ budded in different months represented a treatment and replicated twice. The grafting and budding operations were carried out from 6 Oct 1999 to 14 Feb at 15 days intervals. The results showed that there was a highly significant differences in plant height due to the time after grafting or budding. The maximum plant height (29.77 cm) and diameter (0.69 cm) was observed on 20 Nov, 12 months after grafting. However, maximum success percentage (87.5%) was observed on 31 Jan grafting and it was found at par with 16 Jan (85%), 14 Feb, (77.5 %), 1 Jan (70%) and 21 Oct (72.5%). Minimum (37.5%) was observed on 20 Nov grafting time. It clearly indicates that the grafting and budding can be successfully done from 1 Jan to 14 Feb. However, 16 to 31 Jan is recommended for grafting and budding to get maximum success.

Key words: Grafting and budding time, mandarin, trifoliate

INTRODUCTION

Mandarin orange is an important and indispensable fruit crop grown in the mid hills of Nepal. It covers about 11102.5 ha and produced about 70824 Mt fruits (MOA 2000). Among total area covered, only 6588 ha (59.33%) is under productive stage. Increase in mandarin area coverage is encouraging but its productivity is lower in comparison to other developed countries. So to increase the production and productivity of this crop, emphasis should be given to important measures like development of nursery, selection of good cultivars and their appropriate multiplication. Mandarin is an indigenous fruit of Nepal (Bonavia 1989) and there are several excellent varieties available locally which need to be multiplied to conserve the quality of fruits.

There is a high demand of mandarin saplings every year and most of them are mainly seed propagated, which come in to bearing only after 5-8 years of planting, produce highly variable trees and suffer from various soil borne (gummosis, root rot, foot rot caused by *Phytophthora* sp.) and vector transmitted (citrus greening, citrus tristeza viruses) diseases. Besides these, seed propagated trees suffer from hard soil pain, soil acidity, drought, cold injury, water logging during rainy season, poor plant nutrition and poor orchard management.

It is very difficulty to replace the inferior plants once an orchard has been already established because there is a great loss due to its long gestation period and huge investment. To overcome these problems, different rootstocks have been used for budding and grafting to produce true to type and good quality saplings, which come bearing in a short period of time. However, grafting and budding are restricted only in some government farms and research stations due to its low percentage of success. It could be due to lack of suitable techniques and time for producing mandarin seedlings in different agro-climatic conditions. Most of the techniques and methods adopted to produce mandarin seedlings have been carried out based on the research conducted in India and else where (Shah 1992). In Nepal, a few attempts have been made in past to find out the suitable techniques and time for producing asexually propagated quality seedlings of mandarin orange. Therefore, a trial was carried out at Lumle to investigate the suitable techniques and time for producing vigorous and true to type mandarin

seedlings by sing trifoliate root stocks.

MATERIALS AND METHODS

An experiment was conducted at the RARS, Lumle (1400 masl) during 1999/2000. The trial was conducted in a randomized complete block design (RCBD) with two factorial treatments arrangement. Ten scions grafted/budded in different months represented a treatment and were replicated twice. The level of different factors and their combination were as follows:

Factor 1. Methods of grafting and budding

a. Cleft grafting b. T or shield budding

Factor 2. Dates of grafting and budding

1. 6 Oct 1999 2. 21 Oct 1999 3. 5 Nov 1999 4. 20 Nov 1999 5. 7 Dec 1999 6. 19 Dec 1999
7. 1 Jan 2000 8. 16 Jan 2000 9. 31 Jan 2000 10. 14 Feb 2000

Mandarin scions were selected and collected from Banskharka of Parbat district and grafted and budded in different months at the height of 8 inch on base of trifoliate rootstocks. The age of rootstocks was 21 months old. After grafting and budding they were placed under the shade condition for further observation. Observations were made on plant height from the place of grafting and budding to the tip, diameter of saplings was measured from the base of the rootstock and percentage of success was recorded at 6, 8, 10 and 12 months after grafting and budding operations.

RESULTS AND DISCUSSION

Sapling height

The effect of different time on the grafting and budding showed that there was a highly significant difference in plant height at 6, 8, 10 and 12 months after grafting and budding. The maximum plant height (29.77 cm) in 12 months was observed on 20 Nov and it was at par with 7 Dec (28.33 cm) and 21 Oct (27.06 cm) grafting and budding time. Lowest saplings height (21.69 cm) in 12 months was observed on 6 Oct and it was at par with 19 Dec and 16 January. There was highly significant effect on sapling height due to methods of propagation in 6, 8, 10 and 12 months of time period. In all the months grafting was observed better than budding in respect to plant height.

The combined analysis of data on methods of propagation (Table 1) showed a non significant difference in plant height in 6 and 8 months but there was a significant effect in 10 and 12 months time period. The maximum plant height (34.70 cm) was observed on 20 November grafting and it was found at par with on 7 Dec grafting (30.83 cm).

Collar diameter

The analysis of data showed a significant effect on collar diameter in 6, 8 and 12 months time due to different time of grafting and budding. The maximum collar diameter (0.66 cm) was observed on 21 Oct, 20 Nov, 7 Dec and 31 Jan.

These two methods of sapling production (Table 2) showed a non significant effect on collar diameter in 6, 8, 10 and 12 months after grafting and budding. The interaction effect of different time and methods of mandarin saplings production showed a non significant difference in collar diameter in 10 months but it showed a significant effect in 6, 8 and 12 months after grafting and budding operations.

The maximum collar diameter (0.69 cm) in 12 months was observed on 20 Nov grafting and minimum (0.57 cm) was on 6 Oct budding.

Table 1. Mean height (cm) of mandarin saplings in different months after grafting and budding at ARS, Lumle during 1999/2000

Factor	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	T ₁₀	Mean	CV, %		P-value	LSD (0.05)	
<i>Six months after grafting/budding</i>																
Cleft grafting	10.84	13.70	13.87	10.31	13.41	12.34	13.62	15.97	17.63	20.31	14.10			Factor	0.001	1.747
Budding	6.96	9.04	5.26	6.79	7.61	8.71	9.90	12.59	20.80	21.81	10.95	21.0		Time	<0.001	3.906
Mean	8.90	11.37	9.57	8.55	10.38	10.53	11.76	14.28	19.21	21.06	12.56			F x T	0.185	5.245
<i>Eight months after grafting/budding</i>																
Cleft grafting	11.75	16.41	16.10	26.44	13.37	16.54	20.91	20.11	21.51	23.18	18.63	11.3		Factor	<0.001	1.274
Budding	8.15	11.78	11.53	21.49	10.0	13.13	19.0	14.63	20.85	23.94	15.45			Time	<0.001	2.841
Mean	9.95	14.10	13.82	23.97	11.68	14.84	19.95	17.37	21.18	23.56	17.04			F x T	0.414	4.018
<i>Ten months after grafting/budding</i>																
Cleft grafting	24.93	26.39	24.05	31.44	26.86	21.27	23.91	23.53	24.60	24.69	25.17	8.0		Factor	<0.001	1.237
Budding	21.26	21.61	19.51	23.74	20.87	16.07	22.52	15.80	23.22	25.53	21.01			Time	<0.001	2.766
Mean	23.09	24.00	21.78	27.59	23.87	18.67	23.21	19.67	23.91	25.11	23.09			F x T	0.048	3.911
<i>Twelve months after grafting/budding</i>																
Cleft grafting	22.62	27.70	24.46	34.70	30.83	24.58	26.85	26.92	27.71	26.27	27.57	7.6		Factor	0.001	1.282
Budding	20.75	26.42	21.90	24.85	25.82	19.43	25.83	17.45	25.86	26.90	23.52			Time	<0.001	2.867
Mean	21.69	27.06	24.68	29.77	28.33	22.01	26.34	22.91	26.79	26.59	25.55			F x T	0.011	4.054

T₁ - T₁₀, Dates of grafting and budding, see materials and methods.

Table 2. Mean collar diameter (cm) of mandarin saplings in different months after grafting and budding at ARS, Lumle during 1999/2000

Factor	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	T ₁₀	Mean	CV, %		P-value	LSD (0.05)
<i>Six months after grafting/budding</i>															
Cleft grafting	0.34	0.49	0.46	0.53	0.45	0.44	0.55	0.50	0.49	0.53	0.43	7.3	Factor	0.621	0.022
Budding	0.35	0.55	0.42	0.42	0.57	0.43	0.50	0.52	0.41	0.53	0.47		Time	<0.001	0.051
Mean	0.34	0.52	0.48	0.47	0.51	0.43	0.52	0.51	0.45	0.53	0.47		F x T	0.008	0.072
<i>Eight months after grafting/budding</i>															
Cleft grafting	0.53	0.54	0.53	0.58	0.50	0.49	0.62	0.55	0.59	0.56	0.55	5.4	Factor	0.874	0.019
Budding	0.52	0.60	0.49	0.49	0.63	0.53	0.54	0.58	0.53	0.57	0.54		Time	0.014	0.043
Mean	0.52	0.57	0.51	0.53	0.56	0.51	0.58	0.56	0.56	0.57	0.55		F x T	0.001	0.061
<i>Ten months after grafting/budding</i>															
Cleft grafting	0.60	0.58	0.58	0.63	0.60	0.56	0.63	0.60	0.58	0.61	0.60	6.7	Factor	0.895	0.027
Budding	0.60	0.64	0.55	0.58	0.65	0.56	0.58	0.63	0.59	0.62	0.60		Time	0.299	0.059
Mean	0.60	0.61	0.56	0.61	0.62	0.56	0.61	0.62	0.58	0.61	0.60		F x T	0.382	0.084
<i>Twelve months after grafting/budding</i>															
Cleft grafting	0.64	0.63	0.63	0.69	0.64	0.65	0.68	0.63	0.66	0.65	0.65	4.3	Factor	0.083	0.018
Budding	0.57	0.69	0.69	0.64	0.67	0.59	0.62	0.68	0.64	0.66	0.63		Time	0.043	0.040
Mean	0.61	0.66	0.61	0.66	0.66	0.62	0.65	0.66	0.65	0.65	0.64		F x T	0.022	0.057

T₁ - T₁₀, Dates of grafting and budding, see materials and methods.

Success percentage

The mean success percentage was maximum (82.5, 85.0 and 87.5%) on 31 Jan grafting and budding time in 6, 8, 10 and 12 months respectively after grafting and budding operations. In 12 months, the success percentage remained the same as 10 months after grafting and budding. The maximum success percentage (87.5%) in 12 months was observed on 31 Jan and it was found at par with 16 Jan (85%), 14 Feb (77.5 %), 1 Jan (70%) and 21

Oct (72.5%) and the minimum success (37.5%) was on 5 and 20 Nov dates. There was linear increase in success percentage of saplings from 5 Nov onward and reached a maximum on 31 Jan grafting and budding.

There was a non significant effect of grafting and budding methods on success percentage of saplings production. However, grafting was slightly better than budding in all months. The effects of time and its interaction with grafting and budding method are presented in Table 3.

It can be concluded that there was no significant effect of grafting and budding operations on mandarin saplings production. It is also clear that the grafting and budding operations can be done from 1 Jan to 14 Feb. However, for maximum success, 16 to 31 Jan time period is recommended both for grafting and budding. The maximum height and diameter were observed on 20 Nov and 7 Dec. However, these dates are not suitable for grafting and budding due to low success percentage in saplings production.

Table 3. Mean success percentage of saplings production due to time of grafting and budding at the ARS, Lumle during 1999/2000

during 1999/2000															
Factor	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	T ₁₀	Mean	CV, %	P-value	LSD (0.05)	
Six months after grafting/budding															
Cleft grafting	35	85	35	30	80	80	80	100	95	75	69.5	18.2	Factor	0.047	7.88
Budding	70	60	40	45	45	55	85	65	70	80	61.5		Time	<0.001	17.61
Mean	52.5	72.5	37.5	37.5	62.5	67.5	82.5	82.5	82.5	77.5	65.5		F x T	0.005	24.90
Eight months after grafting/budding															
Cleft grafting	35	85	35	30	80	80	80	100	90	75	69	16.5	Factor	0.074	7.20
Budding	70	60	40	45	45	55	85	65	80	80	62.5		Time	<0.001	16.10
Mean	52.5	72.5	37.5	37.5	62.5	67.5	82.5	82.5	85	77.5	65.7		F x T	0.002	22.76
Ten months after grafting/budding															
Cleft grafting	35	85	35	30	70	80	70	100	95	75	67.5	20.7	Factor	0.172	8.84
Budding	70	60	40	45	45	55	70	70	80	80	61.5		Time	<0.001	19.77
Mean	52.5	72.5	37.5	37.5	57.5	67.5	70	85	87.5	77.5	64.5		F x T	0.039	27.96
Twelve months after grafting/budding															
Cleft grafting	35	85	35	30	70	80	70	100	95	75	67.5	20.7	Factor	0.172	8.84
Budding	70	60	40	45	45	55	70	70	80	80	61.5		Time	<0.001	19.77
Mean	52.5	72.5	37.5	37.5	57.5	67.5	70	85	87.5	77.5	64.5		F x T	0.039	27.96

T₁ – T₁₀, Dates of grafting and budding, see materials and methods.

ACKNOWLEDGEMENTS

Authors are grateful to the Hill Agriculture Research Project (HARP) for funding HARP-PP-103/98 Project. We would also like to thank Dr RP Sah and Mr KB Paudel for their support and encouragement in carrying out the experiment. We sincerely thank all the member of Horticulture Unit, ARS, Lumle, especially Mr JN Chaudhary, Mr Ramjee Paudel and Mr KP Devkota for their tedious and hard work in trial implementation and data recording. Our special thanks go to Mr RR Adhikari for word processing.

REFERENCES

- Bonavia E. 1989. *The cultivated oranges and lemons etc of India and Ceylon*. WH Allen and Co London.
- MOA. 2000. *Statistical information on Nepalese agriculture (1999/2000)*. Agri-Business Promotion and Statistical Division, Singha Darbar, Kathmandu, Nepal
- Shah RB. 1992. *Citrus fruit trainer's manual No.16*. Central Agricultural Training Center. Department of Agriculture.

Effect of Sulphur Levels on Onion (*Allium cepa*) Bulb Production in Acid Soil of Malepatan

Bishnu H Adhikary, Madhu S Ghale, Bhoj B BC, Chiranjibi Adhikary and Durga B Ranabhat

Agricultural Research Station, NARC, Malepatan, Pokhara

ABSTRACT

An experiment was conducted in acid soils (pH 5.2) of Agricultural Research Station, Malepatan during the year 1998/99 to 2000/01 to evaluate the response of sulphur levels on onion production. A randomized complete block design with three replications and six levels of sulphur (0, 5, 10, 20, 30 and 40 kg per hectare) were employed in the experiment. The results revealed that sulphur application was beneficial for plant height and bulb production of the onion crops. 40.94 g of onion bulb per plant and 39.18 cm plant height were produced when 40 kg of sulphur per hectare was applied. The yield of onion bulb was 8.9 t/ha, which was produced when 40 kg per hectare of sulphur was applied. This level found to be significantly different than the other levels of sulphur.

Key words: *Allium cepa*, biomass, bulb production, sulphur levels

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most common vegetable crops of the Nepalese people and can be grown from Tarai to mountains and in almost all types of soils. For higher yields, deep, friable, sandy loam soil with high organic matter content is the best. It is sensitive to soil acidity and alkalinity. It grows well with pH 5.8-6.5 (Pun and Karmacharya 1988). Besides major nutrients nitrogen, phosphorus and potassium (NPK) secondary plant nutrient sulphur (S) is needed in moderate quantity and play an important role in the formation of plant tissues (FAO 1970). It is reported that application of higher doses of sulphur causes reduction of bolting in onions (Shinde and Sontakke 1986). Because of its leaching losses, poor addition of sulphur into the soil through natural process and/or minimum or no use of sulphur containing fertilizers, the sulphur status of the soil is very poor to meet the plant requirement and the crop lacks this nutrient for its own development and production of bulbs. High doses of sulphur is also not beneficial for the crop. Sulphur is constituent of essential proteins and oils produced by certain plants. Lack of sulphur frequently shows yellowing of leaf (Russell 1961) and thus reduction in crop yield. The objective of this study was to study the response of different levels of sulphur on the production of onion bulbs in acid soil of Malepatan.

METHODOLOGY

The field experiments were conducted in Agricultural Research Station, Malepatan for 3 years (1998/99 to 2000/01) in acid soils (pH 5.2) of Malepatan soil series (MSS) to evaluate the effect of sulphur on onion production. A randomized complete block design (RCBD) with 3 replications was employed in the experiments. Six levels of sulphur (0, 5, 10, 20, 30 and 40 kg/ha) containing 66% precipitated sulphur were applied. The variety of onion was Red Creol. The crop was fertilized with manures and fertilizers @ 100:50:50 kg/ha NPK and 20 t/ha of compost. The plot size was 1.75- × 3.15-m, a total area of 5.512m². Plantlets were planted in the month of Mangsir. The spacing was 15- × 25 cm and 6 rows per plot were laid down. Leaf size, bulb size, fresh biomass and bulb production were the parameters taken into the study. All the parameters studied were analysed statistically by LSD method (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

The three years mean results (Table 1) indicated that the plant height and bulb production of onions were affected by the sulphur levels. A minimum plant height (35.37 cm) was observed in the non-treated onions, whereas the maximum plant height (39.18 cm) was observed where 40 kg of sulphur per ha was supplied. Nonsignificant difference was observed in plant height between 10 kg and 40 kg of sulphur application. The average onion bulb weight was found to be affected significantly. A similar response of sulphur level was observed on plant height also. There was no significant difference between 10 kg and 40 kg of sulphur application. Light onion bulb (27.77 g) was produced by control. Non significant differences were observed in leaf size, bulb diameter and onion biomass production.

Table 1. Mean effect of sulphur levels on onion growth (3 years' average)

Sulphur, kg/ha	Plant ht, cm	Bulb wt, g/plant	Bulb diameter, cm	Biomass, t/ha	Leaf length, cm	Leaf number, n
0	35.37	27.77	3.43	9.07	27.97	5.13
5	36.49	32.31	3.50	10.04	28.16	5.76
10	36.70	35.92	3.53	9.98	28.11	5.36
20	38.05	37.35	3.63	10.16	29.84	5.80
30	38.94	36.97	3.68	10.35	27.53	5.33
40	39.18	40.94	3.72	10.79	29.30	5.66
CV, %	4.0	10.2	7.0	14.2	5.0	9.2
F test	*	*	ns	ns	ns	ns
LSD (0.05)	2.69	6.56	0.45	2.59	2.61	0.92

The effects of sulphur level (40 kg/ha) on bulb production was highly significant when compared with control in all the years (Table 2). A maximum of 9.73 t/ha of onion bulbs were produced in 1998/99 when 40 kg/ha of sulphur was applied. In second year (1999/2000) 40 kg sulphur treated plot produced significantly higher onion bulb (8.83 t/ha) as compare to 20 kg of sulphur (7.52 t/ha). But in the third year (2000/01), non significant difference in bulb production was observed among the treated plots except control. Low bulb production was observed in all the years with non-treated plots. Three years mean indicates that a highest bulb production (8.9 t/ha) was recorded when 40 kg sulphur was applied which was significantly higher than the other treatments. Nonsignificant differences were observed between 5 kg and 10 kg, 20 and 30 kg of sulphur application. It is noted that almost 22% higher yields of onion bulbs was observed over non-treated onions and similarly almost 54.5% higher than the control.

Table 2. Effect of sulphur levels on onion bulb production (t/ha) for 3 consecutive years

Sulphur, kg/ha	Bulb weight			Mean	Increment, %
	1998/99	1999/2000	2000/2001		
0	6.08	4.66	6.55	5.76	0.00
5	7.72	5.90	7.47	7.03	22.0
10	7.96	6.71	6.72	7.12	23.6
20	9.09	7.52	7.79	8.13	41.9
30	8.80	7.89	7.40	8.02	39.2
40	9.73	8.83	8.15	8.90	54.5
CV, %	11.0	10.8	7.2	5.3	
F test	**	**	**	**	
LSD (0.05)	2.34	1.18	0.96	0.33	

The effect of sulphur levels over years was nonsignificant, whereas the levels of sulphur and the year interaction was highly significant. The uptake of sulphur by plants was highly significant. The uptake of sulphur on non-treated onions was observed 13.64 ppm whereas the highest uptake (25.19 ppm) was recorded from the plot where 40 kg/ha of sulphur was applied. The uptake of sulphur was found to be increasing with increasing levels of sulphur application to the onion crop (Table 3). The uptake was approximately 84% higher than that with the non-treated plots.

Table 3. Effect of sulphur levels on its uptake by onion plants

Sulphur, kg/ha	Sulphur uptake, ppm	Increment, %
0	13.64	0.00
5	18.75	37.46
10	21.80	59.82
20	21.25	55.57
30	23.23	70.30
40	25.19	84.67
CV, %	10.10	
F test	**	
LSD (0.01)	5.37	

CONCLUSION

Average plant height and bulb weight was influenced by the sulphur levels. Leaf size, total biomass production and bulb diameter were not affected by sulphur level. A maximum bulb (8.9 t/ha) was produced when 40 kg/ha of sulphur was applied to the onion crop in Malepatan condition.

REFERENCES

- FAO. 1970. *Fertilizers and their use*. A pocket guide for extension officers. Second Edition (revised). FFHC Fertilizer Programme, Food and Agriculture Organization of the United Nations, Rome, Italy. 54p.
- Gomez KA and AA Gomez. 1984. *Statistical procedures for agriculture research*. Second Edition. An international rice research book. A Wiley Inter-science Publication, John Wiley and Sons, New York. 680p.
- Shinde NN and MB Sontakke. 1986. Bulb Crops. **In:** *Vegetable crops in India* (TK Bose and MG Som, eds). Naya Prokash, 206 Bidhan Sarani, Calcutta, India. Pp.545-605.
- Pun L and BB Karmacharya. 1988. Bulb Crops. *In: Trainer's manual (vegetables)*. Manpower Development and Training Programme, Manpower Development Agriculture Project (MDAP), Department of Agriculture, Kathmandu. Pp.207-222.
- Russell EW. 1961. The individual nutrients needed by the plants. Soil conditions and plant growth (EW Russell, ed). 10th Edition. Longman Group Ltd, London and New York. Pp.31-46.

Effects on the Cabbage (*Brassica oleracea* var. *capitata*) Head Production to Different Molybdenum Levels in Acid Soil of Malepatan

Bishnu H Adhikary, Madhu S Ghale, Chiranjibi Adhikary and Bhoj B BC

Agricultural Research Station, NARC, Malepatan, Pokhara

ABSTRACT

Five levels of molybdenum (0, 1, 1.5, 2 and 2.5 kg/ha) were taken into study to evaluate their response on cabbage head production. The experiment was conducted in acid soil (pH 4.9) of Agricultural Research Station, Malepatan during the year 1998/99 to 2000/01. A randomized complete block design with three replications was employed in the experiment. The results showed that plant height and head size of cabbage (diameter) were not influenced significantly by the application of molybdenum (Mo), however slight increase were observed with increasing levels of molybdenum application. Mean of the three years results on weight of the head of cabbage indicates a significant positive response to molybdenum. A maximum of 18.22 t/ha of heads were produced by the application of 2.5 kg/ha of molybdenum. It is suggested that application of molybdenum at the rate of 2.5 kg per hectare is essential to increase the cabbage yield.

Key words: *Brassica oleracea* var. *capitata*, cabbage head, molybdenum levels

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) occupies an important position as a fresh vegetable and is consumed as salad in Nepalese diet. It is being grown in almost all parts of the kingdom of Nepal. It is one of the vegetables, which can be cultivated off-season and marketed during the hotter period of the year, which fetches higher price (Pun and Karmacharya 1988). The cabbage can be grown in nearly all types of soils having good drainage. Early crops are best grown on light soils, while late crops thrive heavier soils that can retain soil moisture. The optimum soil pH for cabbage head production is about 6 - 6.5 pH (Chatterjee 1986). Like other vegetable crops, cabbage also needs different plant nutrients, both macro and micronutrients, for its better growth and quality head production. The micronutrient, molybdenum, plays a vital role in quality head production of cabbage. Deficiency of this nutrient chlorotic interveinal mottling of the lower leaves followed by marginal necrosis and in-folding of leaves occurs (Joshi 1997). Chatterjee (1990) reported the sensitivity of cabbage to molybdenum deficiency. Prakash and Bhardwaj (1965) also reported an increase in head weight and volume of the head of the cabbage by the application of molybdenum. The deficiencies of the trace elements such as boron (B) and molybdenum (Mo) cause physiological diseases (Tindall 1983, Pandey 1998). The molybdenum availability in acid soil condition is rather low and need to apply to meet their requirement. It is an essential to investigate proper rate of molybdenum to be supplied to the cabbage head production. The objective was to study the effects of molybdenum levels on cabbage head production in acid soils of Malepatan.

METHODOLOGY

Field experiments were conducted for three consecutive years (1998/99, 1999/2000 and 2000/01) in acid soils (pH 4.9) in Agricultural Research Station, Malepatan to evaluate the effects of molybdenum (Mo) levels on cabbage production. Randomized complete block design (RCBD) with 3 replications was employed in the experiment and 5 levels of molybdenum (0, 1, 1.5, 2 and 2.5 kg/ha) in the form of sodium molybdate containing 39.65% Mo were applied. Fertilizer was applied @ 100:60:60 kg /ha N:P:K and compost was applied @ 20 t/ha. The variety used in the experiment was Coupenehan Market. The plot size was 10.8 m² (3- × 3.6-m). The crop was transplanted in the

month of Mangsir. Soil samples were collected and analysed before the start of experiment. The crop growth and head yield were taken into study and all the parameters were analysed statistically by least significant difference (LSD) method (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

The results (Table 1) indicate that the plant height of cabbage was not affected significantly by the application of molybdenum. However, maximum plant height (24 cm) was observed when 2.5 kg/ha of molybdenum was applied. The size of cabbage (head diameter) was also not affected by the Mo levels to the cabbage crop. The Largest head diameter (11.94 cm) was observed with 2.5 kg of Mo application, which was not significantly different with other levels of Mo and control. However, increasing head size was observed with increasing Mo levels. On the contrary, highly significant response of Mo levels was observed in head production of the cabbage plants. A minimum of 471.0 g of cabbage head per plant was produced by control, whereas 1 kg of Mo application produced 500 g of cabbage head, which was significantly different. A maximum head weight of 551.6 g was obtained when 2.5 kg Mo/ha was applied which was at par with 2 kg Mo/ha (531 g/plant). It is noted that approximately 17% head weight was increased by the application of 2.5 kg Mo/ha as compared to the control. The significant response of Mo levels was observed on head yield in all the years (Table 2). The highest head yield (22.21 t/ha) was observed in the first year (1998/99) when the crop was treated with 2.5 kg of Mo/ha. In this year, a minimum head yield (15.18 t/ha) was produced by control plot and nonsignificant differences among 1.5 kg, 2 kg and 2.5 kg of Mo were observed in the cabbage head weights. The response trend of Mo levels on cabbage head weight in second and third year (1999/2000 and 2000/01) was found similar to that of first year. The highest head weight (17.06 t/ha) was observed with 2.5 kg Mo application and the lowest with control (10.03t/ha). Statistically non-significant differences in head yield among 1.5 kg, 2 kg and 2.5 kg of Mo application were observed in the second year (1999/2000). In the third year (2000/01), maximum of 15.54 t/ha of head yield was obtained with 2.5 kg Mo application and minimum (11.75 t/ha) were by control. Statistically nonsignificant difference in head yield among 1 kg Mo (13.18 t/ha) and 1.5 kg Mo/ha (13.77 t/ha) and, 2 kg (14.94 t/ha) and 2.5 kg Mo/ha (15.54 t/ha) were observed. Three years mean indicates that increasing the levels of Mo to the cabbage plants there was increasing trends of cabbage head yield. A maximum of 18.22 t/ha of heads were produced when 2.5 kg/ha of Mo was applied which was almost 47.8% higher yield to those produced by control. Soil nutrient status is given in Table 3.

Table 1. Effect of molybdenum levels on the growth of cabbage (3 years' mean)

Mo, kg/ha	Plant height, cm	Head diameter, cm	Head weight, g/plant	Increment in head wt, %
0.0	23.94	11.39	471.0	0.00
1.0	23.03	11.32	500.0	6.10
1.5	23.47	11.60	525.3	11.50
2.0	23.71	11.68	531.0	12.70
2.5	24.00	11.94	551.6	17.10
CV, %	3.0	4.1	2.4	
F test	ns	ns	**	
LSD (0.05)	1.35	0.90	23.7	

Table 2. Effect of Mo levels on the head production of cabbage for 3 consecutive years

Mo, kg/ha	Head weight, t/ha			Mean, t/ha	Increment over control, %
	1998/99	1999/2000	2000/01		
0.0	15.18	10.03	11.75	12.32	00.00
1.0	17.27	10.35	13.18	13.60	10.38
1.5	21.49	12.50	13.77	16.47	33.68
2.0	22.12	15.19	14.94	17.41	41.31
2.5	22.21	17.06	15.54	18.22	47.88
CV, %	6.3	19.3	2.8	2.1	
F test	**	*	**	**	
LSD (0.05)	3.46	4.74	1.06	0.62	

**, * Significant at 1 and 5% levels.

Table 3. Soil nutrient status of the experimental site before experimentation

Mo, kg/ha	Organic matter, %	Nitrogen, %	Phosphorus, kg/ha	Potassium, kg/ha
0.0	5.00	0.163	186.66	119.00
1.0	4.24	0.171	175.66	163.33
1.5	5.00	0.150	180.66	104.00
2.0	3.48	0.169	154.00	86.00
2.5	4.42	0.165	204.50	48.50

CONCLUSION

Increasing trend on plant height and head size (diameter) of cabbage was found with molybdenum (Mo) application. Three years mean head yield indicates that maximum yield (18.22 t/ha) could be produced when 2.5 kg/ha of Mo was applied which was approximately 47% higher than control. It is recommended to apply 2.5 kg/ha of molybdenum in acid soils of Malepatan.

REFERENCES

- Chatterjee SS. 1986. Cole crops. **In:** *Vegetable crops in India* (TK Bose and SG Som, eds). Naya Prokash, 206 Bidhan Sarani, Calcutta, India. Pp.165- 247.
- Chatterjee R. 1990. Cabbage. **In:** *Nutrition of vegetable crops* (SK Mitra, MK Sadhu and TK Bose, eds). Naya Prokash Publishers, 206 Bidhan Sarani, Calcutta, India. Pp.114-132.
- Gomez KA and AA Gomez. 1984. *Statistical procedures for agricultural research*. Second Edition. A Wiley Inter-science Publication, John Wiley and Sons, New York. 680p.
- Joshi D. 1997. *Soil fertility and fertilizer use in Nepal*. Soil Science Division, NARC, Khumaltar, Lalitpur, Nepal. 82p.
- Pandey IR. 1998. *Improved technology on vegetable production (farmer's guide)* (in Nepali). Udaya Research and Development Services (URDS), Kathmandu. 182p.
- Pun L and BB Karmacharya. 1988. Vegetable production techniques. **In:** *Trainer's Manual (Vegetables)*. Manpower Development Agricultural Project (MDAP), Department of Agriculture, Kathmandu. Pp.109-303.
- Prakash V and SN Bhardwaj. 1965. *Indian J. Hort.* 22:349-350.
- Tindall HD. 1983. *Cruciferae. Vegetables in the tropics*. English Language Book Society. 533 p.

Efficacy of Growth Regulators on In Vitro Microtuberization of Potato (*Solanum tuberosum* L.) under Different Incubation Conditions

Binesh M Sakha and AK Bhatia

PRP, NARC Khumaltar

ABSTRACT

A study was conducted in 2000/01 to identify the superior medium and incubation condition for in vitro microtuberization in potato. In vitro potato plantlets of Kufri Chandramukhi, Kufri Jyoti and Kufri Badshah were produced on shoot propagation medium (MS+2.0 ppm calcium pantothenate + 0.01 ppm NAA+2.5 ppm GAO in liquid phase using single nodal cuttings as explants. After four weeks of incubation under 16 hr Photoperiod at 24± 1°C, shoot propagation medium was replaced with five different tuber induction media, viz MS+8% sucrose+ 10 ppm AM, MS+8% sucrose+5 ppm KIN, MS+8% sucrose +500 ppm CCC, MS+8% sucrose+5ppm BA+ 500 ppm CCC and MS+ 8% sucrose only. These cultures were, then, subjected to three different incubation conditions –16 hr photoperiod at 24±VC, 8 hr photoperiod for a week followed by darkness at 20±PC and continuous darkness at 20±VC for two month. Tuber induction media with 500 ppm Cycocel gave the highest microtuberization (71.1%) and yield (202 mg per plant) of microtubers. Incubation condition of continuous darkness at 20± VC gave the highest (81.3%) microtuberization and maximum number (2.3) and yield (197 mg) of microtubers per plant.

Key words: Growth regulators, in vitro microtuberization, incubation, potato

Evaluation of Rootstocks on Mandarin (*Citrus reticulata* Blanco) with Respect to Vigor and Citrus Decline in Pokhara

Tej K Lama and Padam P Shrestha

Plant Pathology Division, NARC, Khumaltar

ABSTRACT

The influence of rootstocks on Pokhara mandarin (*Citrus reticulata*, Blanco) with respect to tree vigor and its decline management towards citrus decline for the period of 10 years have been studied. The rootstocks *C. volkameriana*, Troyer citrange, *Citrus macrophylla* and *Carriosa citrange* were better than other in Pokhara condition.

Key words: Rootstock, mandarin, citrus decline

INTRODUCTION

Among the various factors responsible for citrus decline, rootstock plays a key role. It not only influences the horticultural characters, like plant growth but also influence bearing yield and fruit quality etc. Considering the effect of rootstocks on scion, the study was for the first time initiated in Nepal for citrus at Horticulture Research Station, Pokhara and laid out in the year of 1975. The objective of the study is to observe performance and merits of different rootstocks for Pokhara mandarin (*Citrus reticulata*, Blanco). The observation have been taken so far regarding the influence of rootstocks on tree vigor, stock/scion circumference, stock/ scion ratio, height, volume and decline systems.

MATERIALS AND METHODS

In this studies altogether six rootstocks severed as treatments with three replications. One plant in each treatment and replication constitute a plot. The rootstocks selected for this study are Local rough lemon (*Citrus aurantium* L.), Rangpur lime (*Citrus limonia*), *Citrus volkameriana*, Alemow (*Citrus macrophylla* Western), Troyer citrange (*Poncirus trifoliata* x *C. sinensis*) and Carrizo citrange (*Poncirus trifoliata* x *C. sinensis*). Observations on growth performance were measured at fixed level, below and above the graft union. The tree spread was measured at North-South and East- West direction. The height of the tree was recorded from the ground level. The data presented on rootstocks influence on different aspects for the period of 10 years are based on the observation from year of (1975-76 to 1984-85). All sorts of cultural operations were carried out as needed. Foliar applications of sulphate of zinc, manganese, ferrous and boron were given twice a year to avoid nutrient deficiency during the major flush period.

RESULTS AND DISCUSSION

Stock girth

The data presented in Table 1 indicate that the increment in stock girth is higher in *C. volkameriana*, Carrizo citrange, Troyer citrange than rough lemon, Rangpur lime and *C. macrophylla*. An increase in stock girth has been noticed.

Table 1. Stock girth (cm) of different rootstock over years

Rootstock	1975/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	1984/85	Mean
Rough lemon	7.2	20.4	25.6	28.0	38.8	46.0	46.0	46.3	46.3	46.5	35.11
Rangpur lime	9.6	22.4	27.6	28.0	38.8	45.0	45.0	45.0	46.0	46.0	35.94
C. volkameriana	12.8	28.8	32.6	33.6	39.2	47.6	48.0	48.0	48.3	50.3	38.92
C. macrophylla	8.8	20.0	27.6	29.6	36.0	36.3	37.5	38.0	38.8	48.0	32.06
Troyer citrange	8.8	20.0	24.4	26.4	42.6	45.0	46.0	46.6	50.0	50.3	36.01
Carrizo citrange	8.8	24.8	30.4	38.8	42.6	43.6	44.4	45.0	45.0	48.8	37.22
Mean	9.33	22.73	28.03	30.73	39.67	43.92	44.48	44.82	45.73	48.27	35.76

Table 2. Scion girth (cm) of different rootstock over years

Rootstock	1975/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	1984/85	Mean
Rough lemon	5.2	16.8	20.4	22.4	31.6	37.6	39.6	40.0	40.2	40.6	29.39
Rangpur lime	7.2	18.0	23.2	24.0	34.0	38.0	39.0	40.0	40.0	42.9	27.13
C. volkameriana	10.4	23.2	28.0	28.0	23.4	40.3	40.6	42.6	44.6	44.6	33.65
C. macrophylla	6.0	13.2	25.2	25.2	27.5	32.5	35.0	35.5	39.0	44.0	28.31
Troyer citrange	6.0	16.4	19.6	22.4	32.0	37.2	38.6	39.0	39.6	41.6	29.24
Carrizo citrange	6.0	16.8	23.6	28.0	33.6	34.3	35.2	36.1	37.4	40.0	29.10
Mean	6.8	17.4	23.33	25.0	32.18	36.6	38.17	38.87	40.4	42.28	29.47

Table 3. Scion/stock ratio of different rootstock over years

Rootstock	1975/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	1983/84	1984/85	Means
Rough lemon	0.72	0.78	0.80	0.80	0.80	0.81	0.82	0.86	0.86	0.87	0.81
Rangpur lime	0.75	0.80	0.82	0.84	0.85	0.85	0.86	0.86	0.86	0.87	0.84
C. volkameriana	0.80	0.81	0.83	0.84	0.84	0.86	0.87	0.88	0.88	0.92	0.85
C. macrophylla	0.66	0.68	0.74	0.85	0.90	0.91	0.92	0.93	0.94	0.95	0.85
Troyer citrange	0.68	0.75	0.80	0.82	0.83	0.84	0.84	0.85	0.86	0.86	0.82
Carrizo citrange	0.67	0.68	0.72	0.75	0.75	0.77	0.78	0.81	0.83	0.84	0.76
Mean	0.71	0.75	0.79	0.82	0.83	0.84	0.85	0.87	0.87	0.89	

Table 4. Height (m) of different rootstock over years

Rootstock	1975/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	1983/84	1984/85	Mean
Rough lemon	0.56	1.64	1.81	3.23	3.51	3.65	3.73	3.75	3.80	3.95	2.96
Rangpur lime	0.88	1.89	2.50	3.28	3.31	3.33	3.34	3.35	3.38	3.49	2.88
C. volkameriana	1.30	2.40	3.00	3.61	3.67	3.70	3.85	3.87	3.88	4.20	3.35
C. macrophylla	0.74	1.33	2.57	2.22	3.28	3.30	3.37	3.50	3.85	4.39	2.85
Troyer citrange	0.68	1.60	2.45	2.93	3.77	3.91	4.09	4.12	4.15	4.55	3.23
Carrizo citrange	0.67	1.96	2.74	3.06	3.31	3.35	3.48	3.67	3.83	3.88	3.07
Mean	0.81	1.80	2.57	3.76	3.48	3.54	3.64	3.71	3.82	4.08	3.06

Table 5. Volume (m³) of different rootstock over years

Rootstock	1975/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	1983/84	1984/85	Mean
Rough lemon	0.04	1.97	2.85	8.84	9.44	13.99	15.87	17.87	19.13	20.79	11.08
Rangpur lime	0.15	1.82	5.21	9.8	1049	12.04	12.08	12.93	13.21	13.30	9.10
C. volkameriana	0.47	3.64	7.09	12.62	13.05	14.52	15.94	16.91	18.58	19.15	12.20
C. macrophylla	0.06	0.96	5.12	5.72	1207	12.19	14.14	14.15	16.93	18.92	10.03
Troyer citrange	0.07	1.44	4.80	11.42	13.37	16.90	18.65	19.96	20.27	21.19	12.81
Carrizo citrange	0.07	2.37	6.94	9.06	10.06	11.27	11.74	13.26	14.14	18.88	9.79
Mean	0.14	2.03	5.34	9.58	11.25	13.49	14.74	15.85	17.03	18.71	10.83

Table 6. Critical differences

Rootstock	Stock girth, cm	Scion girth, cm	Scion/stock ratio	Height, m	Volume, m ³
CV, %	6.42	7.5	4.10	6.48	13.41
CD (5%)	4.84	4.65	4.90	0.42	3.05
Years					
CV, %	35.47	38.66	6.75	34.00	59.41
CD (5%)	18.15	16.65	0.08	1.52	9.19

Scion girth

The data presented in Table 2 indicate that the increment in scion girth is higher in *C. volkameriana* and medium in Rangpur lime, while it is lesser in rough lemon, Troyer citrange, Carrizo citrange and *C. macrophylla*. An increase in scion has been noticed.

Scion/stock ratio

The data presented in Table 3 indicate that increment in *C. volkameriana*, *C. macrophylla* is higher and medium in Rangpur lime and Troyer citrange, while it is lesser in Carrizo citrange.

Tree height

The data presented in Table 4 indicates that the increment in the tree height is comparatively higher in *C. volkameriana*, Troyer citrange, *C. macrophylla* and citrange, medium in rough lemon and Rangpur lime. The year wise data an increase in tree volume has been noticed.

Tree volume

The data presented in Table 5 indicate that the increment in tree volume is comparatively higher in Troyer citrange, *C. macrophylla* and Carrizo citrange, while medium in Rangpur lime and rough lemon. In An increase in tree volume has been noticed.

Rootstock evaluation

C. volkameriana, troyer citrange and *C. macrophylla* are comparatively performing well in all respects to tree vigor but a slight foot rot development recorded in *C. volkameriana*. Certain plants on rough lemon and Carrizo citrange stocks also developed systems of decline (greening).

ACKONWLEDGEMENT

The authors are grateful to Dr Pits, USAID/Nepal for providing necessary rootstocks.

Exploration of Saffron (*Crocus sativus* L.) Cultivation under High Hills Condition

BN Chaudhary¹ and Yam R Pandey²

¹ Agriculture Research Station, Rajikot, Jumla

² Agriculture Research Station, Lumle

ABSTRACT

The experiment was conducted at Agriculture Research Station, Rajikot, Jumla during 1997/98 - 1999/00. The main objectives of the study were to evaluate the different sizes of saffron bulbs (corms) for flower yield and to explore the economic method of saffron cultivation for the income generation of high hills farmers of Nepal. For the evaluation of different sizes of mother corms, four treatments viz. less than 5 g, 5-10 g, 10-15 g and more than 15 g bulb sizes were evaluated for flower and bulb yields. The economic analysis of input cost and net return, input cost and return ratio were analyzed for both traditional and artificial methods of saffron cultivation separately. The treatments had significant differences for flower and bulb yields in three years of the experiment. The highest number of flowers 11700, 10665 and 11640 per ropani was received from the treatment more than 15 g bulb size in first, second and third years respectively and the lowest from less than 5 g bulb size. Similarly, the highest bulb yield 390, 493 and 445 kg per ropani was obtained from bulb size and more than 15 g and lowest from less than 5 g. In three consecutive years higher net returns (Rs 97,700/ropani) was gained from artificial method than traditional method of saffron cultivation (67,300/ropani). Similarly, input cost and return ratio was also observed higher (1:2.5) in artificial method than traditional (1:2). The flower yield was higher in each consecutive year in artificial method than traditional method. In third year, 13000 flowers/ropani were obtained from artificial method and 5466/ropani from traditional method. Corm (bulb) yield was also higher (500 kg/ropani) in artificial method than traditional (400 kg/ropani). Thus, the results recommend for planting of higher sizes of mother bulbs with artificial method of saffron cultivation.

Key words: Artificial method, flower, saffron, traditional method

INTRODUCTION

Saffron (*Crocus sativus* L) is believed to be native of Eastern Greece. It is the triploid form of a species *Crocus cartwrightianus* found in Eastern Greece. Because of triploid, saffron is necessarily sterile and its beautiful flowers cannot produce any seeds. Propagation is possible only via corms. Today, saffron is cultivated in Spain, Iran, India (Kashmir), Italy and Japan. In Nepal, cultivation of saffron has started in Jumla, Makawanpur (Daman) and Lalitpur (Godavari). Saffron favors cold climate. It can be cultivated in an altitude of 1500 m to 2500 m with average temperature of 15°C and average rainfall 600-1000 mm. It requires well-drained sandy soil with slightly alkaline.

Saffron has lavender flower, blooms in fall and bears fragrant stigma tips that are dried to make the spice saffron. Flowers reach 5 inches high and the narrow blade like leaves with 12 inches long. Saffron bears bulbs (corms) like onion and garlic. Each bulb produces 6-9 leaves and bears violet flowers. Saffron flowers bear stigmas, also called style (central part of a flower, female sexual organ) that is dried to make the spice saffron and also stamina (male sexual organ), which do not have any taste for their own. The intensive color of saffron is caused by carotenoids especially crocetin esters. Saffron has very intensively fragrant, slightly bitter in taste. Saffron turns into a bright yellow-orange solution immediately after soaking in warm water.

Saffron is the most expensive spice in the world. It is also very intensive and therefore used in minute amount. Half a teaspoon (1/5 g) of saffron is, for example, enough for one liter of saffron pudding. Saffron is used for several dishes to make it tasty and as a coloring agent for high value foods. It is also used in sweets, yoghurt, rice

dishes and cakes. Saffron is more important in Central Asia and Southern India, where it is used extensively for rice dishes. Indian and Nepali (*Kheer*, *Rashmalai*) are sometimes prepared with saffron. It is also used for several Mediterranean dishes. In addition, saffron is also used for various medicines especially for colds and heart diseases. This study was taken with the objectives to evaluate the different sizes of saffron for higher production and to explore the economic method of saffron cultivation for the income generation of high hills farmers of Nepal.

MATERIALS AND METHODS

Experiment 1. Experiment on corm (mother bulb) size of saffron

This experiment was conducted at Agriculture Research Station, Rajikot, Jumla during 1997/98-199/00. The experiment was laid out in randomized complete block design (RCBD) with four replications. The treatments were the bulb sizes <5 g, 5-10 g, 10-15 g and >15 g. The crop was planted in September (Bhadra) and saffron flowers and bulbs were harvested in November and April respectively in three experimental years. The plot size of each treatment was 1.5- × 1.0-m with 15- × 10-cm spacing.

Experiment 2. Economic analysis of saffron cultivation

Traditional method

This experiment was conducted in Agriculture Research Station, Rajikot, Jumla during fiscal year 2054/055 to 2056/057 (1997/98 to 1999/2000). A total of 500 saffron bulbs (mother corms) of 5 g bulb size were planted in Bhadra (September). Five beds were prepared each with 1.5- × 1.0-m × 30-cm and 100 bulbs were planted in each bed with 15- × 10-cm spacing. A basal fertilization of N:P:K 30:30:100 kg/ha and compost 1 t/ha were applied. Flowers were harvested early in the morning in the month of Kartik/Mangsir (October/November) and data were analyzed. Details are given in Annex 1.

Artificial method

This experiment was also conducted during the same period as traditional method. Under this method also 500 bulbs (mother corms) were kept inside the room on the table. Outer layer of the bulbs were removed before keeping it on the table to facilitate the flower stalk emergence. Bulbs were kept inside the room in September and flowers were harvested in October. Bulbs were kept moist by sprinkle water. Immediately after harvesting the flower, bulbs were planted in the field for multiplication. Before planting the bulbs bud selection were done according to bulb sizes. Usually only one bud was kept in less than 10 g of bulb and two buds for 20 g of bulb. Saffron corms were harvested in April and stored in the room till September. Room cultivation was done for flower yield and field cultivation for the bulb multiplication. Flower yield and bulb yield were recorded for analysis.

RESULTS AND DISCUSSION

Experiment on corm (mother bulb) size of saffron

The results are presented in Table 1. The treatments had highly significant differences for flower and bulb yields. The highest number of flowers (500 m²) 11700, 10665 and 11640 per ropani was obtained from the treatment >15 g bulb size planted in first, second and third experimental years respectively. The lowest number of flowers 46, 66 and 62 per ropani was received from the treatment <5 g in three consecutive experimental years respectively.

Table 1. Yield of saffron flower and bulb obtained from different bulb size planted during 1997/98 – 1999/00.

Treatment, g	First year (1997/98)		Second year (1998/99)		Third year (1999/00)	
	Flower per ropani, n	Bulb per Ropani, kg	Flower per ropani, n	Bulb per ropani, kg	Flower per ropani, n	Bulb per ropani, kg
<5	46	86	66	105	62	95
5-10	1830	190	2334	186	2054	192
10-15	7200	240	5466	257	6030	248
>15	11700	390	10665	493	11640	445
F test	**	**	**	**	**	**
CV, %	12.7	5.56	11.2	6.8	15.18	3.7

Value with same letter are not significantly different at 0.05 level.

Similarly, the highest bulb yield 390, 493 and 445 kg per ropani was received from bulb size of > 15 g in three consecutive experimental years respectively. The lowest bulb yield 86, 105 and 95 kg per ropani was obtained from bulb of < 5 g in three years respectively. The results of the experiment revealed that flower and bulb yields depend upon the size of the saffron bulb planted.

Economic analysis of saffron cultivation

The results are presented in Tables 2 and 3. The input cost and return were calculated on the basis of present local market price. The input cost calculated for three consecutive years (1997/98 to 1999/00) was higher (Rs 66,000/Ropani) in artificial method of saffron cultivation than traditional method (Rs 62,000/Ropani). The net return in three consecutive years was more (Rs 97,700/Ropani) in artificial method of saffron cultivation than traditional method (Rs 67,300/Ropani). The input cost and return ratio was higher (1:2.5) in artificial method than traditional method (1:2).

Table 2. Cost and returns analysis of saffron cultivation (based on traditional method)

A. Input cost for 1 ropani (500m²) in Rs											
S N	Input	First year			Second year			Third year			Total cost
		Unit	Rate	Amount	Unit	Rate	Amount	Unit	Rate	Amount	
1	Mother bulbs	150kg	300	45000	-	-	-	-	-	-	45,000
2	Fertilizer Nitrogen	1.5kg	100	150	1.5kg	100	150	1.5kg	100	150	450
	Phosphorus	1.5kg	100	150	1.5kg	100	150	1.5kg	100	150	450
	Potassium	5.0kg	100	500	5.0kg	100	500	5.0kg	100	500	1,500
	Compost	40 Doko	30	1200	40 Doko	30	1200	40 Doko	30	1200	3,600
3	Labor	50	100	5,000	30	100	3,000	30	100	3,000	11,000
	Total			52,000			5,000			5,000	62,000

B. Returns

SN	Description	First year			Second year			Third year			Total return
		Unit	Rate/unit	Amount	Unit	Rate	Amount	Unit	Rate	Amount	
1	Saffron flower, n	1866			2334			5466			
	Saffron	13 g	50	650	16 g	50	800	37 g	50	1850	3300
2	Saffron bulb	-	-	-	-	-	-	400kg	300	120,000	120,000
3	Inter crop (beans)	50 kg	40	2000	50kg	40	2000	50kg	40	2,000	6,000
	Total			3,750			4,500			123850	129300

Net returns in three years, Rs = 129,300 – 62,000 = 67,300. Input cost and return ratio = 1:2.

The reason for gaining high net returns and more input cost and return ratio in artificial method of saffron cultivation is that in this method bulb multiplication is done every year after the bud selection per bulb according to their sizes. Hence, more number of flowering bulbs are produced. In traditional method of saffron cultivation bulbs are harvested in 4-5 years and bud selection are not possible. Total bulbs are produced more in number but higher sizes of bulbs produced less and vice versa in artificial method.

The flower yield was obtained higher in each consecutive year in artificial method than traditional method of saffron cultivation. In third year 13000 flowers/ropani were obtained from artificial method and 5466 flowers/ropani from traditional method. Bulb yield was also higher in third year (500 kg/Ropani) in artificial method than traditional method (400 kg/Ropani).

The results suggest that saffron cultivation is not economical in first and second planting year because of flowering bulbs are less number of bulbs in initial years. More than 10 g of saffron bulb size produces economic flowers (Pandey 2000, Chaudhary 2001).

Table 3. Cost and returns analysis of saffron cultivation (based on artificial method)

A. Input cost in 1 ropani (500m²) in Rs											
SN	Input	First year			Second year			Third year			Total cost
		Unit	Rate	Amount	Unit	Rate	Amount	Unit	Rate	Amount	
1	Mother bulbs	150kg	300	45000							45,000
2	Fertilizer Nitrogen	1.5 kg	100	150.0	1.5 kg	100	150.0	1.5 kg	100	150.0	450.0
	Phosphorus	1.5 kg	100	150.0	1.5 kg	100	150.0	1.5 kg	100	150.0	450.0
	Potash	5.0 kg	100	500.0	1.5 kg	100	500.0	5.0 kg	100	500.0	1500.0
	Compost	40 Doko	30	1200	40 Doko	30	1200	40 Doko	30	1200	3,600
3	Labor	50	100	5,000	50	100	5,000	50	100	5,000	15,000
	Total			52,000			7,000			7000	66,000

B. Returns (Rs)

SN	Description	First year			Second year			Third year			Total return
		Unit	Rate	Amount	Unit	Rate	Amount	Unit	Rate	Amount	
1	Saffron flower, n	2100			8000			13000	-	-	-
	Saffron	14 g	50	700	55 g	50	2,750	85 g	50	4250	7700
2	Saffron bulbs (corms)							500 kg	300	150,000	150,000
3	Additional crop (beans)	50 kg	40	2000	50 kg	40	2000	50 kg	40	2,000	6,000
	Total			2,700			4,750			156,250	163,700

Net returns in three years, Rs = 163700 – 66,000 = 97,700.00. Input cost and return ratio = 1:2.5.

Artificial method of saffron cultivation is to maximize returns from the crop. However, in this method more skilled is required. The author experienced that net returns per unit area may differ with mother bulb sizes planted in initial year and crop management practices as well.

REFERENCES

- Pandey YR. 2000. Adaptive research on saffron cultivation under high hill condition of Nepal. **In:** *HARP Annual technical report*.
- Chaudhary BN. 2001. Adaptive research on saffron cultivation under high hill condition of Nepal. **In:** *Annual technical report*.

Annex 1. Methods of saffron cultivation

A. Traditional system

Under this method, saffron flowers are harvested every year but bulbs are harvested only after 4 -5 years. Cultivation practices of saffron are given below.

Preparation of beds/ridge

Length : as required
Width : 1-1.5 m
Height : 30 cm with slope

Manure and fertilizers

Compost (FYM) : 40 *Doko* per Ropani
Nitrogen : 1.5 kg per Ropani
Phosphorus : 1.5 kg per Ropani
Potash : 5.0 kg per Ropani

1 *Doko* = 25 kg, 1 Ropani = 500 m².

Planting methods (bulbs/corms)

Planting time : Bhadra (September)
Row-to-row distance : 15 cm
Bulbs-to-bulb distance : 10 cm
Depth of bulb : 30 cm
Weight of bulb : More than 5 g
Seed rate : 150 kg per Ropani

Flower harvesting

Time : Kartik/Mangsir (Oct/Nov)

Method

Flower are harvested early in the morning within 24 hours of flowers bloomed. After harvesting the saffron flowers, plucked off the bright color tips-the stigmas inside the flowers and dry to store. It is generally stored in airtight bottle after packing saffron in transparent paper.

Yield, kg/ha

India : 2
Spain : 4-5
Nepal : 1
(150,000 flowers of dried saffron = 1 kg).

Intercropping

Saffron flowers are harvested in Oct/Nov (Kartik/Mangsir) and bulbs are multiplied and developed till April (Baisakh). Bulbs are either harvested in April or left to the field for next year flowering. From April to September, bulbs are remained dormant and during this period leguminous crop like peas and beans can be cultivated as an additional benefit and for soil improvement as well.

Bulbs/corms production

Bulbs/corms are harvested after 4-5 years under traditional method but every year under artificial method. Bulbs are harvested in April (Baisakh) and dried under room condition. Bulbs are separated in September under different weight groups and then it is planted. In general, it produces 2-4 times more bulbs than mother bulbs.

B. Artificial method

Under this method flowering bulbs (more than 10 g weight) are flowered inside the room and then bulbs are planted in field for its multiplication. Different sizes of bulbs (usually more than 10 g) are kept inside the room on the table in the month of September and flowers are harvested on October. Immediately after flower harvesting the bulbs are planted in the field. Before planting the bulbs, care should be taken on buds selection. Usually one bud is kept in 10 gram of bulb size, two buds in 20 gram of bulb size, and three buds in 30 gram of bulb size and so on. By this many numbers of flowering bulbs can be obtained according to the bud kept. If it is not done, number of small bulbs will be more but number of flowering bulbs will be less. Other cultivation practices are same as practiced in a traditional system.

Farmers' Perception and Reaction to Various Green Manure Species: Results of a Participatory Research Conducted in Chitwan and Nawalparasi districts

DP Sherchan, B Emmett, P Stevens and FL Sinclair

NMRP, NARC, Rampur Chitwan

ABSTRACT

The importance of green manure to sustain crop production and to improve soil quality has been known for some time and highlighted in recent years. Indigenous species suitable for use as green manure in the hills of Nepal have been identified and evaluated for their efficacy for increasing crop production, however, the adoption of green manure technology throughout the country is not very satisfactory. The adoption of green manure technology may be enhanced if farmer's perceptions are known since the choice of technology depends upon many factors. Therefore, the aim of the participatory on farm research was to acquire farmers' perception and reaction regarding the use of green manure species. Three clusters, two from Chitwan and one from Nawalparasi districts were selected respectively. The study area represents a very intensive agriculture. From each cluster, 18 volunteer farmers were chosen representing three-wealth class based on food sufficiency. Each farmer was given two packets of green manure species, which are sufficient for 0.033 ha of land (one ropani). The green manure species were wild sunflower (*Tithonia diversifolia*), sunhemp (*Crotalaria juncea*), rice bean (*Vigna umbellata*) sesame (*Sesamum indicum*) and dhaicha (*Sesbania cannabina*). The majority of participating farmers reported that green manures have a beneficial effect on rice yields. The priority of ranking criteria for green manure crops are: growth rate, decomposition properties, amount of biomass production, effect on rice yield and effect on companion crop when grown under relay system. However, the important preference criterion for green manure is, it should fit into the current crop rotation. The major constraints associated with the adoption of green manure technology as expressed by the participating farmers are the availability of seeds and labour required to incorporate biomass into the field. *Tithonia* requires more time to produce the same amount of biomass. In addition, *tithonia* is quite susceptible to water logged condition and germination of seeds is a problem. Therefore the cut and carry system is more acceptable to farmers than in situ production. To promote the green manure technology seeds source be secured first for that a market opportunity should be developed.

Key words: Farmers' perception, green manure, participatory research, Chitwan, Nawalparasi

Identification of Appropriate Planting Time for Rainy Season Tomato Production in the Hills of Nepal

Kalika P Upadhyay, Khadga B Poudel, Ishwori P Gautam, Jeet N Chaudhary and Bhogendra Khatri

RARS, Lumle Kaski

ABSTRACT

A field experiment was conducted at two agro-ecological research sites (AER sites) of the Regional Agriculture Regional Station, Lumle, namely Chambas in Tanahun (riverbasin) from 1999 to 2002) and Deurali in Palpa (mid-hill) from 2001 to 2002. The main objective of the experiment was to find out the appropriate planting time for rainy season tomato production in the hills. Treatments were planting dates of tomato (15th May, 1st June, 15th June and 1st July in Chambas and 15th May, 1st June, 15th June, 1st July, 15th July and 1st August in Deurali). Planting was done at fifteen-day interval starting from 15th May to 1st July in Chambas and from 15th May to 1st August in Deurali. The treatments were laid out in a RCBD and replicated five times considering farmer as a replication. Seedlings of tomato genotype BL-410 (thirty-day-old) were used for planting. Observations were recorded on days to first flowering, days to first harvesting, days to last harvesting, marketable fruit yield (t/ha) and unmarketable fruit yield (t/ha). The pooled analysis of data over year at both sites separately indicated that the marketable fruit yield was significantly higher on fifteenth May planting (22.0 t/ha in Chambas and 19.25 t/ha in Deurali) than the other planting dates. Similarly, unmarketable fruit yield was also significantly higher on fifteenth May planting (1.57 t/ha in Chambas and 3.1 t/ha in Deurali). However, planting on first July took a shorter time for first flowering (10.6 days), first harvesting (29.3 days) and last harvesting (41.7 days) in Chambas where as, in Deurali, there was no significant difference between planting dates on first flowering and first harvesting but first June planting took a significantly longer time (92.5 days) for the last harvesting.

Key words: Hills, planting time, rainy season, tomato

INTRODUCTION

Tomato (*Lycopersicon esculentum*, Miller) is one of the most important cash generating vegetable crops particularly in the hills of Nepal. It has been described as a versatile commodity that can be eaten fresh or processed for a wide range of product, and equally processing a seemingly endless number of ways. It can also be utilized to improve the flavors characters of other foods (Villareal 1980). Its area coverage, production, and productivity in the world is 3,98,589 ha, 108,499,056 tons and 27.2 tons per hectare respectively (FAO 2002). Similarly, in Nepal, it has 10530 hectare of coverage, 72657 metric tons of production and 6.9 tons per hectare of productivity (Bhurtyal 2001). Tomato is grown in the *terai* during winter but supply of the produces to the local and national markets during summer and rainy season is not sufficient. Due to high temperature and heavy rainfall the production of tomato in *terai* during summer season is not possible. The change in food habit of the people and development of highways and feeder roads in the hills, demand for tomato in emerging market and established market and higher farm gate price are the important factors for increasing potentiality of tomato cultivation in the hills of Nepal. In the hills, tomato can be grown in two distinct seasons i.e. spring-summer (Feb-June) and rainy season (June-September). With development and adoption of off-season specific package of practices, the production and productivity of tomato can be enhanced to a considerable extent. Considering these facts, availability of tomato in the market through out the year to fulfill the national demand has been noted.

Rainy season tomato in the hills has tremendous potential for income generation and employment generation for resource poor hill farmers. Prices are unpredictable from season to season, however, tomato has the good profit

potential for hill farmers who produce high quality fruit and market effectively during rainy season. It has been experienced that the price of tomato in the market increases from mid July to October. Thus, rainy season tomato in the hills fetches off-season market enabling farmers to realize very attractive market price, which is obviously a more profitable business opportunity for those hill people.

Maximum day and night temperatures above 32°C and 21°C are known to limit fruit set due to an impairs complex of physiological processes in the pistil resulting in floral bud and fruit abscission where as incidences of bacterial wilt causes considerable to complete yield loss of the crop (Bhattarai and Subedi 1996). Similarly other diseases like septoria leaf spot, buck eye rot, tomato yellow leaf curl virus (TYLCV) etc. are also constraining the crop production during the season. At temperatures above 35°C yield decline is reported and photosynthesis seems to be affected by stomatal conductance as well as by mesophyll resistance (Bar-Tsur et al 1985). Other studies on tomato plant show that water stress causes a decrease in transpiration, an increase in foliage temperature and a closure of stomata (Tan 1993).

The heavy tropical rains tend to cause mechanical damages especially to flowers and coupled with the high humidity that prevails create an environment conducive to infections and infestations by diseases and pests (Nongkas 1994) Hot humid climate and heavy rainfall during the season favor higher incidence of above mentioned diseases. High rainfall is one of the main causes to occur *Fusarium* wilt. High moisture in soils and flooding cause damping off and diminish the rate of establishment of seedlings so that a large number of seedlings are damaged and a lot of resources are wasted. Soils become saturated from rainfall and high moisture and hence pore space in between the soil particles is filled (roots of tomato require aeration but adhesion of soil particles or blocking of pore space cause reduced aeration).

Tomato production during rainy season is the main option for income generation and employment in the hills, however, the appropriate planting time for it has not been recommended yet. Since rainy season is an off-season for tomato production, any research conducted so far have not recognized much to the aspect of appropriate planting time, there is no recommended planting date for this season and farmers are using same practice as they are following traditionally. Due to their ignorance of planting time for rainy season tomato, they are achieving low yield and poor quality of tomato fruits because of poor establishment and decreased growth of seedlings and lower production of the crop. Therefore, this study attempted to focus on identification of appropriate planting time for rainy season tomato production.

MATERIALS AND METHODS

A field experiment was conducted in a randomized complete block design (RCBD) at the two agro-ecological research sites of the Regional Agricultural Research Station, Lumle namely Chambas in river basin (450 masl) of Tanahun district from 1999 to 2002 and Deurali in mid hill (1200 masl) of Palpa district from 2001 to 2002. The planting dates starting from 15th May to 1st July in Chambas and 15th May to 1st August at in Deurali at fifteen-day interval were considered as treatments for the experiment. The treatments were replicated five times in each site considering farmer as a replication with four treatments in Chambas and six treatments in Deurali. The tomato genotype BL-410 was selected for the experiment. Seedlings were raised in nursery bed and the thirty-day-old seedlings were transplanted in main fields of both sites. Seedlings were uprooted just before transplanting and were transplanted in raised beds. Spacing was maintained at 90 cm between rows and 30 cm between plants. The length of rows was 2.1 m and width of the plot was 3.6 m. (4 rows of 2.1m length). Fertilizers were applied at the rate of 20 tons farm yard manure with 150:60:60 kg N:P:K per hectare. A half dose of nitrogen and full dose of FYM and other fertilizers were applied as basal application where as the remaining half dose of nitrogen was split twice and applied at the time of first flowering and after first harvesting. Basal dose of fertilizers was incorporated in soils before transplanting. Fields were irrigated in drought with farmers' practice. Good drainage was provided in the blocks to remove excess water. One spray of multiplex was given @ 2.5 ml/liter of water at the time of first flowering. Spray of Krylaxil was given to protect the crops against late blight diseases. Other cultural practices were followed as farmers practiced. Detail of treatments is as follows:

Treatments: Planting dates

Chambas (River basin)

1. May 15 th	2. June 1 st
3. June 15 th	4. July 1 st

Deurali (mid-hill)

1. May 15 th	2. June 1 st	3. June 15 th
4. July 1 st	5. July 15 th	6. August 1 st

RESULTS AND DISCUSSION

Days to first flowering

Days to first flowering were recorded on the basis of transplanting dates. Thirty-day-old seedlings were transplanted and flowering days were counted from transplanting dates. The effect of planting dates on days to first flowering in rainy season tomato at the AER site Chambas, Tanahun showed a non significant difference during the years 1999 and 2000 but it showed a significant difference and highly significant difference during 2001 and 2002 respectively.

The pooled analysis of data showed a highly significant difference on days to first flowering. The planting on the 15th May to 15th June has more or less same number of days to first flowering. The 1st July planting has less number of days to first flowering (Table 1a). It could be due to high accumulation of carbohydrate in plant system with response to high light intensity and high temperature. High temperature and high light intensity favors early flowering. Flowering also depends on nutritional status of soil and that of plant body.

At the AER site Palpa, the effect of planting dates on days to first flowering showed a non-significant difference in both years. However, at this site, the days to first flowering was found nearly a week earlier than that at Chambas (Table 1b). It could be due to high nutritional status and moisture content in soils.

Table 1a. Effect of planting dates on days to first flowering in rainy season tomato at the AER site, Chambas, Tanahun, 1999-2002

Planting dates	Days to first flowering				Pooled
	1999	2000	2001	2002	
15 th May	25.6	26.6	38.4	32.4	30.75
1 st June	26.4	26.1	36.4	33.6	30.65
15 th June	25.6	26.1	39.0	32.8	30.87
1 st July	25.2	26.6	-	16.5	22.7
Mean	25.7	26.35	37.9	26.4	29.08
P	ns	ns	*	***	***
CV, %	5.0	1.5	2.3	23.2	14.3
LSD	-		1.521	9.570	6.670

Table 1b. Effect of planting dates on days to first flowering in rainy season tomato at the AER site, Deurali, Palpa, 2001-2002

Planting dates	Days to first flowering		Pooled
	2001	2002	
15 th May	28.4	18.4	23.4
1 st June	26.8	19.8	23.3
15 th June	23.2	19.2	21.2
1 st July	22.2	19.2	20.7
15 th July	26.6	19.2	22.9
1 st August	25.8	19.2	22.5
Mean	25.5	19.17	22.3
P	ns	ns	ns
CV, %	14.1	4.9	13.5
LSD	-	-	-

Days to first harvesting

The period from transplanting of seedlings to first picking was considered as days to first harvesting. Harvesting time from transplanting depends on climatic condition, plant vigor, and occurrence of diseases and pests and nutritional status in the soils and in the plant. The days to first harvesting showed a significant difference due to planting date at the AER site Chambas only in 2001 (Table 2a). The main cause of the significance was non establishment of seedlings in 1st July planting due to heavy rainfall.

Like wise, at the AER site, Deurali, there was a non-significant difference on days to first harvesting in 2002 but significant difference was observed in 2001. The lowest days to first harvesting (50.8 days) was observed on 15th July planting, which was at a par with other planting dates except the 1st June planting (Table 2b).

Table 2a. Effect of planting dates on days to first harvesting in rainy season tomato at the AER site, Chambas, Tanahun, 1999-2002

Planting dates	Days to first harvesting				
	1999	2000	2001	2002	Pooled
15 th May	61.2	76.6	74.2	74.4	71.6
1 st June	61.6	82.0	74.6	77.0	73.4
15 th June	62.4	85.5	71.0	65.6	73.3
1 st July	62.0	103.0	-	77.5	68.6
Mean	61.8	86.8	73.0	70.9	71.7
P	ns	ns	*	ns	ns
CV, %	2.1	13.7	3.8	22.7	16.0
LSD	-		4.777	-	-

Table 2b. Effect of planting dates on days to first harvesting in rainy season tomato at the AER site, Deurali, Palpa, 2001-2002

Planting dates	Days to first harvesting		
	2001	2002	Pooled
15 th May	53.2	52.5	52.63
1 st June	55.6	48.5	52.18
15 th June	51.2	55.25	52.74
1 st July	52.6	48.25	50.41
15 th July	50.8	49.25	49.85
1 st August	55.2	49.0	52.18
Mean	53.1	50.23	51.66
P	*	ns	ns
CV, %	4.4	12.5	9.3
LSD	3.048	--	--

Days to last harvesting

It is important parameter for higher production of tomato especially in indeterminate types. Longer harvesting duration is one of the most important criteria for evaluation of the yield potential of the crop. The days to last harvesting at the AER site, Chambas was found a non-significant difference in 1999 and highly significant difference from 2000 to 2002. The longest period (157.99) for harvesting was recorded on First July planting in 2000, 15th May planting (105.6 days to last harvest) in 2001 and 15th May planting (101.6 days to last harvest) in 2002. The combined analysis of data over the year also showed a significant difference. The longest period (109.1 days to last harvest) for harvesting was observed on 1st July planting date. Where as, the shortest period (99.1 days) for last harvesting was observed on 1st June planting (Table 3a). It could be due to lower incidence of diseases and low rainfall during later stage of the crop.

Similar result was observed at the AER site, Deurali in 2001 and combined analysis of result in 2001 and 2002. Where as, a non-significant result was observed in 2002. The days to last harvesting was found longer in all planting dates during 2002 than 2001 (Table 3b). It could be due to better crop performance and suitable environment.

Table 3a. Effect of planting dates on days to last harvesting in rainy season tomato at the AER site, Chambas, Tanahun, 1999-2002

Planting dates	Days to last harvesting				
	1999	2000	2001	2002	Pooled
15 th May	89.0	128	105.6	101.6	106.0
1 st June	86.2	123.9	98.4	99.2	102.4
15 th June	84.6	116.9	83.0	98.0	99.1
1 st July	86.4	157.9	-	90.0	109.1
Mean	86.5	131.7	96.0	100.1	104.1
P	ns	***	**	**	*
CV, %	3.8	1.4	6.7	6.5	9.3
LSD	-	3.67	11.15	8.91	6.19

Table 3b. Effect of planting dates on days to last harvesting in rainy season tomato at the AER site, Deurali, Palpa, 2001-2002

Planting dates	Days to last harvesting		
	2001	2002	Pooled
15 th May	73.8	97.0	85.44
1 st June	84.2	100.0	92.55
15 th June	78.4	103.0	90.66
1 st July	80.4	99.75	84.33
15 th July	72.0	97.75	84.77
1 st August	71.4	100.0	85.44
Mean	76.7	99.69	88.20
P	***	ns	***
CV, %	4.3	3.7	4.5
LSD	4.316	-	3.604

Marketable yield

It is the most important parameter to achieve maximum profit from rainy season tomato. The effect of different planting dates on marketable fruit yield of rainy season tomato was found a highly significant difference at the AER site, Chambas from 1999 to 2002. Among the different planting dates, 15th May planting date was found better for higher yield of tomato fruit in all the years. There is linear decrease in yield as advance in the planting dates. Heavy clay soils that are compacted and prone to water logging during heavy rains or continued wet weather will adversely affect plants in a way known as de-nitrification (Bodnar and Garton 1997). The combine analysis of data over the year showed that the highest yield (22 t/ha) of tomato fruit was found on 15th May planting. The lowest yield (2.06 t/ha) was recorded on 1st July planting which was at a par with 15th June planting and the 15th June planting was at a par with 1st June planting. The detail result of marketable fruit yield in different years is presented in Table 4a.

Like wise, at the AER site Chambas, there was a significant effect of planting date on marketable fruit yield at the AER site, Deurali. The pooled analysis of the data showed a linear decrease in tomato fruit yield in succeeding planting dates. The maximum yield (19.25 t/ha) was recorded on 15th May planting followed by 1st June planting date (12.64 t/ha). Whereas, the lowest yield (6.23 t/ha) was recorded on 1st August planting. The detail result is presented in Table 4b.

Table 4a. Effect of planting dates on marketable yield in rainy season tomato at the AER site, Chambas, Tanahun, 1999-2002

Planting dates	Marketable fruit yield, t/ha				
	1999	2000	2001	2002	Pooled
15 th May	6.8	22.0	31.0	28.27	22.0
1 st June	6.61	4.10	14.4	8.68	8.43
15 th June	6.01	3.10	1.20	7.59	4.47
1 st July	5.48	2.40	-	0.34	2.06
Mean	6.22	7.9	11.6	11.22	9.2
P	***	**	**	***	***
CV, %	4.8	84.8	49.2	31.4	77.7
LSD	0.410	9.22	7.88	4.853	5.31

Table 4b. Effect of planting dates on marketable yield in rainy season tomato at the AER site, Deurali, Palpa (2001-2002)

Planting dates	Marketable fruit yield, t/ha		
	2001	2002	Pooled
15 th May	24.92	11.57	19.25
1 st June	10.66	14.52	12.64
15 th June	5.10	18.25	11.21
1 st July	5.53	14.65	9.85
15 th July	5.40	12.07	8.63
1 st August	1.42	11.64	6.23
Mean	8.84	13.76	11.30
P	***	***	***
CV, %	16.6	15.1	45.9
LSD	1.931	2.80	4.678

Unmarketable yield

The effect of planting dates showed a highly significant difference on unmarketable fruit yield at the AER site, Chambas in the year 2000, 2001 and 2002 but showed a non-significant effect in 1999. The pooled analysis of data showed the lowest unmarketable fruit yield (0.532 t/ha) on first June planting and highest (1.715 t/ha) on 15th June planting. The highest unmarketable fruit yield was found at a par with 15th May planting. It is undesirable character for higher production of the crop, however, the higher unmarketable yield on 15th May planting date is due to higher tomato fruit production in this planting date. A detail is presented in Table 5a.

At the AER site, Deurali, there is also a higher significant difference on unmarketable fruit yield of tomato due to different planting dates (Table 5b). At this site, higher unmarketable yield (3.1 t/ha) was recorded on 15th May planting followed by 1st June planting (2.66 t/ha) where as the minimum yield (0.33 t/ha) was observed on 15th July planting date. However, this date is not suitable for higher production of tomato due to low marketable fruit yield (8.63 t/ha).

Table 5a. Effect of planting dates on unmarketable yield in rainy season tomato at the AER site, Chambas, Tanahun, 1999-2002

Planting dates	Unmarketable fruit yield, t/ha				
	1999	2000	2001	2002	Pooled
15 th May	0.87	1.11	1.42	2.91	1.577
1 st June	1.44	0.50	0.84	1.72	1.125
15 th June	1.36	0.29	0.22	1.16	1.759
1 st July	1.51	0.38	-	0.24	0.532
Mean	1.29	0.57	0.62	1.51	0.998
P	NS	*	**	***	***
CV, %	42.1	61.8	86.5	34.8	68.9
LSD	-	0.487	0.739	0.723	0.434

Table 5b. Effect of planting dates on unmarketable yield in rainy season tomato at the AER site, Deurali, Palpa, 2001-2002

Planting dates	Unmarketable fruit yield, t/ha		
	2001	2002	Pooled
15 th May	5.76	0.01	3.1
1 st June	4.98	0.03	2.66
15 th June	0.89	0.17	0.46
1 st July	0.84	0.13	0.42
15 th July	0.60	0.24	0.33
1 st August	0.38	1.15	0.61
Mean	2.24	0.28	1.26
P	***	*	***
CV, %	24.3	176.7	115.7
LSD	0.719	0.699	1.318

CONCLUSION

The effect of planting dates on rainy season tomato production was significant for higher yield of tomato. The 15th May planting date was suitable for higher production in river basins and mid hills of the western hills of Nepal. The main reason behind this fact is good establishment of seedlings before onset of monsoon. In later planting dates, heavy rainfall and high moisture favored poor establishment of seedlings, occurrence of damping off, late blight and bacterial wilt diseases. Before 15th May, there is low opportunity to catch higher price due to the competition of the product with spring season crop and there is a possibility of drought with high temperature that causes floral drop (Upadhyay 2002).

ACKNOWLEDGEMENTS

Authors are grateful to the Hill Agriculture Research Project (HARP) for funding HARP-PP-83/99 Project. We would also like to thank Dr RP Sah, former station Chief, for his support and encouragement for carrying out the experiment. We sincerely thank all the member of Horticulture research team, RARS, Lumle, especially Mr Amar Pun, Mr Ramjee Paudel and Mr KP Devkota for their tedious and hard work in trial implementation. Our gratitude and thanks are due to Mr YR Pandey and Dr SR Ghimire for their valuable comments and suggestions for this paper. Our special thanks go to the site

coordinators and recorders of the AER site Chambas, Tanahun and Deurali, Palpa for their painstaking responsibility of trial implementation and daily monitoring. We would like to express our sincere appreciation to Ms Nirmala Sharma, who was the first project leader.

REFERENCES

- Bar-Tsur A, J Rudich and B Bravdo. 1985. High temperature effects on gas exchange in heat tolerant and sensitive tomatoes. *Journal of the American society for horticultural science*.
- Bhattarai SP and PP Subedi. 1996. Assessment of tomato varieties for heat and bacterial wilt tolerance in low hills during 1992/93. *LARC working paper no. 96/36*. Lumle Agriculture Research Centre, Kaski, Nepal.
- Bhurtyal P. 2001. Golbhenda Kheti: Bemausami Utpadanko Sandarbham (Nepali version). *Bimonthly Krishi* Year 30, No. 1 (Vegetable special). Agricultural information and communication centre, Harihar Bhawan, Nepal.
- Bodnar J and RW Garton. 1997. *Fresh-market tomato production*. Ministry of Agriculture and Food, Ontario, Queen's Printer for Ontario. <http://www.gov.on.ca>.
- FAO. 2002. *FAOSTAT Database results*. © Copyright FAO 1990-1998
- Nongkas Alfred. 1994. Fertilizer and mulching trial on processing tomato. *ARC-AVRDC training report 1994*.
- Tan CS. 1993. Tomato yield evapotranspiration relationships, seasonal canopy temperature and stomatal conductance as affected by irrigation. *Canadian Journal of Plant Science*, 73.
- Upadhyay KP. 2002. *Barkhe Golbhendako phool jharne samasya: Karan ra samadhan* (Nepali version). Agriculture Research Station, Lumle, Kaski, Nepal.

Improving Manure Quality and its Use in Maize and Upland Rice Production in the Hills of Western Nepal

Bhaba P Tripathi¹ and Jim Ellis-Jones²

¹ Agriculture Research Station, Lumle PO Box 1, Pokhara

² Silsoe Research Institute Wrest Park, Silsoe Bedford MK45 4HS, England

ABSTRACT

Organic manure is the major source of plant nutrients in the hill farming system of Nepal but the quality of manure is not maintained by the farmers during the storage as well as application in the field. Therefore, the objectives of the study were to enhance the quality of manure and its use in the production of maize and upland rice in the farmers' field in different agro-climate conditions of the western hills of Nepal. Manure heaps or pits practiced by the farmers were covered with black plastic sheets (improved practice) and uncovered (farmers' practice). After two and a half month period, manure samples were taken from both the practices and analysed for nitrogen (N), phosphorus (P) and potassium (K). Covering manure with black plastic sheet significantly increased N content (19%) as compared to farmers' method of preparation at the mid hill (Upper Pakuwa, Parbat) site. Nitrogen (3-9%) and potassium (1-31%) contents increased at high hill (Bhakimli, Myagdi), mid hill (Upper Pakuwa, Parbat), low hill (Lower Pakuwa, Parbat) and river basin (Chambas, Tanahun). With the black plastic cover, phosphorus content increased at high hill (8%) and mid hill (12%) only and decreased at low hill (9%) and river basin (1%) sites. Manures prepared by improved and farmers' methods were applied to the main season maize crop of high hill (Myagdi, >1600-2300 m) and mid hill (Parbat, 1000-1600 m) and spring maize of low hill (Parbat, 900-1000 m) as well as upland rice of river basin (Tanahun, <650 m). Maize grain and stalk yields increased by upto 36% and 31% respectively while upland rice and straw yields increased upto 21% and 17% respectively. The result revealed that covering manure with black plastic sheets increased nutrients (N, P, K) contents, crop yields of maize and upland rice.

Key words: Chemical fertilizer, farmers practice, maize and rice, organic manure

INTRODUCTION

In the hills of Nepal, farmyard manure (FYM) has been the major and traditional source of plant nutrients. Nepalese hill farmers have been recycling FYM and compost (a mixture of crop residues, animal manure, forest litters and other wastes) to maintain soil fertility (Tripathi and Tuladhar 1997). Many farmers feel that continuous application of chemical fertilizers without adding FYM cause the soil to deteriorate and crop productivity is consequently declining (Mathema 1999). Soil and nutrients loss by erosion and leaching has also been contributing to a decline in soil fertility (Tripathi 1999, Tripathi et al 1999). Farmers do not cover manure and keep exposed to the air, which results gaseous losses of nitrogen in the atmosphere and leaching losses beyond root zone during the raining season. Manure prepared by most farmers is of low quality through poor decomposition as result of inappropriate methods of preparation and application (Subedi et al 1995). There is a need to increase the quality of FYM/compost for the efficient utilization of locally available organic materials. The objectives of the study were to enhance the quality of manure and its use in the production of maize and upland rice in the farmers' field in different agro-climate conditions of the western hills of Nepal.

MATERIALS AND METHODS

Improvement on quality of manure/compost

Ten farmers in each site of Chambas (river basin), Pakuwa (low to mid hill) and Bhakimli (high hill) were selected. The existing heap or pit method of preparation of manure was divided into two equal halves. Half of the

manure was covered with black plastic sheet and remaining half was left as farmers' method of preparation. Everyday or alternate days depending on the practices, farmer put manure in equal amount in both plastic covered and farmers' own method of preparation from November 2000 to February 2001. After three months of preparation, manure samples were collected in March from each farmer both from plastic covered and uncovered places (farmers' method) before applying to maize and upland rice for analyzing pH, N, P and K contents. In total, 82 samples (twenty from each, Chambas, Upper Pakuwa and Lower Pakuwa and twenty two from Bhakimli) were collected: Weight of fresh samples were taken and oven dried by maintaining temperature between 60-65°C for 72 hours until the weight of the samples remained constant. Nitrogen content in manure was determined in Soil laboratory, Lumle by following standard procedure.

At the same time soil samples were analyzed for each farmer's test plot before manure spread to ensure that there were no major differences in soil fertility between treatment plots. The benchmark soil analysis data of different agro-ecological regions are presented in Table 1.

Table 1. Benchmark composite soil analysis of farmers' field before planting summer maize at Bhakimli (Myagdi) and Upper Pakuwa (Parbat) in rainfed upland (bari), spring maize at Lower Pakuwa (Parbat) in irrigated low land (khet) and summer upland rice at Chambas (Tanahun) in rainfed upland (Tar) in 2001

Sites	pH	Total N, %	Available P, mg/kg	Exchangeable K, mg/kg	Organic C, %	Organic matter, %
Bhakimli (Myagdi)	4.5	0.19	19.3	269	1.7	2.9
Upper Pakuwa (Parbat)	4.9	0.16	52.6	183	1.6	2.9
Lower Pakuwa (Parbat)	4.0	0.12	32.4	172	1.6	-
Chambas (Tanahun)	5.3	0.11	10.6	300	0.8	1.3

Farmers' evaluation during manure decomposition

This involved continuous assessment during the season both individually and as groups to note differences between covered and uncovered manure. The different criteria noted were colour, smell, moisture content, rate of decomposition, uniformity of manure, temperature, texture (hard or soft), weight of the manure and some indicator of quality as the manure was moved to the field. During transport from the heap or pit to the field and while spreading and incorporating the manure, farmers noted any increase or decrease in labour required.

Demonstration of black plastic covered manure vs farmers' manure

In all the above 4 agro-ecological zones, demonstration of black plastic covered manure and farmers' manure on summer maize and upland rice in rainfed upland (bari) and spring maize in irrigated lowland (khet) were carried out in each 10 farmers' field in an area of 100 m². During the crop growth period, farmers were asked to judge the crop performance and note down their observations. Their observations were recorded at different growth stages. The crop was harvested from both the plastic covered manure plots and farmers' manure plots and their yields were recorded separately.

Farmers' evaluation during the growth of the crop and mid season

Differences in crop condition were noted at different stages eg 1) at crop emergence-colour and crop stand, 2) at first weeding-plant stand, 3) at tasseling-stem thickness, colour and size of ear were compared together with any difference in termite damage and 4) at harvest-the weight of grain and straw. Grain and straw yields were sampled and yields per ha were determined at 12% moisture. Further comparative soil analysis was undertaken after harvest to determine any residual soil fertility differences in farmers' plot.

Farmers' field days

Before crop harvest, farmer's field days were organized at Chambas, Pakuwa and Bhakimli to show the response of two types of manures in upland rainfed summer maize and upland rice, and spring maize on 23 August, 5 July and 6 August 2001 respectively. During the field days, representatives of district agriculture office, NGOs, Chairman of the Village Development Committee (VDC), high school head master and district level media representatives were also present.

In each site, 3 to 4 groups of farmers (male + female) were formed and a group leader was nominated by each group. Groups were asked to comment on the field observations. Each group visited upland rice and maize fields to observe the response of quality manure prepared by covering with black plastic sheets and farmer's method. After the field visit group leaders presented their group findings or comments and interacted on the importance of farmers' field days.

RESULTS AND DISCUSSION

Demonstration on quality improvement of manure

Mean N, P and K contents of each ten samples in black plastic covered manure and farmers' manure at Bhakimlin (high hill), Upper Pakuwa (mid hill), Lower Pakuwa (low hill) and Chambas (river basin) are presented in Tables 2, 3, 4 and 5 respectively. Manure analysis indicated that covering manure with black plastic sheet significantly increased nitrogen contents from mid to high altitudes (>1000 to 2000 m) as compared to manure prepared by farmers' practice. Nitrogen content in river basin to low hill (>600 to 1000 m), phosphorus from mid to high altitudes (>1000 to 2000 m) and potassium from river basin to high altitudes (>600 to 2000 m) were higher in covered manure than that of farmers' manure confirming that covering manure did enhance the nutrients contents of the manure, most probably through gaseous and moisture losses being reduced. Farmers remarked that three month old plastic covered manure is equivalent to ten months old farmers method of prepared manure indicating faster decomposition with plastic cover.

Table 2. N, P and K contents of plastic covered manure and uncovered manure at Bhakimli

SN	N, %		P, %		K, %	
	Covered	Uncovered	Covered	Uncovered	Covered	Uncovered
1	2.73	2.41	0.5	0.6	1.88	1.62
2	2.59	2.07	0.8	0.55	2.09	1.79
3	2.29	2.25	0.6	0.95	2.18	2.31
4	2.15	2.03	1.1	0.6	3.2	2.52
5	2.31	2.29	0.65	0.75	2.27	2.6
6	1.65	1.58	0.5	0.55	1.43	1.78
7	1.8	1.54	0.25	0.2	1.11	2.15
8	2.92	2.56	0.85	0.65	2.43	2.06
9	2.35	2.34	0.45	0.5	1.59	1.73
10	1.77	1.89	0.45	0.45	1.88	1.44
11	1.57	1.83	0.65	0.5	1.82	1.75
Mean	2.19	2.07	0.62	0.57	1.99	1.98
P value	0.10		0.51		0.93	
t value	2.22		2.22		2.23	
% increase	6		8		1	

Table 3. N, P and K contents of plastic covered manure and uncovered manure at Upper Pakuwa

SN	N, %		P, %		K, %	
	Covered	Uncovered	Covered	Uncovered	Covered	Uncovered
1	1.08	0.68	0.29	0.17	2.08	1.97
2	1.49	1.16	0.39	0.46	1.23	1.24
3	1.91	1.34	0.33	0.32	1.6	2.46
4	1.47	1.99	0.63	0.43	1.54	1.49
5	1.8	1.06	0.25	0.26	2.73	1.44
6	1.78	1.4	0.43	0.42	2.02	1.99
7	1.91	1.16	0.56	0.36	1.61	1.54
8	1.82	1.76	0.31	0.25	2.05	2.07
9	1.13	1.37	0.22	0.29	2.36	2.19
10	1.18	1.11	0.35	0.4	2.05	1.55
Mean	1.56	1.30	0.38	0.34	1.93	1.79
P value	0.08		0.24		0.45	
t value	1.62		0.78		0.71	
% increase	19		12		7	

Effect of covered manure vs farmers' manure on crop yields

Application of manure prepared by covering with black plastic sheet produced significantly higher yield of maize (7.01 t/ha) than uncovered manure (farmers' method) (6.05 t/ha) at Bhakimli, Myagdi (high altitude) site (Table 6). Significantly higher yield of maize (1.44 t/ha) was recorded with plastic covered manure at mid altitude (Upper Pakuwa, Parbat) as compared to uncovered manure (1.06 t/ha) (Table 7). Similarly, significantly high yield of maize stalk (9.82 t/ha) was recorded in the plots, where manure prepared by covering with black plastic was applied as compared to farmers' manure (7.48t/ha). The low yield of maize in both plastic covered manure and uncovered manure at Upper Pakuwa (mid hill) site is due to damage of maize crop by monkeys at

silking stage. Spring maize grain yield at low hill (Lower Pakuwa, Parbat) site was not significantly increased, although covered manure gave an average a greater yield (2.99 t/ha) than that of farmers' manure (2.65 t/ha) (Table 8). At river basin (Chambas, Tanahun) site, application of plastic covered manure to upland rice gave significantly higher yield (3.34 t/ha) as compared to upland rice yield (2.77 t/ha) obtained from farmers' manure (Table 9). The straw yield of upland rice also increased significantly (3.84 t/ha) with plastic covered manure as compared to farmers' manure (3.29 t/ha).

Table 4. N, P and K contents of plastic covered manure and uncovered manure at Lower Pakuwa

SN	N, %		P, %		K, %	
	Covered	Uncovered	Covered	Uncovered	Covered	Uncovered
1	1.46	1.43	0.45	0.5	2.64	1.99
2	1.8	1.49	0.3	0.25	2.02	1.68
3	1.7	1.28	0.5	0.65	1.87	0.99
4	1.19	1.56	0.33	0.46	1.1	0.82
5	1.44	1.19	0.27	0.43	1.66	1.35
6	2.05	1.8	0.42	0.46	1.49	1.42
7	1.54	1.49	0.36	0.27	2.05	1.62
8	1.58	1.62	0.35	0.24	1.85	2.1
9	1.33	1.34	0.4	0.39	1.73	0.99
10	1.59	1.15	0.34	0.42	1.71	0.86
Mean	1.57	1.44	0.37	0.41	1.81	1.38
P value	0.12		0.24		0.28	
t value	1.33		0.76		2.22	
% increase	9		-9		31	

Table 5. N, P and K contents of plastic covered manure and uncovered manure at Chambas

SN	N, %		P, %		K, %	
	Covered	Uncovered	Covered	Uncovered	Covered	Uncovered
1	1.03	1.48	0.33	0.42	1.78	1.65
2	1.35	1.41	0.5	0.33	1.55	0.69
3	1.36	1.52	0.54	0.77	1.34	1.80
4	1.89	1.49	0.49	0.43	2.15	2.02
5	2.00	1.26	0.52	0.34	1.98	1.67
6	1.29	0.93	0.32	0.19	2.50	2.02
7	1.60	1.16	0.42	0.24	1.78	1.28
8	0.30	0.36	1.75	2.28	1.57	1.62
9	1.79	2.03	0.39	0.50	1.33	1.67
10	1.62	2.22	0.50	0.33	2.75	2.42
Mean	1.42	1.39	0.58	0.58	1.87	1.68
P value	0.79		0.92		0.16	
t value	0.16		0.03		0.98	
% increase	3		-1		11	

Table 6. Yields of maize from farmer testing of improved manure management of Bhakimli

SN	Grain yield, kg/ha	
	Covered	Uncovered
1	5999	5530
2	4879	5609
3	8741	6116
4	6029	5922
5	8473	6529
6	6237	7036
7	8734	5435
Mean	7013	6025
P value	0.16	
t value	1.59	
% increase	16	

Table 7. Yields of maize from farmer testing of improved manure, Upper Pakuwa, Parbat

SN	Grain yield, kg/ha		Straw yield, kg/ha	
	Covered	Uncovered	Covered	Uncovered
1	1152	864	12200	7000
2	1248	1008	10400	8600
3	1778	1104	10900	8600
4	1392	1248	10200	9000
5	1152	960	5600	5000
6	1296	1104	8600	6200
7	1584	1248	12600	9000
8	1708	960	11000	8000
9	1440	1056	6200	5000
10	1632	1056	10500	8400
Mean	1438	1061	9820	7480
P value	0.00		0.00	
t value	5.54		5.51	
% increase	36		31	

Table 8. Yields of maize from farmer testing of improved manure management, Lower Pakuwa

SN	Grain yield, kg/ha		Straw yield, kg/ha	
	Covered	Uncovered	Covered	Uncovered
1	2880	2880	9200	9000
2	3648	2304	11370	8600
3	2016	2208	7100	6800
4	4224	4032	12200	10400
5	2496	2016	10200	8600
6	2064	2016	9000	6700
7	2448	2208	9300	7060
8	2976	2352	11200	9000
9	3168	3072	11600	8700
10	3986	3360	11220	8386
Mean	2991	2645	10239	8325
P value	0.03		0.00	
t value	2.46		6.21	
% increase	13		23	

Table 9. Yields of upland rice from farmer testing of improved manure management, Chambas

SN	Grain yield, kg/ha		Straw yield, kg/ha	
	Covered	Uncovered	Covered	Uncovered
1	2652	2494	6023	5431
2	3297	2209	3398	2614
3	4291	3532	2415	2982
4	2698	2731	2673	2465
5	3663	2718	4225	2826
6	3488	2910	4283	3392
Mean	3348	2766	3836	3285
P value	0.023		0.10	
t value	3.23		2.00	
% increase	21		17	

Farmer's field days

Eighty farmers took part in farmers' field days at Chambas and thirty five farmers took part at Pakuwa and Bhakimli sites. All the group leaders of three sites reported similar comments after visiting the field demonstration on upland rice at Chambas, spring maize at Pakuwa and rainfed upland summer maize at Bhakimli. They remarked that the plastic covers manure performed better crop growth as compared to farmers' manure.

Farmers' assessment vs scientists' evaluation of soil fertility

There was close agreement between farmers' assessment and scientist evaluation of soil fertility management. Farmers particularly use the indicators such as soil and crop color, diameter of the maize stalk, number of tillers of upland rice and number of cobs per plant and ultimately the crop yield as well as weed abundance.

CONCLUSION

- Covering manure (mixed with bedding materials and other waste materials) with black plastic sheets increases N (3-19%), P (8-12%) and K (1-31%) contents of manure as compared to farmers' method of preparation at different altitudes.
- Decomposition process of manure along with other wastes is fast in plastic covered manure due to which the well rotten manure is ready to apply within 2-3 month time but the same manure takes 9-10 months to decompose in the farmers practice.
- Grain yield of summer maize at high hill (Bhakimli, Myagdi) and mid hill (Upper Pakuwa, Parbat) as well as spring maize at low hill (Lower Pakuwa, Parbat) and river basin (Chambas, Tanahun) can be increased to 16%, 36%, 13% and 21% respectively with the use of plastic covered manure

ACKNOWLEDGEMENTS

We are grateful for the funding support of this research by Department for International Development (DFID), UK through Silsoe Research Institute (SRI), UK. The farmers of Chambas (Tanahun), Pakuwa (Parbat) and Bhakimli (Myagdi) are highly appreciated for their co-operation during the field study.

REFERENCES

- Mathema SB. 1999. *Socio-economic research on management of soil fertility in mid hills of Nepal*. Main Report, Volume 1. Department of Soil Science, the University of Reading, UK. 170p.
- Subedi KD, M Subedi and BR Sthapit. 1995. Research highlights on composting, compost utilization and in-situ manuring in the western hill of Nepal. **In:** *Formulating a strategy for soil fertility research in the hills of Nepal*. Proceedings of a workshop held in Lumle Agricultural Research Centre, Pokhara, Nepal from 17-18 August, 1995.
- Tripathi BP. 1999. Soil erosion and fertility losses in the western hills of Nepal: An Overview. *Lumle Seminar Paper No 99/9*. Agriculture Research Station, Lumle PO Box 1, Pokhara, Kaski, Nepal.
- Tripathi BP, Mawdesley, KJ Gardner, R Acharya GP Shrestha, SP and RC Tripathi. 1999. Study of leaching losses of nutrients in the western hills of Nepal. *Lumle Seminar Paper No 99/14*. Agriculture Research Station, Lumle PO.Box 1, Pokhara, Kaski, Nepal.
- Tripathi BP and JK Tuladhar. 1997. Effect of low and high quality organic materials on maize yield and soil properties. **In:** Proceedings of the 20th National Summer Crops Workshop, Regional Agriculture Research Station, Parwanipur, Bara, Nepal from 22-24 April, 1997.

Potential of Promising Varieties of Garden Pea in Relation to Determinate Characters, the Efficiency of Green Pod Yield and Monetary Returns under the Mid-hill Environments of Dailekh

Tul B Poon, Hom N Regmi, Bhanu B Pokhrel, Om B Oli and Shashi R Sharma

Agriculture Research Station, Dailekh

ABSTRACT

This study was carried out in Agriculture Research Station, Dailekh for two years from 2001/02 to 2002/03. The main objective of the study was to verify the most appropriate determinate variety coupled by high yield efficiency. Seeds of eight varieties of garden pea were planted on October 16 and 4 respectively in 2001 and 2002. The use of seed rate was @ 55 kg/ha. A total fertilizer dose N (40 kg/ha), P (60 kg/ha) and K (60 kg/ha) was applied. The varieties significantly influenced the number of the first flower node, the first day of flowering, plant height, crop duration, green pod yield, and efficiency of production and gross monetary returns. Lincoln revealed significantly the highest pooled green pod yield (9,221 kg/ha) pursued by Arkel (9,151 kg/ha) and Azad (8,492 kg/ha) but the check variety Dailekh Local produced the lowest pooled green pod yield (2,355 kg/ha). Arkel contributed to the highest pooled production efficiency (62.55 kg/ha/day) followed by Azad (60.22 kg/ ha/ day) and Lincoln (50.68 kg/ha/day). Dailekh Local gave the lowest production efficiency (14.07 kg/ha/day). The result revealed that Arkel, Azad and PM-2 are the best-suited determinate varieties that either can be grown as sole crop without stacking or can be tested in the mixed or intercropping pattern.

Key words: Crop duration, determinate, *Pisum sativum*, Sikkim Local, stacking

INTRODUCTION

Garden pea (*Pisum sativum* L. ssp *hortense*) is an important vegetable. It is cultivated as a winter season crop throughout the mid-hills of Nepal. Green immature and dry peas are all season favorite food and are always in great demand. Additionally, it enriches the soil fertility with organic matter and nitrogenous compound. Dwarf Gray, New Line Perfection and Green Arrow showed better performances under Rukum environment of Nepal (Regmi 1983/84). Bolaro, Green Arrow and Ford Hook Wonder were reported to have produced the higher green pod yields 5,700 kg/ha, 5,400 kg/ha and 4,250 kg/ha respectively under Khumaltar, Lalitpur (Pun 1986/87). Varietal evaluation of garden pea revealed the highest pod yield (9795 kg/ha) of Sikkim Local under Pokhara condition (ARS 1999/2000). There are a few recommended varieties of pea such as Early Giant and Sikkim Local, which are of indeterminate type, as a result, their crop duration is long and requires stacking for satisfactory yield. Farmers prefer determinate varieties Arkel Azad and New Line Perfection. An indeterminate variety Sikkim Local intercropped with Rai Pusa Bold resulted in decreased fresh pod yield (LARC 1991/92). Local genotypes being available in this region are, too of indeterminate group and their sole crops require stacking for good yield, yet mixed cropping or intercropping with other crops does not appear to be fitted perfectly. Because of these reasons, farmers in this region have not been able to fetch satisfactory yield from the local genotypes. Hence, the comparative studies of determinate and indeterminate varieties of garden pea have been worked out for green pod yield, yield contributing characters, production and gross returns efficiency.

MATERIALS AND METHODS

The present study was carried out for two years from 2001/02 to 2002/03 in Agriculture Research Station, Dailekh. The station is located at an altitude of 1300 meter. The soil was sandy loam having 1.60% organic

matter, 0.09% total N, 72 and 198 kg/ha available P and K respectively, with pH 6.0. Eight varieties of garden pea, namely Early Giant, Azad, Tikot, PM-4, Lincoln, Arkel, Sikkim Local and Dailekh Local (as a check) were tested in randomized block design replicated thrice. Plot size was 2.4- × 3.5-m. Three hundred seeds were planted (@ 55 kg/ha), maintaining the spacing of 8- × 35-cm apart in an individual plot. The planting dates were on 16 and 4 October in 2001 and 2002 respectively. A total dose of N (40 kg/ha), P (60 kg/ha) and K (60 kg/ha) was applied to the crop at the time of planting. The additional cultural practices such as weeding, irrigation and plant protection measures were done as per needed. Keeping with nature of these varieties, their crop durations vary from 141 to 185 days. Observations were made on the ensuing time and components (a) Plant population was recorded one month after planting, (b) Date for the first flowering and the number of first flowering node were observed in 33-65 days after planting, (c) Green pod yield, crop duration and plant height were recorded in 132 -190 days after planting, depending upon types of varieties, (d) The production efficiency figure in terms of kg/ha/day was obtained by total production in a sequence divided by total duration of the variety of crop, (e) The gross return efficiencies figure in terms of Rs/ha/day was obtained by the total monetary returns divided by the duration of the variety of the crop.

RESULTS AND DISCUSSION

The analysis of variance gave highly significant results on crop duration (Table 1), production and gross monetary return efficiencies (Table 2), the number of the first flower nodes, plant height (Table 3). It showed a statistically significant results ($P<0.05$) on green pod yield (Table 1), days to the first flowering (Table 2) and non-significant results ($P>0.05$) on plant population (Table 1).

Table 1. Performances of different promising varieties of garden pea on the yield components at ARS, Dailekh during 2001/02 and 2002/03

Variety	Plant population/ha in a month after planting			Crop duration in days			Green pod yield, kg/ha		
	2001-02	2002-03	Pooled	2001-02	2002-03	Pooled	2001-02	2002-03	Pooled
Early Giant	2,50,000	2,64,286	2,57,143	180	190	185	1,714	7,971	4,843
Azad	2,25,000	2,71,429	2,48,215	149	133	141	8,000	8,984	8,492
Tikot	2,25,000	2,78,571	2,51,786	177	187	182	3,536	5,323	4,430
PM-2	2,71,429	2,46,429	2,58,929	157	154	155	6,429	5,832	6,131
Lincoln	2,50,000	2,60,714	2,55,357	177	185	181	5,857	12,585	9,221
Arkel	2,89,286	2,32,143	2,60,715	156	132	144	12,857	5,444	9,151
Sikkim Local	2,53,571	2,79,762	2,60,715	180	178	179	5,607	11,080	8,344
Dailekh Local (check)	2,67,857	2,71,429	2,69,643	180	164	172	1,714	2,995	2,355
Mean	2,66,518	2,62,946	2,64,732	169	165	167	5,804	7,536	6,671
CV, %	8.91	8.83	8.87	7.71	14.02	10.86	63.97	28.89	46.43
P value	>0.05	>0.05	>0.05	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01
LSD _{0.05}	-	-	-	-	-	-	668	-	-
LSD _{0.01}	-	-	-	8.061	10.876	9.468	-	3815	2241.50

Plant population

The eight varieties of garden pea did not significantly influence the pooled plant population (Table 1). This result presumably came up with the more or less homogeneity in respect of germination of tested varieties.

Days to the first flowering

The eight varieties of garden pea contributed significantly to the first day of flowering, as both varieties Azad and Arkel simultaneously produced the pooled flowering time (40.50 days after planting) at the first of all, followed by Dailekh Local as check (45.50 days after planting) and Tikot (49.50 days after planting). Azad and Arkel are statistically at par with Dailekh Local and Tikot in this respect (Table 2). The first flowering by Azad and Arkel was inherently resulted due to earliness and determinate character. Secondly, Tikot and Dailekh Local had shown somewhat variation in terms of time for the flowering despite their long crop duration.

The number of the first flower nodes

The eight varieties of garden pea imparted a highly significant influence on the yield contributing characters. The variety Azad produced the pooled first flower at 8.76 node at the lowest of all followed by Arkel (9.33 node) and Lincoln (12.70 node) whereas the check variety Dailekh Local produced the pooled first flower (14.44 node) at the highest of all varieties. Azad is at par with Arkel in this regard (Table 3). The first pooled flowering at the low number of nodes by Azad and Arkel was inherently resulted due to earliness and determinate character in them.

Table 2. Performances of different varieties of garden pea at ARS, Dailekh during 2001/02 and 2002/03

Variety	Days to first flowering			Production efficiency, kg/ha/day			Gross returns, Rs/ha/day		
	2001-02	2002-03	Pooled	2001-02	2002-03	Pooled	2001-02	2002-03	Pooled
Early Giant	63	47	52.5	9.78	41.88	25.83	146.70	628.20	387.45
Azad	48	33	40.50	54.55	68.00	60.22	818.19	1020.00	919.09
Tikot	58	41	49.50	19.84	28.91	21.27	297.65	433.65	365.65
PM-2	56	53	54.50	40.86	37.89	39.37	612.87	568.35	590.61
Lincoln	64	50	57.00	33.13	68.24	50.68	496.95	1033.60	760.27
Arkel	47	34	40.50	83.18	41.92	62.55	1247.65	628.80	938.22
Sikkim Local	62	49	55.50	31.15	61.54	46.34	467.25	923.10	695.17
Dailekh Local (check)	56	35	45.50	9.63	18.52	14.07	144.46	277.80	211.13
Mean	57	43	49.40	35.26	45.86	40.04	528.97	687.90	608.43
CV, %	13.75	19.35	16.55	87.26	44.86	66.06	87.26	44.86	66.06
P value	<0.05	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
LSD _{0.05}	8.847	6.562	7.704	43.24	23.34	33.29	648.60	350.100	499.350

Plant height

The eight varieties of garden pea had a highly significant influence on the pooled plant height, in which Arkel contributed to the shortest plant height (71.03 cm) followed by Azad (72.63 cm) and Lincoln (78.06 cm) but Early Giant had the highest pooled plant height (253.40 cm). Nevertheless, Arkel is statistically at par with Azad, Lincoln and PM-2 (Table 3). The shorter rather than taller height of these varieties are due to the existence of determinate and indeterminate inherent traits in them.

Crop duration

Eight varieties of garden pea had imparted a highly significant influence on the pooled crop duration (days), as Azad revealed the shortest pooled crop duration (141 days) followed by Arkel (144 days) and PM-2 (155 days), on the contrary, Early Giant revealed the longest pooled crop duration (185 days). Azad is, however, at par with Arkel (Table 1). The Arkel and Sikkim Local had the crop duration of 90 and 121 days respectively when planted on 15 November 1985 under Khumaltar (Pun 1986/87). As compare to the crop durations of the aforementioned varieties, quite longer crop durations were found in Dailekh than in Khumaltar. It is because of differences in planting dates, climatic condition and most possibly the harvesting stage of green pod yield, as planting date was nearly one month earlier; and green pod retaining fully developed green grains were harvested in Dailekh. However, the shorter crop duration and longer crop duration recorded in both of these varieties are due to the existence of determinate and indeterminate inherent traits.

Green pod yield

The pooled green pods yield was significantly influenced by different varieties of pea, as Lincoln produced significantly the highest pooled green pod yield (9,221 kg/ ha) followed by Arkel (9,151 kg/ha) and Azad (8,492 kg/ha) but the check variety Dailekh Local produced the lowest pooled green pod yield (2,355 kg/ha). The top yielder Lincoln is, nevertheless at par with Arkel, Azad and Sikkim Local. The highly fluctuated green pod yield was noted in the same variety in the different years.

Production efficiency

The eight different varieties exerted a highly significant influence on the pooled production efficiency. As Arkel contributed to the highest production efficiency (62.55 kg/ha/day) followed by Azad (60.22 kg/ ha/ day) and Lincoln (50.68 kg/ha/day). Dailekh Local as a check variety gave the lowest production efficiency (14.07 kg/ha/day). Arkel is statistically at par with Azad, Lincoln, Sikkim Local and PM-2 (Table 2). The higher production efficiency than lower production efficiency is attributed to the present of short duration coupled by high yielding capability in the determinate type of pea varieties.

Gross monetary returns efficiency

The eight varieties of garden pea produced a highly significant influence on the pooled gross monetary return efficiency, in which Arkel showed the highest gross monetary returns efficiency (Rs 938.22/ha/day) pursued by Azad (Rs 919.09/ha/day) and Lincoln (Rs 760.27/ha/day) but the check variety Dailekh Local gave the lowest gross monetary returns efficiency (Rs 211.13/ha/day). Arkel is, however, at par with Azad, Lincoln, Sikkim Local and PM-2 (Table 2). The higher gross monetary returns in Arkel and Azad are because of shorter crop duration despite the higher green pod yield in Lincoln.

Table 3. Performances of different varieties of garden pea on the first flower node and plant height at ARS, Dailekh during 2001/02 and 2002/03

Variety	Number of first flower node			Plant height, cm		
	2001/02	2002/03	Pooled	2001/02	2002/03	Pooled
Early Giant	14.40	14.13	14.17	252.80	254.00	253.40
Azad	8.62	8.90	8.76	72.93	72.33	72.63
Tikot	14.00	13.56	13.78	224.66	234.33	229.49
PM-2	12.93	13.20	13.06	90.00	85.66	87.83
Lincoln	12.8	12.60	12.70	81.80	74.33	78.06
Arkel	9.6	9.06	9.33	70.73	71.33	71.03
Sikkim Local	14.23	14.13	14.18	230.33	237.33	233.83
Dailekh Local (check)	14.53	14.36	14.44	179.33	180.33	179.83
Mean	12.64	12.49	12.56	150.34	151.23	150.785
CV, %	18.25	19.11	18.68	56.00	58.06	57.03
P value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
LSD _{0.01}	1.22	1.65	1.435	72.31	87.86	80.085

CONCLUSION

Arkel and Azad can be verified as the best varieties among these varieties for most of the yield and yield contributing components. Both varieties are determinate type that can be fitted perfectly in the mixed or intercropping pattern and do not need stacking for support of climbing. Azad was somewhat more tolerant to powdery mildew. Secondly, PM-2 and Lincoln also showed better performances than the standard check variety Dailekh Local. The influence of these four varieties cum planting dates will need to be further tested to obtain the outputs prior to testing with intercropping or mixed cropping pattern under the mid-hill condition.

ACKNOWLEDGEMENT

The authors acknowledged all the staffs of Agriculture Research Station, Dailekh, who overtly contributed to the research work even in a critical situation. Constructive suggestions from Dr Kedar Budhathoki, Horticulture Research Division, are also indebtedly appreciated.

REFERENCES

- ARS. 2000.. Highlights on horticultural crop research. *Annual Report 1999/2000*. Agriculture Research Station, Pokhara, Nepal Agricultural Research Council.
- LARC. 1992. Highlights on vegetable crop research. *Annual Report 1991/92*. Lumle Agriculture Research Centre, Kaski, Nepal. Pp.13-15.
- Pun L. 1986/87. Evaluation of pea varieties for green pod yield. **In:** *Technical Report on Varietal Evaluation, seed production and Agronomic Studies conducted during the year 1986-1987* (L Pun and SS Chatterjee, eds). VDD, Khumaltar. Pp.36-37.
- Regmi S. 1983/84. Pea varietal evaluation trial for seed production. **In:** *Technical Reports on Variety Evaluation Trial for Seed Production and Agronomic Studies Conducted during the Year 1983-84*. VDD, Khumaltar, Nepal. 60p.

Present Status of Cole Crops Cultivation in Hills of Nepal

Sharmila Piya and Purushottam P Khatiwada

Agricultural Research Station, Pakhribas

ABSTRACT

To understand the current practices of nursery and cultivation of cauliflower and cabbage in hills, surveys were carried out in different semi-commercial vegetable crops growing areas of Ilam, Terhathum, Dhankuta, Makawanpur, Kaski and Parbat districts. Farmers of the mid and high hills were only interested to grow the cole crops during off-season (April-October) period. Because of three to five times higher market prices than that of winter season production of these crops, farmers have been extending the cultivation area and also altering the cultivation practices. Damping off was the major disease of rainy season nursery management. Red ants and cut worms were the most problematic insects during rainy season cultivation. Farmers of the study areas reported that they had used the recommended practices for cultivation of these crops. However, great variability was recorded during the study. Plant population for cauliflower ranged from 1004 to 1083 and 1824 to 2223 for cauliflower and cabbage per ropani respectively. Similarly use of compost application ranged from 875 to 1175 kg/ropani. Method and doses of chemical fertilizers application were also highly variable. The study has clearly demonstrated that there is an acute need of development of package of practices for summer season cultivation of cole crops.

Key words: Cole crops, hills, status

INTRODUCTION

Cole crops in general and cabbage and cauliflower in particular occupy an important position in Nepalese commercial vegetable crops. The documented area under production of cauliflower and cabbage were 19267 and 15514 ha respectively in 1993/94 (Shrestha and Ghimire 1996). Increasing trends of cultivation of these two vegetable crops in summer season along with the north-south road corridors should have played a significant role in the increment of the area under cultivation at the present day. These vegetable crops are orthodox categorized as the winter season, however, these can be grown all the year round with manipulating the variety and time of planting (PAC 1991, HRD 2002). To exploit the niche of the hills, farmers of the eastern hills have been cultivating in the rainy season. Recent statistics revealed that 9000 tones cabbage and 3000 tones of cauliflower were exported to India from Sindhuwa Cooperative of Dhankuta district alone during the year 2002 (M Gurung, personal communication). Increasing trend of the cultivation of these vegetable crops during rainy season is basically due to lucrative market as they fetch three to five times higher price than that of winter season (Bista 1996). A study on average market price at Kalimati shows that the price of cauliflower is the highest in Aswin (Rs 35/kg) and the lowest in Baisakh (Rs 12/kg). Likewise, the market price of cabbage is highest in Kartik (Rs 16/kg) and lowest in Chaitra (Rs 2.60/kg) (KFVWMD 2056 BS). Not only suitable for sole cropping, cauliflower and cabbage can also be successfully cultivated under maize in the potato + maize system after the harvest of potato (Khatiwada 1997).

Despite the great economic importance and varietal research support, the average national productivity of cauliflower and cabbage are 7.8 t/ha and 9.7 t/ha respectively (Shrestha and Ghimire 1996). Many experimental results have shown an average yield of more than 15 t/ha for cauliflower and 50 t/ha for cabbage (Khatiwada 2000, Thapa and Khatiwada 1997). It has clearly demonstrated a pertinent need to identify the causes manifested with the yield gap in research field and farmers' field. Hence, this study was planned to find out elements associated with the yield gap of cabbage and cauliflower in the hills situation of Nepal.

METHODOLOGY

Surveys were carried out using semi-structured questionnaires in Barbote Village Development Committee (VDC) of Ilam, Basantapur VDC of Tehrathum, Parewadin VDC of Dhankuta, Daman VDC of Makawanpur, Lekhanath Municipality of Kaski and Dhairing VDC of Parbat districts. Thirty farmers in each site were interviewed by agricultural technicians. Field visits of the corresponding respondents were made to triangulate the obtained information. Information on nursery was gathered with particular references with rainy season cultivation while for the cultivation technology, basically husbandry practices, it was not restricted with production season. The collected information was analyzed by using SPSS software.

RESULTS AND DISCUSSION

Cropping pattern

The traditional cropping pattern of the high hills of the Eastern Nepal is potato+maize. Maize intercropping with potato is a very popular practice in these areas. Not only the maize grains, but also the maize stover are used as roughages for domestic animals during lean season (January–April). Farmers do not want to wipe out maize even knowing that the commodity is no more lucrative. Considering the system perspective, farmers have modified the traditional practice of potato + maize system by growing vegetable crops after the harvest of potato. Majority of the studied areas of the Eastern hill farmers (55%) have changed the pattern as potato + maize-cauliflower/cabbage–pea + radish. Approximately, 25% farmers cultivate potato + maize-cauliflower/cabbage-fallow. A tiny proportion of the respondents (3%) are still cultivating wheat and finger millet before cauliflower and cabbage.

Varieties

Snow Crown is the popular variety of cauliflower in the eastern hills due to heat tolerance, short duration and suitability for intercropping. 83.3% farmers of Sindhuwa area cultivated Snow Crown while 10% grew Snow Crown and Kathmandu Local. In Basantapur, 57% grew Snow Crown and 23% grew Snow Crown and Kathmandu Local. About 3% farmers of the both sites cultivated Kibo Giant. It depicted that Snow Crown is the very popular variety in the eastern hills and Kathmandu Local has still maintained its faith with few growers. In case of cabbage Green Coronet and Green Stone are being cultivated in Sindhuwa (80%) while in Basantapur Green Coronet was only in practice (77%). Although, Green Coronet and Green Stone were in use, farmers preferred Green Coronet as compared to Green Stone due to its long durability in the field after its maturity. Green Stone was also vulnerable to head cracking in growing fields, if it cannot be harvested within fifteen days of maturity.

Season

Generally seed sowing of cauliflower for rainy season production start from Chaitra to Asar. The mean seedling age for field transplantation was 29 day. Cauliflower harvesting started from Bhadra and goes up to Kartik. In case of cabbage seed sowing generally completed between Baisakh and Asar. On an average, 32 day old seedlings were transplanted in the main field. Days to harvest started generally from three and a half month after transplanting during the season.

Soil treatment

At Sindhuwa, around 53% respondents treated the soil before seed sowing and rest of them do not treated. However, at Basantapur only 30% of the respondents treated the soil. 50% farmers from Sindhuwa used Malathion for soil treatment while 67% farmers from Basantapur used ash for the same purpose.

Fertilizers

Only 34.5% farmers of Sindhuwa and 23.3% of Basantapur used chemical fertilizers in nursery plots. Rest of farmers used only compost or they used forest top soils instead of compost in the nursery beds. All respondents reported have been using compost in cauliflower and cabbage growing fields. The rate of compost application in Ilam, Makawanpur, Kaski were highly variable. The doses of application were varied from 750 to 1125 kg/ropani. Rate of application was found to be 875 to 1175 kg compost per ropani in Ilam, 1075 to 1175 kg/ropani in Makwanpur and 1075 kg compost per ropani in Kaski. The rate of chemical fertilizers application was also highly variable. Farmers were using less compost and more amount of chemical fertilizers in semi-commercial growing areas. On an average, about 60% farmers of Ilam and Kaski district used less than 3 kg DAP per ropani and 40% used 4 to 7 kg/ropani for cauliflower. About 73% farmers used less than 5 kg

urea/ropani, whereas 23% used 6 to 10 kg and a little portion (4%) used more than 11 kg urea/ropani for cauliflower. Regarding potash, farmers of Ilam district did not use potash at all. While the farmers residing in Kaski district had the complete opposite response. 68% used MoP less than 3 kg/ropani, 29% used 4-7 kg and a small fragment (4%) of the respondents used more than 8 kg/ropani. For cauliflower, farmers of Makwanpur used very high dose of fertilizers than that of Ilam and Kaski districts. About 13% farmers of Makwanpur used less than 10 kg DAP/ropani, 67% used 11-20 kg and 20% used DAP more than 21 kg/ropani. In the case of urea in Makwanpur district, 22% applied less than 10 kg, 40% applied 11-20 kg and 38% applied more than 21 kg/ropani for cauliflower. The fertilizers application for cabbage on an average for DAP, 51% used less than 5 kg, 41% applied 6-10 kg and 8% applied more than 11 kg per ropani. In the case of urea, 54% used less than 5 kg, 33% used 6-10 kg and 13% used more than 11 kg urea per ropani. While taking accounts of MoP, 56% used less than 3 kg, 26% applied 4-7 kg and 18% administered more than 8 kg per ropani.

There were general practices to perform two top dressings for cabbage and cauliflower. In Kaski district, the rate of compost and chemical fertilizers application in cabbage and cauliflower were basically the same. Two top dressings were the common practice, but some had given three top dressings. Generally top dressings were performed in 20 and 45 day after transplanting. In Kaski district the rate of urea application as basal dose was between 0 and 10 kg/ropani. Farmers who did not use urea as basal, supply high dose of chemical fertilizers while top dressings. Similarly the rate of MoP application was 0-5 kg/ropani. Mainly urea was used for top dressing; however, a few of the respondents used MoP as well. Top dressing was done in between 20 and 60 day after transplanting for 2-3 times. In Ilam district roughly a half farmers used urea as basal and a few used MoP. The rate of application of urea, DAP and MoP were 1-5, 2-6 and 1-2 kg/ropani respectively. Generally two top dressings were common at 30 and 60 day after transplanting. The rate of urea for top dressing was 20.4 kg/ropani. In Ilam 7 month old, in Makwanpur 9 month old and in Kaski 7 month old compost was used in the main growing fields. 44% respondents kept compost in pit for decomposition while 34% of them do worry about for decomposition. In totality, compost application rate was satisfactory (1075 kg/ropani which is enough as recommendation). In the case of chemical fertilizers the recommendation is 8:7:4 kg Urea:DAP:MoP. The chemical fertilizer application range was 4-25 kg urea, 4-14 kg DAP and 1-8 kg MoP per ropani. The application of chemical fertilizer will invite the problem for soil health both in under and over use and both of these are experienced in these areas.

Insects and diseases

Among the major insects, aphids (27), cutworms (16), white grubs (16) and red ants (3) are problems for nursery in Sindhuwa (Figure 1). Farmers from Basantapur area reported aphids (24), cutworms (18), white grubs (15) and red ants (3) as their problems (values in parentheses are frequency). Most of the farmers from Sindhuwa used anumite (cypermethrin) for insect control and rest of others used metacid (methyl parathion), metasystox (methyl demeton). Farmers from Sindhuwa used more chemical fertilizers and insecticides than that of Basantapur (Figure 2).

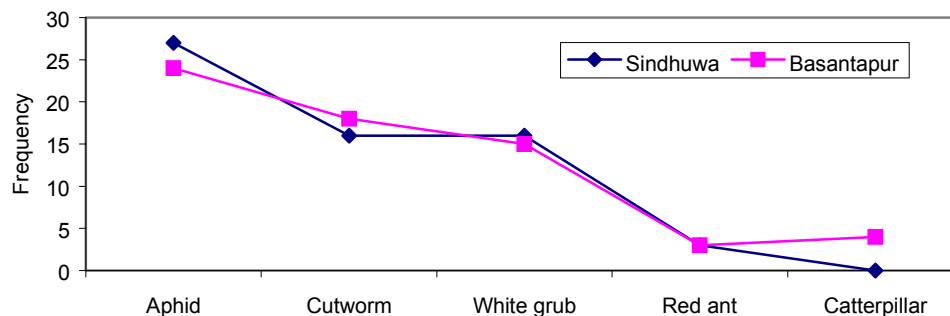


Figure 1. Insects problems in nursery.

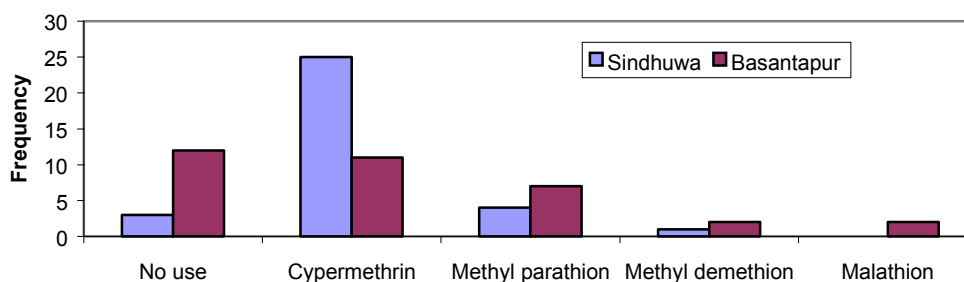


Figure 2. Insecticides used in the eastern hills.

Insects of economic importance were red ants, aphids, cabbage butterflies, cutworms and white grubs in the growing fields. For these insects farmers sprayed cypermethrin and methyl parathion. From this information, it can be inferred that farmers were unaware about insecticide specification. Farmers just spray any insecticide to any insect without having proper technical know how.

In case of diseases, 100% farmers accepted that damping off was the major problem. Only 9% farmers reported that downy mildew was also a problem for seedlings. Seedling raising in rainy season cauliflower and cabbage was more difficult due to high rainfall and high humidity. Gurung and KC (1993) reported that the period during April to August is the hottest time of the year and most of the rainfall is concentrated from May to September in the eastern hills. For the protection of seedlings from heavy and direct rainfall, most of the farmers used shade of Chitro (made by bamboo). Most of the farmers used plastic tunnel until seed emergence. After seed emergence, farmers constructed shade using chitro after removing plastic tunnel. 60% farmers sprayed mancozeb (Dithane M-45 and Indofil) for damping off control while 35% farmers did not use any fungicides (Figure 3). The most important disease after transplanting was alternaria leaf spot and sclerotinia stalk rot (*Sclerotinia sclerotiorum*). For these diseases, farmers used mancozeb.

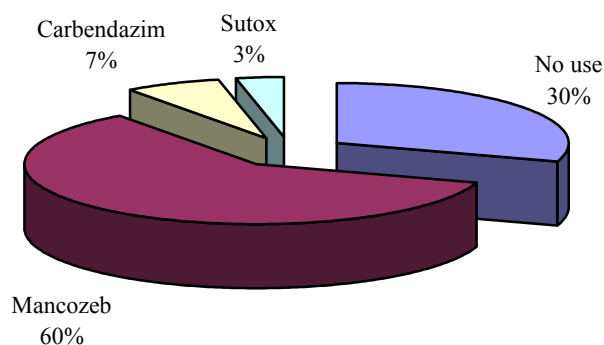


Figure 3. Pesticides used for disease control.

Diseases and insects were the most important causes for yield losses. Damping off disease, aphids, red ants and cut worms insects were the principal agents for seedling losses in nursery. The economic losses of cauliflower in the high hills was up to 50% due to damping off at the nursery stage and 30–46% losses in the mid and low hills due to *sclerotinia* stalk rot disease (Duwadi 1991, Baidhya, Unpublished). Despite using pesticides for

controlling problematic insects and diseases, farmers were not getting the potential yield. The main reason behind it is not using appropriate pesticides against the insects or diseases. For example most of them use *Cypermethrin* and methyl parathion for all of insects (aphids, red ants, cutworms, white grubs). In the same way for damping off control, farmers had sprayed *Mancozeb*. Though *Mancozeb* is the appropriate fungicide for damping off control, however, it can't control those seedlings already infected by pathogens. As the damping off is the soil and seed borne disease, seed and soil treatment is pivotal for the control. Foliar spray alone can't fully control the disease. Soil treatments by soil burning and formalin application can control to a significant level (Ghimire 1994). While to control sclerotinia stalk rot, a fungus antagonist (*Trichoderma harzianum*) found to be the best alternative (Duwadi 1991, Baidhya, Unpublished).

Plant spacing

Approximately 23.3% of the participating farmers of Ilam district and 39.1% farmers of Kaski district used recommended plant spacing for winter cauliflower. The closest spacing observed was 30- × 30-cm and the widest was 60- × 60-cm. However, in the case of cabbage 73.3% farmers of Ilam district used closer spacing ie 30- × 30-cm. In Kaski district, 60.7% farmers used 45- × 45-cm spacing for winter cabbage. For summer season cauliflower, only 15% farmers from Ilam district used recommended (45- × 45-cm) plant spacing. Whereas in Kaski district 46.2% farmers used 45- × 45-cm plant spacing. About ¼ of the respondents of Kaski district 46.2% farmers used 45- × 45cm plant spacing. About ¼ of the respondents (27.3%) of Makwanpur district used closer spacing of 30- × 30-cm and 52.9% farmers of Kaski district used 45- × 45-cm spacing for summer cabbage. For dry season cabbage, the plant spacing used by the 40% farmers of Makwanpur district was 35- × 45-cm and 40% farmers used 45- × 45-cm. Earlier studies have proved that closer spacing for cauliflower (45- × 30-cm) and cabbage (45- × 30-cm) have shown promise during off-season (Khatiwada 2000).

Gap filling and production

43% respondents of Ilam did not gap fill while 57% of Ilam, 90% of Makwanpur and 97% of Kaski districts gap-filled the seedlings when the transplanted seedlings died due to different causes. All the farmers did gap filling in between 15 and 20 day after transplantation. The production of cauliflower and cabbage are portrayed in Table 1.

Table 1. Productions (kg/ropani) of winter, summer and dry season cauliflower and cabbage

District	Winter cauliflower	Summer cauliflower	Winter cabbage	Summer cabbage	Dry season cabbage
Ilam	169	NA	678	NA	NA
Makawanpur	NA	567	NA	186	283
Kaski	636	873	814	1246	NA

NA, Not available.

Yield range is highly variable and in some places farmers were obtained more than national average and in some places lower than that of national average. In all cases, yield potential has not been explored in both cabbage and cauliflower.

CONCLUSION

The study has figured out different elements responsible for the yield gap between research field and farmers' field. Variety, a major input, has not played significant role as the farmers have been using heat tolerant hybrid varieties in summer season. Plant spacing, a crucial husbandry aspect has played significant role for yield variability as farmers were practicing variable spacing ranging from 30- × 30-cm to 60- × 60-cm. Despite making great effort to control diseases and insects, farmers were not benefiting due to the improper uses. Imbalance and variable use of chemical fertilizers as well as ignorance of soil pH were the next important reasons seem to be responsible for low yield.

ACKNOWLEDGEMENTS

We are indebt to Hill Agriculture Research Project of DFID for the financial support. Our sincere thanks go to ASR Bajracharya, S Baidya, BP Choudhary, JL Mandal, CP Shrestha, DP Shrestha and CM Bhusal for their support in data collection. Last but not the least, special thanks go to all respondent farmers for their time and sharing valuable information.

REFERENCES

- Baidhya S. Unpublished. Biological control of stalk rot (*Sclerotinia sclerotiorum* Lib de Bary) disease in cauliflower in the hills of Nepal. *HARP 52/99 Project Completion Report*.
- Bista HB. 1997. *Study of marketing practices of major vegetables crops in Dhankuta*. District Agriculture Development Office, Dhankuta, Nepal.
- Duwadi VR. 1991. Integrated management of stalk rot disease (*Sclerotinia sclerotiorum*) of cauliflower in the Eastern hills of Nepal. *PhD Thesis*. University of Greenwich, UK.
- Ghimire SR. 1994. Damping off disease management of cauliflower. *LARC Working Paper No. 94/31*. Lumle Agricultural Research Centre, Kaski, Nepal.
- Gurung GB and Resham KC. 1993. Review of climatological information of PAC: It's importance and implications in Agriculture. *PAC Working Paper No. 67*. Pakhribas Agriculture Centre, Dhankuta, Nepal.
- HRD. 2002. *Annual Report (2002)*. Horticulture Research Division, Nepal Agricultural Research Council, Khumaltar, Nepal.
- KFVWMDP. 2056 BS. *Monthly Kalimati Market Situation (7 Bhadra 2055 to 5 Baisakh 2056 BS)*. Kalimati Fruit and Vegetable Wholesale Market Development Board, Ministry of Agriculture.
- Khatiwada PP. 2000. Plant spacing: A key husbandry practice for rainy season cabbage production. *Nepal Agric. Res. J.* 4: 48-55.
- Khatiwada PP. 1997. Intercropping of cauliflower under maize: An approach to extend the cauliflower production season for subsistence farmers. *Kasetsart J. (Nat. Sci.)* 32(5)72-80.
- PAC. 1993. Madya Pahadi Chhetrama Barsai Bhari Banda Kopi Utpadan (All year round cabbage production in the mid hills). *PAC Technical Bulletin Horticulture-4*. Pakhribas Agriculture Centre, Dhankuta, Nepal.
- Shrestha TN and NP Ghimire. 1996. Fresh vegetable production in Nepal. **In:** *Proceedings of the National seminar on vegetable Development 11-12 June 1996*. Department of Agriculture, Vegetable Development Division, Kathmandu, Nepal.
- Thapa MP and PP Khatiwada. 1997. Off-season cauliflower production in the Eastern mid hills of Nepal. *PAC Working Paper No. 218*. Pakhribas Agricultural Centre, Dhankuta, Nepal.

Productivity and Profitability Measurement of Potato Crop under Rice-Based Cropping Sequences

BB Khatri, SL Shrestha, GP Rai and D Chaudhari

Potato Research Programme, NARC, Khumaltar, Lalitpur

ABSTRACT

In order to assess the residual effect of different leguminous crops in productivity and profitability of potato crop under different rice-based cropping sequences, six different cropping systems were compared and evaluated with two existing ones from mid-hill conditions of Nepal over the period of 1998/1999 to 1999/2000 at Khumaltar. Both the years, treatments with potato and rice crops grown after legumes produced comparatively higher yields compared to the control. In the treatments, where potato was not included, legume pods were left upto the maturity for the grain yields and harvested which increased additional farm income. A positive response was observed between the amount of legume biomass incorporated and yields of both of the succeeding crops. Fababean was observed the best legume for the foliage dry matter and grain yield production in tons per hectare and its superior residual effect on succeeding potato and rice crops among all the three legume crop species evaluated. Fababean + potato-rice for the potato tuber yield and fababean-rice for the rice grain and straw yield was found the best sequence among all the sequences evaluated in the trial. Results further indicated the necessity of exploring various benefits of legume crops in crop sequences in Kathmandu valley and mid-hill conditions of Nepal. However, some highly beneficial crop sequences from this experiment are recommended for on-farm trials so that farmers will have opportunity to select one or more of the modified cropping systems and that all his/her land receives a legume crop as and often necessary to sustain the soil fertility.

Key words: Cropping sequences, legumes, potato, rice

INTRODUCTION

Experts claim that with the increase in cropping intensity and adoption of improved varieties, the net removal of plant nutrients from the soil has far exceeded the rate of replenishment in Nepal (Pradhan et al 1992). As a result, it has caused soil fertility deterioration, nutrient deficiencies and some other associated problems in the hills as well as in Tarai, causing unsatisfactory productivity rate of most of the crops.

To meet the country's requirement of food, several crops are grown and among them, rice is the main dietary staple food of Nepalese people and number one crop of the country (RRP 2001). Potato is another important food crop used as a staple food in the mountains and as an important vegetable in the mid-hills and in the plains. Since potato yields the highest amount of food per unit area and fits well in multiple cropping systems, it has the potentiality of providing the opportunity for many other crops in sequences.

In response to increasing land scarcity and decreasing food availability to the galloping population, potatoes are increasingly planted in intensive sequential cropping systems by the farmers, such as rice-potato-rice and in more intensive inter-crops, rice-potato-maize and rice-potato-potato-rice (Bhandari and Devkota 1998). All of these major crops heavily draw the nutrients from the soil and the average use of chemical fertilizer in Nepal is extremely below the recommended doses to compensate it for the particular crops (Khatri et al 2002). Potato being a tuber crop, it depletes more nutrients from the soil compared to the cereals and requires correct nutritional management to optimize its productivity and quality and to minimize impact on the environment (Maier and Williams 2000).

Legumes are grown approximately in 3,07,110 ha in Nepal (APSD 2002). According to Schreier et al (1994) and Pandey et al (1995) a slight improvement in their N fixing efficiency or a change in the way they are grown in the farming system could bring substantial amounts of atmospheric N into the soil system and beneficial effects of crop rotation will be observed on yield and soil condition. Rice after dhaincha is well studied and found effective in Tarai conditions, but only little information is available on the potential for N-fixing legumes to supply all or a portion of the N required for potato crop (Griffin and Hesterman 1991, Khatri and Wells 1996). Honeycutt et al (1995) observed substantial N effects associated with crop rotation which included legumes on selected chemical and physical soil properties in potato cropping systems. The results from one study in Kathmandu valley showed that the potato and rice crops grown after legumes produced more yield and biomass both than where no legumes were included in the cropping pattern (Khatri and Wells 1999).

The effect of legumes on the productivity of agriculture in general and of potato under rice-based cropping systems in particular has not received much attention and not many studies are carried out in Nepal. The present study was therefore carried out at Hattiban Research Farm Khumaltar to measure the productivity and profitability of potato crop under different rice-based cropping sequences modified for mid-hill conditions of Nepal.

MATERIALS AND METHODS

The field experiments were undertaken at Hattiban Research Farm Khumaltar located at an elevation of 1350 masl during 1998/1999 to 1999/2000. Field was made uniform with the transplanting of rice over the entire experimental area before the trial establishment. Immediately after rice crop harvest, the most representative cropping patterns with some modification were selected and compared with farmers' practices from mid-hills without any chemical fertilizer applied. The experiments were composed of two phases, 1) legume crops grown upto the maximum vegetative stage (ie October to February) and incorporated in subsequent plots, potato planted and then rice, and 2) legume crops grown upto its maturity, grain harvested (October to June), biomass incorporated and then rice transplanted (Table 1).

Table 1. Crop months and treatments adapted in the studies

Treatment	October	February	June
1	Pea	Potato	Rice
2	Lentil	Potato	
3	Faba bean	Potato	Rice
4	Fallow	Potato	Rice (1 check)
5	Pea	Pea left upto the maturity	Rice
6	Lentil	Lentil left upto the maturity	Rice
7	Faba bean	Faba bean left upto the maturity	Rice
8	Fallow	Fallow	Rice (2 check)

The trial was established on four replications of plots measuring 3- × 5-m in a randomized complete block design (RCBD). All treatments with legume crops in the trials were grown using minimum tillage, while both the fallow treatments were left uncultivated. Potato was planted in treatments 1 to 4 after harvest and incorporation of the leguminous vegetative materials at their maximum vegetative stage as a green manure in both the years. The matured pods were harvested for the grains and crop residues from all those treatments were then incorporated into the soil prior to rice transplanting on all treatments. After the rice crop harvest in October, the same crop sequences were repeated for another years. Crop cultivars used in the studies were Khumal-4, Kufri Jyoti, Arkel, Simal and Local for rice, potato, pea, lentil and faba bean, respectively. The biomass and grain husk of legume crops was incorporated into the soil in subsequent plots before potato planting or rice transplanting based upon the nature of the treatments.

The experiment was irrigated as per the requirement. After harvesting the rice, composite soil samples at 0-15 cm depth was taken from all the treatments. Three soils samples per plot composited across replicates and analyzed for the N, P₂O₅, K₂O, OM and soil pH at Soil Science Division Khumaltar. Samples of paddy grain and straw having more than 200 g weight were taken randomly from the plots and oven dried for 72 hours for dry matter content in 70°C.

Fresh and dry matters of biomass and grain yield parameters were recorded for legumes. For potato crop, percentage ground cover, number of main stems per plant and tuber yield t was recorded, whereas in the rice crop only plant height (cm), grain yield and straw yield t was recorded. Data on morphological features, yield contributing characters and yield was collected and analyzed using MSTATC computer package programme and least significant difference (LSD) test was used for mean comparison.

RESULTS AND DISCUSSION

Performance of the legume crops

The amount of legume foliage biomass dry mater produced in February harvest grown through the winter season varied from 382 (in faba bean) to 1024 (in pea) kg/ha. In June harvest faba bean produced highest foliage (4288 kg DM/ha) followed by lentil (3088 kg DM/ha) and pea (1988 kg DM/ha) giving contrast results among the crops in two different stages of harvest (Table 2). On the plots of treatments 5 to 7 where legume crops were left upto the maturity stage, grain yields were obtained as an additional income, highest in faba bean (1268 kg/ha) and lowest in pea (750 kg/ha).

Table 2. Combined data on performance of legumes and their residual effect on succeeding crops

SN	Cropping patterns	Legumes			Potato harvest			Rice harvest		
		February harvest, foliage DM, kg/ha	June harvest, DM, kg/ha		Ground cover, %	Stems /plant, n	Tuber yield, t/ha	Pl ht, cm	Grain yield, DM, t/ha	Straw yield, DM, t/ha
			Foliage	Grain						
1	Pea + potato-rice	1024	-	-	56	3.0	13.6	42 b	3.8abc	10.1ab
2	Lentil + potato-rice	502	-	-	63	3.4	13.2	41 b	3.5abc	9.7ab
3	Faba bean + potato-rice	382	-	-	66	3.6	13.7	42 b	3.9abc	10.4ab
4	Fallow - potato-rice (ch)	-	-	-	54	3.3	12.7	40 b	3.3bc	9.1b
	Mean				59.8	3.3	13.3	41.3	3.6	9.8
5	Pea - rice	-	1988	750	-	-	-	42 b	3.5abc	9.3ab
6	Lentil - rice	-	3088	945	-	-	-	47 a	4.0ab	10.7ab
7	Faba bean - rice	-	4288	1268	-	-	-	49 a	4.3a	11.4a
8	Fallow - rice (ch)	-	-	-	-	-	-	40 b	3.1c	8.8b
	Mean							44.5	3.7	10.1
	CV, %				20.6	19.6	26.7	7.2	15.2	15.2
	F test				ns	ns	ns	**	**	**
	LSD (0.05)				-	-	-	4.4	0.5	2.205

DM, Dry matter. Pl ht, Plant height. ch, Check.

Residual effect on potato crop

The residual effects of legume was not significant over percent ground cover, number of main stems per plant and yield tons per hectare on potato crop. Plots, which were green manured from faba bean had the highest effect on all the three above-mentioned parameters followed by lentil and pea (Table 2). Highest potato yield (13.7 t/ha) was obtained from faba bean-grown plots and lowest from lentil (13.2 t/ha) grown plots. Since average national production is 10.9 t/ha during 2002 (APSD 2002), it is about 2 ton higher than that from the national average.

The fresh biomass of legumes, which was turned over and potato planted just after had low biomass and of course organic matter was not sufficient as required to the potato crop. However, potato yielded well in all the plots, indicating that green manuring alone might not be sufficient to a high feeder crop like potato so, application of chemical fertilizer is unavoidable. However, the performance of potato crop depended mostly upon the amount of foliage biomass incorporated and the duration of the legume crops left in the field. So, it is required to grow early maturing varieties of paddy to extend the legume crop period and avoid poor growth of legumes in earlier season due to cool climate and short crop period before potato planting.

Residual effect on paddy crop

In the plant height, treatment number 1 to 5 and 8 ranked same but significantly differing with treatment 6 and 7 which were grown after lentil and faba bean crops (Table 2). Tallest plants were 49 cm with the rice crops grown after faba bean followed by after lentil (47 cm).

Paddy grain yield was significantly higher in rice plots after faba bean (4.3 DM t/ha) and rice after lentil crop (4.0 t/ha) as compared to fallow-potato-rice (3.3 t/ha) and fallow-rice (3.1 t/ha). Grain yields were produced higher in the plots where legumes were left upto its full maturity than the plots where legumes were harvested and incorporated at their vegetative stage. Total 23% paddy grain yield was increased from after faba bean and 13% from after lentil in the plots where they were grown up to the maturity as compared to the pea.

Highest straw yield (11.4 DM t/ha) was also obtained from the rice plots grown after faba bean and lowest (8.8 DM t/ha) after fallow. The effect of different treatments on straw yield was highly significant. The mean straw yield was higher in the treatments where the legume crops were left upto their maturity, likewise in grain yield comparing to the treatments where the legumes were harvested in February and potato planted.

Benefit-cost ratio

Cost of production was highest in the treatment pea, potato-rice (Table 3) followed by faba bean, potato-rice attributing to the factors of higher seed cost of pea. The seed requirement of potato is higher and costly (upto its 50% of total cost of production) and it yields highest among major cereal crops. The cost of production was more than half in potato-included treatments (1 to 4). Net income was highest in fallow, potato-rice followed by faba bean, potato - rice. Due to the potato crop, net income of treatment 1 to 4 remained very high than that of treatments 5 to 8. The experiment indicated that if stresses during growing season of the legume crops will be minimized, additional income through the pod harvest especially from peas and faba bean can add farm income significantly.

Highest benefit-cost ratio of different treatments was obtained from fallow, potato-rice (1.81) followed by fallow-rice (1.74), faba bean- rice (1.72) and lentil-rice (1.70) respectively indicating that potato cultivation before rice crop is economically viable. But the situation will be changed in the long run and the yield will be lower due to the gradual depletion of the available nutrients in the soil. Therefore, to sustain the soil fertility levels especially in the fields where high feeder crops are grown, cultivation of the legume crops in sequence or in between is highly recommended.

Table 3. Effect of 8 different cropping sequences on different economic parameter

Cropping pattern	Cost of production, Rs/ha	Gross income, Rs/ha	Net income, Rs/ha	Benefit-cost ratio
1. Pea, potato-rice	1,54,133.00	2,28,450.00	+ 74,317.00	1.48
2. Lentil, potato-rice	1,41,800.00	2,21,000.00	+ 79,200.00	1.56
3. Faba bean, potato-rice	1,45,466.00	2,30,900.00	+ 85,434.00	1.59
4. Fallow, potato-rice (ch)	1,16,294.00	2,10,600.00	+ 94,306.00	1.81
Mean	1,39,423.25	2,22,737.5	83,314.25	1.61
5. Pea- rice	66,933.00	92,675.00	+ 25,742.00	1.38
6. Lentil-rice	58,000.00	98,785.00	+ 40,785.00	1.70
7. Faba bean - rice	60,867.00	1,04,889.00	+ 44,022.00	1.72
8. Fallow-rice (ch)	34,000.00	59,200.00	+ 25,200.00	1.74
Mean	54,950.00	8,88,872.5	33,937.25	1.64

Effect on soil fertility level

Analysis of soil samples for soil pH, percent organic matter, available nitrogen (%) and available P₂O₅ and K₂O from two years data did not show any major differences between treatments (Table 4). Perhaps, over a number of years, a trend might become evident. In addition to the total N, the effect of different treatments on pH, P₂O₅, and K₂O has to be further studied.

Table 4. Effect of different cropping patterns on soil parameters at Hattiban Farm Khumaltar during 1998 to 2000 at soil depth of 0-15 cm

SN	Treatment	Soil pH		Organic matter, %		Total N, %		Availability, kg/ha			
		1998	2000	1998	2000	1998	2000	P ₂ O ₅		K ₂ O	
1	Fallow- potato- rice	5.7	5.7	2.28	2.68	.151	.136	79	232	124	250
2	Fallow-rice	5.2	5.0	2.28	2.81	.158	.122	83	226	124	250
3	Pea- potato-rice	5.2	5.0	2.01	2.01	.138	.109	120	117	124	230
4	Pea-rice	5.2	4.8	2.14	2.81	.138	.183	173	237	124	230
5	Lentil-potato-rice	5.3	5.0	2.14	2.68	.151	.095	98	236	115	288
6	Lentil-rice	5.2	4.5	3.22	2.81	.132	.129	92	119	106	159
7	Fababean-potato- rice	5.2	5.0	2.28	2.68	.151	.109	89	137	159	150
8	Fababean-rice	5.5	5.4	1.88	1.61	.092	.067	72	128	106	192

CONCLUSION

Performance of the legumes

- Faba bean showed very excellent performance in foliage biomass production, grain yield and residual effect on succeeding crops as indicated by two succeeding crops.
- Lentil crop showed good production potential in Kathmandu valley, if water logging condition and wilting problems is avoided.
- Peas were also appeared to be highly potential crop in the winter season even in February harvest with the scope of pods are harvested and marketed for additional farm income.

Residual effects of legumes on succeeding crops

- The effect of legumes on soil fertility was determined by the performance of potato and rice crops and soil analysis in the experiment. The inclusion of leguminous crop before potato and rice crop contributed large amount of foliage biomass, N to the system and substantially increases the yield of subsequent potato and rice crops.
- A wide range of legume crops can be grown in Kathmandu valley condition during winter season and high biomass and N yields may be obtained at least to substitute partly the costlier and environmentally unhealthy chemical fertilizer. However, the trend shows that large quantities of legume foliage are needed to produce detectable residual effects on succeeding crops like potato and rice.
- High production potential of potato and rice crop and the yield results obtained in the trial indicates that green manuring alone may not be sufficient in these crops. If in the case of addition of chemical fertilizer is unavoidable; the contribution of legume crops in succeeding crops through the addition of organic matter and effects on pH, OM and K₂O and exact doses of FYM and chemical fertilizer has to be further examined.
- With a high production potential per unit time and area, the potato crop has further scope to grow in between different legumes in the systems. This study has indicated that the use of legume crops in the sequences could also make real differences in food production where chemical fertilizer is difficult to afford to enhance the soil fertility conditions. However, the magnitude of the residual effect depends upon several factors. Residue management practices such as time and depth of incorporation should be evaluated to substitute poorer quality farm yard manure in the hills.

REFERENCES

- APSD. 2002. *Statistical information on Nepalese agriculture, 1997/98*. Agriculture Statistics Division, Ministry of Agriculture, His Majesty's Government, Kathmandu, Nepal.
- Bhandari DR and B Devkota. 1998. *Cropping system inventory*. Crop Development Division, Department of Agriculture, Harihar Bhawan, Lalitpur.
- Griffin TS and OB Hesterman. 1991. Potato response to legume and fertilizer nitrogen sources. *Agronomy J.* 83:1004-1012.
- Honeycutt CW, WM Clapham and SS Leach. 1995. Influence of crop rotation on selected chemical and physical soil properties in potato cropping systems. *Am Potato J.* 72:721-735.
- Khatri BB and G Wells. 1996. The effect of legumes on the production of rice and potato based cropping systems. **In:** *Proceedings First National Horticulture Workshop* (PP Subedi, PR Bhurtyal and SP Bhattarai, eds), held on 1-2 May 1996, Lumle Kaski. Nepal Agricultural Research Council. Pp.211-214.
- Khatri BB and GJ Wells. 1999. Effect of grain and forage legumes on the yield of rice-and potato-based cropping systems in Nepal. *International Rice Research Notes* (IRRN). IRRI. Pp.34-35.
- Khatri BB, SL Shrestha and DN Ojha. 2002. Effect of legumes on the production of potato and rice under modified cropping systems of mid-hills of Nepal.
- Maier N and C Williams. 2000. Nutritional management of potato crops: Changes and challenges. *Potatoes 2000*, Linking researches to practice.
- Pandey SP, DB Tamang and SN Vaidya. 1995. Soil fertility management and agriculture production issues with references to the middle mountain regions of Nepal: Challenges in mountain resource management in Nepal. **In:** *Proceedings of ICIMOD/IDRC Workshop*, Kathmandu, Nepal, 10-12 April 1995.
- Pradhan M, SP Pandey and D Joshy. 1992. Marginal agricultural land: A country paper presented at *Seminar on Development of Marginal Agricultural Land*, Bangkok, Thailand, 19-24 April 1992.
- RRP. 2001. *Annual Report*. Rice Research Programme, Nepal Agricultural Research Council, Hardinath, Janakpur, Nepal.
- Schreier H, PB Shah, LM Lavkulich and S Brown. 1994. Maintaining soil fertility under increasing land use pressure in the middle mountains of Nepal. *Soil use and management*, 137-142.

Relative Response of Potato cv Desiree with N and K Nutrients

SL Shrestha, BB Khatri, GP Rai and D Chaudhari

Potato Research Programme, NARC, Khumaltar, Lalitpur

ABSTRACT

In order to determine and recommend the optimal dose of two major chemical fertilizers; nitrogen (N) and potassium (K_2O) for particular environment and particular potato variety during 1998 to 2000, a field experiment was carried out at Hattiban Research Farm, Khumaltar having low nitrogen, medium organic matter and medium potassium and high phosphorous conditions. The relative response of potato crop cv Desiree a highly nutrient responsive and widely grown potato cultivar of Nepal was evaluated with four different levels of nitrogen (0, 50, 100 and 150 kg/ha) and four different levels of potassium (0, 30, 60 and 90 kg/ha) fertilizers. Phosphorous and farmyard manure was applied in all the experimental plots uniformly at the rate of 100 kg and 20 tons per hectare respectively. In the trial, the increment in nitrogen level significantly increased the plant uniformity, canopy cover and plant height and thus the tuber yield. All four levels of potassium fertilizer had no any significant effect on tuber yields however, the numerical differences with the increased rate of K_2O level was distinct in the results. Specific gravity and dry matter content of tubers was not affected by increased or decreased level of nitrogen fertilizer but potassium had slightly negative effects above 60 kg per hectare applied. Nitrogen at 150 kg and potassium at 60 kg levels per hectare gave the best results in the studies under on-station conditions of Khumaltar. Based on yield results obtained and cost benefit ratio, further verification of most effective N and K levels under farmers' field conditions in Kathmandu valley and some other mid hill conditions is recommended.

INTRODUCTION

Potato is one of the major food crop as well as an important vegetable in Nepal. It is grown all over the country from Tarai to the mountain up to the 4,400m from sea level (Joshi 1997). It is considered as a heavy feeder crop and its shallow root habit and rapid growth rate further necessitates a good supply of plant nutrients to obtain higher yields (Pandey 1991). The intensive cultivation, unbalanced application of nutrients and difficulty of obtaining quality manure and fertilizer during the crop seasons have put an immense burden further in the soils of Nepal (Khatri et al 1999).

The main source of nutrients for potato crop is soil, organic and inorganic fertilizers applied. Since, intensive cultivation for many years on the same piece of land with decreasing quantities of manure has resulted decreasing crop yields severely, a good production can not be expected without applying organic or inorganic fertilizers in right dose and proper method (Khatri and Shrestha 1998).

Nitrogen is an essential constituent of protein and chlorophyll where as potassium helps in translocation of carbohydrate and enhances plant resistance to withstand stresses against drought and frost. The application of N and K nutrients along with P is indispensable for its successful cultivation. Since most of the studies conducted in Nepal are concentrated on the effect of individual nutrients and meager information is available regarding N and K requirement of potato cv Desiree in mid-hill condition, the present investigation was conducted at Hattiban Research Farm of Khumaltar under silty-loam soil texture.

MATERIALS AND METHODS

The experiment was conducted during 1998-2000, laid out in randomized complete block design (RCBD). Plot size was maintained with 7.2 m². Farmyard manure was applied at the rate of 20 tons per hectare for all the

treatments. All the fertilizer and manure were applied in furrows at the time of planting potatoes. Sixteen different treatments were taken from four levels of nitrogen (0, 50, 100 and 150 kg/ha) through urea and diamonium phosphate (DAP) and 4 level of potassium fertilizer (0, 30, 60 and 90 kg/ha) through muriate of potash. Phosphorus was applied at the rate of 100 kg per hectare through single super phosphate and DAP in all plots of the trials. To make study manageable, the phosphorus level was kept constant of 100 kg per hectare for all the study years. Bonds of 50 cm spacing were separated within each and every plot to minimize the experimental error. All the cultural practices were followed as per the recommendations of Potato Research Programme Khumaltar.

Soil samples were taken at 0-15 and 15 to 30 cm depth block wise before planting potatoes and treatment wise after the harvest and analyzed for N, P₂O₅, K₂O, pH and OM at Soil Science Division Khumaltar. Plant parameters recorded were emergence, ground cover, plant height, number of main stems and late blight disease incidence. Plant maturity, number and weight of different tuber size fractions and tuber yields tons per hectare were recorded. In yield parameter, after harvesting the tubers, dry matter percentage were identified by keeping the tubers in a oven at 60°C for 72 hours while specific gravity was calculated by using the formula:

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{weight under water}}$$

Similarly, the marginal rate of return (MRR) was calculated by using the formula:

$$\text{MRR} = \frac{\text{Value of additional crop} - \text{Value of additional fertilizer}}{\text{Value of additional fertilizer}}$$

The data recorded for growth and yield characteristics during both the years of investigation were pooled and statistically analyzed.

RESULTS AND DISCUSSION

Effect on growth parameter

Plant uniformity was measured from 1 to 3 in the scale. Plants fertilized with 150 kg nitrogen were significantly uniform as compared to others but there was no any effect of K₂O. Effect of nitrogen was significant on ground coverage, which was increased as the dose increased. But K₂O levels did not affect it. The highest ground cover (78%) was noticed in 150:100:60 kg NPK per ha and lowest in 0:100:60 kg per ha (Table 1). There was a clear relationship of the plant height and average ground cover percentage with the increased level of N fertilizer as the taller plant was measured with higher ground coverage. The tallest plants (25.3 cm) were measured in 150:100:90 kg NPK applied plot, however effect of K was not noticed. Highest number of stems per plant (3.1) was counted in 150 kg N applied plot. Average number of main stems per plant was also increased as the N fertilizer level was increased but no any effect of K was observed.

Effect on yield parameter

Under sized tubers weight percentage was decreased in every increment of N level and as a result the lowest under sized tubers weight (14%) was recorded in 150 kg N applied plot followed by 100 kg N per ha (19%). Highest percent of under sized tubers (22%) was recorded in 0 kg N/ha. The trend of effect was appeared same with potassium level although it was not statistically significant.

Number of seed sized tuber were decreased but over sized tubers weight was increased as the nitrogen level increased as a result the highest over sized tuber weight (22%) and lowest seed sized tubers weight (64%) was recorded in 150 kg N applied plot. Likewise, seed sized tubers and oversized tubers number was significantly increased as the level of N increased. Highest number of seed sized tuber (93) and oversized tubers (14) was counted in 150 kg N applied plots. Hence, every increment of nitrogen level increased larger sized tubers in number and weight. This trend was also noticed in the application of potassium fertilizer.

Table 1. Effect of different levels of nitrogen fertilizer and potassium fertilizer on potato 1999/2000 and 2000/2001 at Khumaltar

Treatment, kg/ha	Unifor mity	Ground cover, %	Plant Ht, cm	Stem /plant, n	Tubers grading in no. and wt, %						Yield, t/ha	Total		Specifi gravity	% dry matter	% yield increment
					US		SS		OS			tubers/plant	g			
					No.	Wt.	No.	Wt.	No.	Wt.						
0:100:0	3	47	16.0	2.7	67	23	65	71	2	6	9.69		145	1.068	16.3	-31.9
0:100:30	3	47	15.8	2.3	72	21	67	71	4	9	10.94	7.0	164	1.072	17.1	-23.1
0:100:60	3	38	15.3	2.6	71	27	51	70	1	3	8.34	6.0	125	1.074	17.6	-41.4
0:100:90	2	51	15.5	2.5	80	19	72	73	3	7	10.70	7.5	160	1.069	16.8	-24.8
50:100:0	2	59	16.8	2.8	83	20	82	75	2	5	12.11	8.0	181	1.071	16.1	-14.9
50:100:30	2	64	22.0	3.5	92	27	84	66	4	7	14.17	8.5	212	1.066	17.2	-0.4
50:100:60	2	55	18.2	2.8	81	18	81	72	6	10	13.12	8.5	197	1.068	17.1	-7.8
50:100:90	1	64	19.7	3.0	100	18	82	71	6	11	14.37	9.5	216	1.069	16.1	-1.0
100:100:0	2	62	19.3	3.2	79	21	68	64	8	15	12.93	7.8	194	1.071	16.9	-9.1
100:100:30	2	64	18.3	3.1	73	19	84	71	5	9	13.63	7.8	204	1.071	16.8	-4.2
100:100:60	1	70	18.8	2.8	68	13	82	65	11	21	14.23	8.0	213	1.072	17.4	0
100:100:90	2	64	18.2	3.0	77	22	74	68	4	9	13.67	6.7	205	1.067	16.5	-3.9
150:100:0	1	76	21.5	3.2	78	17	97	66	12	17	17.87	9.2	268	1.072	18.3	+25.6
150:100:30	1	74	20.3	3.0	87	14	95	67	11	19	18.21	9.5	290	1.071	17.4	+28.0
150:100:60	1	78	20.0	3.2	75	13	97	65	14	22	20.84	9.5	312	1.069	16.3	+46.4
150:100:90	1	76	25.3	3.1	76	14	84	57	17	28	19.60	8.3	294	1.069	16.4	+37.7
Nitrogen, kg/ha																
0	2	46	15.7	2.5	72	22	64	71	3	6	9.92 c	6.7	149	1.071	16.9	
50	2	61	19.2	3.0	89	21	82	71	4	8	13.44	8.6	202	1.068	16.2	
											b					
100	2	65	18.7	3.0	74	19	77	67	7	14	13.61	7.6	214	1.070	16.9	
											b					
150	1	76	21.8	3.1	79	14	93	64	14	22	19.13	9.1	291	1.070	17.1	
											a					
F test	**	**	**	**	ns	**	**	**	**	**	**	**	**	**	**	
LSD (.05)											2.38					
Potash, kg/ha																
0	2	61	18.4	3.0	77	20	78	69	6	11	13.22	7.8	197	1.071	16.9	
30	2	62	19.1	3.0	81	20	83	69	6	11	14.24	8.2	218	1.070	17.1	
60	2	60	18.1	2.8	74	18	78	68	8	14	14.13	8.0	223	1.071	17.1	
90	2	64	19.7	2.9	83	18	78	67	7	14	14.58	8.0	217	1.068	16.4	
N × K	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns		
CV, %	20.9	8.7	17.4	14.9	29.6	34.3	23.0	11.7	-	-	29.6	23.3	28.0			

With respect to the potato yield, highly significant difference was observed in tubers yield tons per hectare. Highest yield (20.84 t/ha) was obtained from treatment combination of 150:100:60 kg NPK per ha followed by 150:100:90 (19.60 t/ha). These treatments had increased yield by 46.4% and 37.7% respectively as compared to the PRP recommended control treatment 100:100:60 kg/ha. Nitrogen with 150 kg per hectare gave significantly higher tuber yields (19.31 t/ha).

But the effect of potassium was not distinct. As the level of N fertilizer increased tuber number and yield per plant was also increased. Highest tuber number per plant (9) was counted in 150 kg N level whereas it was only 6.7 in 0 kg N applied plot. Likewise, highest tubers yield on per plant (291 g) basis was harvested in 150 kg N application followed by 100 kg N/ha (214 g). Tubers yield per plant was increased up to 60 kg K application.

With the different level of N and K fertilizer, the response of specific gravity and dry matter percentage did not show any clearer differences. It could be generalized that higher dose of N up to 150 kg/ha and K₂O 60 kg/ha did not decreased the quality of tubers with respect to specific gravity and dry matter percentage, however, highest dry matter (17.1%) was recorded in 150 kg N and 30 or 60 kg K application.

Effect on economic parameter

In the economic use of nitrogen and potassium, highest marginal rate of return was achieved by 150 kg N/ha (27.1) and 30 kg K/ha (10.9) (Table 2 and 3).

Table 2. Economics of N fertilizer use

N, kg/ha	Value of added nutrient cost, Rs	Tuber yield, t/ha	Yield increment, t/ha	Value of added potato cost, Rs	Marginal rate of return (MRR)
0	0	9.92	0	0	0
50	1630	13.44	3.52	28160.0	16.3
100	3260	13.61	3.69	29520.0	8.0
150	4890	19.13	9.21	73680.0	14.1

Table 3. Economics of K fertilizer use

K, kg/ha	Value of added nutrient cost, Rs	Tuber yield t/ha	Yield increment, t/ha	Value of added potato cost, Rs	MRR
0	0	13.22	0	0	0
30	750	14.24	1.02	8160.0	9.9
60	1500	14.13	0.92	7360.0	3.9
90	2250	14.58	1.36	10880.0	3.8

Table 4. Effect of different fertilizer combinations on its economical benefit and production cost per hectare (all other factors making constant)

N:P:K, kg/ha	Total cost for fertilizer, Rs	Total income, Rs	Benefit, Rs	Benefit cost ratio	Cost of production, per kg
0:100:0	5626.00	77520.00	71895.00	12.8	0.58
0:100:30	6375.00	87520.00	81145.00	12.7	0.58
0:100:60	7125.00	66720.00	59595.00	8.4	0.85
0:100:90	7875.00	85600.00	77725.00	9.9	0.73
50:100:0	4702.00	96880.00	92178.00	19.6	0.39
50:100:30	5452.00	113360.00	107908.00	19.8	0.38
50:100:60	6202.00	104960.00	98758.00	15.9	0.47
50:100:90	6952.00	114960.00	108008.00	15.5	0.48
100:100:0	6334.00	103440.00	97106.00	15.3	0.49
100:100:30	7084.00	109040.00	101956.00	14.4	0.52
100:100:60	7834.00	113840.00	106006.00	13.5	0.55
100:100:90	8584.00	109360.00	100776.00	11.7	0.63
150:100:0	7963.00	142960.00	134997.00	16.9	0.44
150:100:30	8713.00	145680.00	136967.00	15.7	0.48
150:100:60	9463.00	166720.00	157257.00	16.6	0.45
150:100:90	10213.00	156800.00	146587.00	14.3	0.52

Table 5. Effect of different treatments on soil parameter

NPK Treatments		N, %		K ₂ O, kg/ha		pH	
		1998	2000	1998	200	1998	2000
0:100:0		0.145	0.117	206	191	5.0	4.5
0:100:30		0.152	0.160	186	260	5.0	5.0
0:100:60		0.118	0.129	227	269	5.0	4.6
0:100:90		0.134	0.148	237	243	5.0	4.8
50:100:0		0.124	0.148	186	329	4.8	4.8
50:100:30		0.124	0.148	155	503	5.0	4.7
50:100:60		0.131	0.142	175	364	5.0	4.8
50:100:90		0.134	0.148	196	434	5.4	4.8
100:100:0		0.134	0.154	165	200	5.0	4.9
100:100:30		0.097	0.142	155	329	5.0	4.9
100:100:60		0.118	0.123	186	242	5.0	4.7
100:100:90		0.124	0.142	206	416	5.0	4.8
150:100:0		0.145	0.136	206	324	5.0	4.8
150:100:30		0.138	0.204	134	249	5.0	5.0
150:100:60		0.137	0.142	144	274	4.6	4.7
150:100:90		0.152	0.166	155	332	4.5	4.7
N	K						
0	0	137	139	214	241	5.0	4.7
50	30	128	163	178	407	5.0	4.8
100	60	118	139	178	297	5.0	4.8
150	90	143	151	260	295	4.8	4.8

Among the 16 different doses of fertilizer combination evaluated, treatment level of 150:100:60 gave the highest economic benefit (Rs1,57,257) followed by 150:100:90 (Rs1,46,587.00) per ha where control 100:100:60 gave only Rs.1, 06,006.00 per hectare basis. With respect to benefit cost ratio, 50:100:0 gave the highest (19.8) followed by 50:100:0 (19.6), where 150:100:60 gave the 16.6 only. When cost of fertilizer to produce 1 kg potato was calculated, treatment of 150:100:60 had Rs.0.45 and 100:100:30 had Rs0.55 whereas 50:100:30 had only Rs0.38 followed by 50:100:0 kg/ha (Table 4).

Effect on soil parameter

There is no any distinct change in soil parameter. It may be due to very short period to show the significant effect on soil parameter (Table 5). However, the mean value calculated showed that there is a considerable increase in nitrogen (%) and K₂O (kg/ha) and decreased in pH from 1998 to 2000.

CONCLUSION

Based on the results of two years at Khumaltar NPK level at 150:100:60 kg along with 20 tons FYM (compost) per hectare is recommended for better crop yields of potato. With the increased dose of any fertilizer, requires more investment on the crops and becomes expensive. However, at this moment, most effective nitrogen level and potassium level should be tested in farmer's field condition in Kathmandu valley and other mid-hills condition before further recommendation.

REFERENCES

- Joshi D. 1997. *Soil fertility and fertilizer use in Nepal*. Soil Science Division, Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal. Pp.19.
- Khatri BB, SL Shrestha and DN Ojha. 1999. Effect of legumes on the production of potato and rice under modified cropping system of mid-hills of Nepal. **In**: Proc. of Potato Global Research and Development, vol. II (SM Paul Khurana, GS Shekhawat, SK Pandey and BP Singh, eds). Pp.964-967.
- Khatri BB and SL Shrestha. 1998. Organic and inorganic fertilizer research on potato in Nepal: A review. *Nepalese Horticulture* 2(1): 60-69.
- Pandey SP. 1991. *Economic use of fertilizer on rice. Field documents*. Fertilizer and related inputs program (FRIP). Dept of Agriculture/Agriculture Input Corporation. HMG/N and FAO.

Response of Cabbage to Nitrogen and Phosphorus during Rainy Season in High Hills

Purushottam P Khatiwada and Sharmila Piya

Agriculture Research Station, Pakhribas

ABSTRACT

A study to identify an appropriate dose of nitrogen and phosphorus for summer season cabbage production was accomplished in the high hills of eastern Nepal. The experiment was conducted during the two summer seasons (May - September) of 2000 and 2001 AD. Three levels of nitrogen (60, 100 and 140 kg/ha) and the phosphorus (40, 60 and 80 kg/ha) were tested to Green Coronet variety with spatial arrangement in 45- × 30-cm. 60:80:50 N:P:K/ha yielded a significantly higher head yield (56.2 t/ha) in June transplanting. Individual analysis of nitrogen, phosphorus and their interaction failed to show a significant effect on cabbage head yield. There was a positive trend of increased level of phosphorus ($P = 34.98 + 3.65x$) but not a clear trend of nitrogen. The results have opened up avenues for the fertility management for rainy season cabbage cultivation in the hills.

Key words: Cabbage, nitrogen, phosphorus, rainy season

INTRODUCTION

Cabbage is an important commercial vegetable crop in Nepal. It occupies the second largest area under cultivation after cauliflower among the vegetable crops (Shrestha and Ghimire 1996). Extensive research carried out at Pakhribas for all year-round production revealed that hybrid varieties performed well during rainy season (PAC 1990). The Sindhuwa Cooperative of Dhankuta district alone exported 9,000 t of cabbage to India during the year 2002 (M Gurung, Marketing Manager of Sindhuwa Cooperative, Personal communication). As a result, a number of hybrids are extensively cultivated particularly during autumn and rainy seasons in the eastern hills despite the crop has classified as a winter vegetable. The previously recommended hybrid, KK Cross (Thapa et al 1997) has been replaced by new hybrids (Green Stone and Green Coronet) due to their small in size and tight heads, relatively better storability and easy to market.

The average productivity (9.7 t/ha) of cabbage (Shrestha and Ghimire 1996) is low in Nepal. It could be due to lack of husbandry technologies as Nepalese farmers have been using hybrid seed imported from overseas. A recent study showed that the closer spacing of cabbage is appropriate for rainy season cabbage cultivation in the hills (Khatiwada 2000). Information on fertilizers recommendation for cabbage is not available for hill situation of Nepal. Optimum amount of compost and fertilizers does not only help to maximize the crop production but also help to maintain chemical and physical properties of the soils. Farmers of Sindhuwa area have experienced decline in physical and chemical properties of soil in cabbage growing fields. Realizing this fact, hill farmers residing along the road corridor have started to bring and apply poultry manure from Tarai. Gregory (1997) recommended that the increased emphasis on horticultural crops in the hills together with intensification of production during the off-season needs up to-date information regarding fertilizers requirement to the crops for long-term sustainability of vegetable crops. Hence, an experiment was carried out to identify the appropriate dose of nitrogen and phosphorus for rainy season cabbage cultivation with close spacing.

MATERIALS AND METHODS

The experiment was carried out at the High Altitude sub-Station, Sindhuwa (2200 masl) of Dhankuta district during the summers of 2000 and 2001. The aspect was east facing. The soil was sandy loam and slightly acidic. Three levels of nitrogen (60, 100 and 140 kg/ha) and phosphorus (40, 60 and 80 kg/ha) were tested along with organic matter. The K was supplied at a rate of 50 kg/ha. The contribution of N, P and K from the compost was not calculated. The design was randomized complete block and replicated four times.

A five metre long and one metre wide nursery was prepared and a high shade was constructed to cover the nursery bed. Compost at a rate of 5 kg/m² and Malathion dust at a rate of 1 g/m² were applied in the nursery bed. Seed of Green Coronet variety was sown in the first week of May. Mulching was done using dried grasses immediately after sowing, which was followed by watering. One weeding and one spraying of Indofil M-45 (Mancozeb) at the rate of 2 g/l as a prophylactic measure were performed in the nursery. In the year 2000, larva of cabbage butterflies were noticed and Nuvan (Dichlorvos) at a rate of 1 ml/l was sprayed two day before transplanting.

Liming was done a month earlier in the experimental field at a rate of 1.6 t/ha. Farmyard manure was applied at the rate of 33 t/ha and incorporated into the soil during land preparation. Malathion dust (5%) at a rate of 20 kg/ha was applied at the final land preparation stage. A half of the nitrogen as per the treatments and all phosphorus and potash were applied as basal dose. Thirty to thirty-two day old seedlings were transplanted into the main field. To maintain the required plant population (seedlings killed by cutworms and red ants) gaps were filled. To minimize the damage, Chlorpyrifos granules were applied near the root zone of individual plants.

Rest half of the nitrogen was further split into two and applied as top dressings. The first and second top dressings were accomplished at 30 and 45 day after transplanting. Weeding was carried out at a month interval. During the whole growing season, 2-3 sprayings of insecticides (Metacid-Methyl parathion, at a rate of 2 ml/l and Chlorpyrifos at a rate of 1.5 ml/l) and fungicide (Indofil M-45 at a rate of 2 g/l) were carried out. For the plant nutrient analysis, plants were uprooted from the boarder rows after 65 to 66 day after harvesting. Heads were harvested when they matured physiologically, which was judged by head firmness. In addition to the marketable head weight, other parameters like unmarketable head weight, total upper ground biomass, outer leaf number, head polar as well as equatorial diameter, leaf length, leaf diameter and disease and insect incidence were also recorded. Leaf length was measured by taking average leaf length of five leaves (consisting outer, middle and inner leaves) of 10 plants and leaf breadth was measured by taking average leaf length of five leaves (consisting of outer, middle and inner leaf) of 10 plants. After the crop harvest, representative soil samples were collected from each plot. Soil analyses were performed for nitrogen, phosphorus, potash and organic matter. The data from the experiment were analyzed using GENSTAT-5 package.

RESULTS AND DISCUSSION

Marketable head weight

The marketable head yield of cabbage was reckoned significantly ($P < 0.05$) different among the treatments. 60:80:50 N:P:K/ha yielded significant highest yield (56.2 t/ha) than that of rest of the treatments except 100:80:50 N:P:K/ha (Figure 1).

Analyzing the data without using control treatment - considering 3×3 factorial condition, statistical analysis failed to show significant different among three levels of nitrogen and phosphorus. However, a linear relationship ($Y = 34.98.0 + 3.65x$) was calculated with the increase level of phosphorus but not with the nitrogen.

After the exploration of year round cabbage production in the upper mid hills and high hills of the Eastern Nepal (PAC 1990), its cultivation in the summer season has increased dramatically in the road access areas. By using closer spacing (Khatriwada 2000), only compost application yielded higher head yield than the national average (9.7 t/ha reported by Shrestha and Ghimire 1996). This could be due to the use of hybrids. During selling the cabbage heads, farmers usually keep 6-7 outer leaves instead of keeping 2-3 leaves along with heads, which is a common practice amongst the researchers. An observation in this aspect has revealed that 13.6% weight was increased than that of technicians' harvest method. Hence, the yield in farmers' field conditions should be much higher. A prominent effect of phosphorus and no effect of higher dose of nitrogen were found from this

experiment. In both years, every day rain was experienced during the period of transplanting as well as cultivation. Gurung and KC (1993) reported that 87% of total rainfall concentrated between May and September. Almost all growing season of this experiment fell during this period. Because of continues rain and mobile nature of nitrogen, the N might has leached despite uptake by the plants. Acharya and Tripathi (2001) reported the mean seasonal losses of NO_3 and P were 57.57 and 0.24 kg/ha respectively from Bari land cropping systems. Furthermore, nutrients use efficiency can also be expected poor because of very little solar radiation due to fog overcast. It might be the reason for not coinciding the results of this experiment with the others. For winter season cabbage 100 kg/ha and more nitrogen have been recommended for Nepal and India (Tandon 1987, VDD 1990, Subba 1991, Man and Shadu 1995, Lal 1996). However, Chaudhary (1993) suggested to apply 75-100 kg each nitrogen and phosphorus for cabbage. Additionally, 80 kg/ha phosphorus recommended for the Sikkim hills (Subba 1991) is analogous with this result.

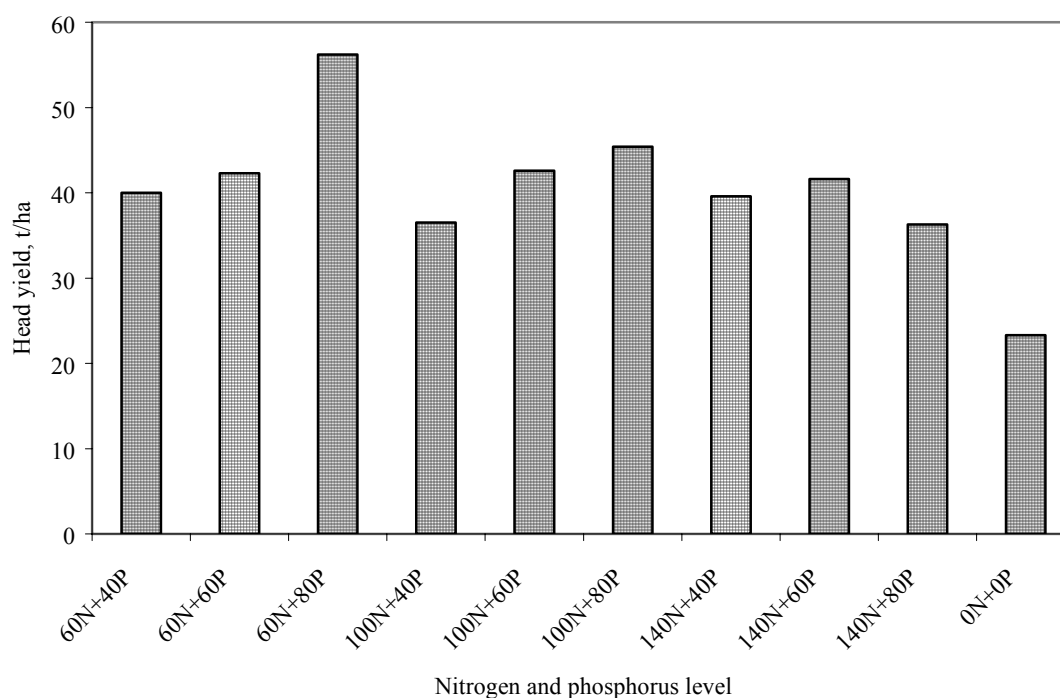


Figure 1. Effect of different levels of nitrogen and phosphorus on cabbage head yield.

Head compactness

The interactive effect of nitrogen, phosphorus and year was not significantly different. Similarly, the compactness level was not significant due to the different levels of nitrogen and phosphorus. There is a general notion that poor fertility caused the loose head. But this experiment has showed that only compost is sufficient enough for compact head of Green Coronet despite the low yield.

Head weight

The single factor effect of nitrogen and phosphorus excluding control failed to show statistical difference in head weight. However, 60:80:50 N:P:K kg/ha has produced significantly large head weight (0.87 kg) than that of rest of the treatments. As expected the smallest (0.52 g) head was recorded from the control. This result has proved that head size can be manipulated by providing closer spacing and nutrients availability despite genetic potential of bigger head size. From earlier experiment, Green Coronet has yielded 566 g head weight with this spacing but from different fertility levels (Khatiwada 2000). Hence, the new fertilizer rate has increased the efficiency of its yielding capacity.

Cropping duration

Effect of different levels of nitrogen and phosphorus was not prominent on the days to head maturity. Few heads (18%) were ready for harvest after 93 days after transplanting irrespective of the treatments. The harvest was completed in between 123 to 132 days.

Unproductive plant number

The non-headed plants were regarded as unproductive plants. The mean number ranged between 0.5 to 3 per plot. There was not a clear trend of effect of nitrogen and phosphorus on the unproductive head number.

Plant height

Plant height was significantly ($P<0.001$) different among the tested treatments. 60N+80P combination produced the tallest (31.55 cm) plant, which was statistically higher than that of rest of the treatments (Table 1). As in the yield, the higher dose of nitrogen did not influence on the plant height of cabbage.

Table 1. Plant height in centimeter of cabbage

Nitrogen, kg/ha	Phosphorus, kg/ha		
	40	60	80
60	27.82	29.31	31.55
100	26.97	27.26	28.12
140	25.67	25.99	26.99
	Nitrogen	Phosphorus	Interaction
P value	<0.001	<0.001	0.024
SED	0.338	0.338	0.586
CV, %	4.2	4.2	4.2

Plant spreading

Plant spreading was significantly ($P<0.001$) influenced by the different levels of nitrogen and phosphorus. The result showed that 60:60:50 N:P:K kg/ha and 60:80:50 N:P:K kg/ha combination gave a maximum coverage of 34.96 cm and 33.1 cm respectively. While analyzing the data excluding the control treatment, interaction was found non-significant but the level of nitrogen and phosphorus were calculated highly significant (Table 2). The result has clearly demonstrated that lower level of nitrogen has more prominent effect than that of higher doses of nitrogen. However, not a clear trend has been noticed with phosphorus.

Table 2. Effect of nitrogen and phosphorus on plant spreading of cabbage

Nitrogen	Spreading, cm	Phosphorus	Spreading, cm
60 kg/ha	32.23	40 kg/ha	26.51
100 kg/ha	27.23	60 kg/ha	30.82
140 kg/ha	26.46	80 kg/ha	28.59
P value	<0.001		<0.001
SED	1.02		1.02
CV, %	12.4		12.4

Leaf length

Effect of leaf length was found statistically prominent ($P<0.001$). The result showed that the 60:60:50 N:P:K kg/ha had the mean length of 25.48 cm and 60:80:50 N:P:K kg/ha had 25.94 cm, which were statistically higher than that of rest of the treatments. The result clearly showed that 60 kg nitrogen along with more than 60 kg phosphorus had the longer leaf (Table 3).

Table 3. Effect of the fertilizers on leaf length, cm of cabbage

Nitrogen, kg/ha	Phosphorus, kg/ha			
	40	60	80	
60	22.65	25.46	25.94	P value, <0.001 SED, 0.529 CV, 4.6%
100	22.36	22.72	22.76	
140	20.78	21.32	21.3	

Leaf breadth

Statistical difference ($P<0.001$) was seen in the leaf breadth in different levels of nitrogen and phosphorus. The result showed that the 60:60:50 N:P:K kg/ha had the mean breadth of 19.22 cm and 60:80:50 N:P:K kg/ha had 19.61 cm, which were statistically higher than that of rest of the treatments. The trend of leaf breadth was exactly similar with the leaf length (Table 4).

Table 4. Effect of the fertilizers on leaf breadth, cm of cabbage

Nitrogen, kg/ha	Phosphorus, kg/ha			
	40	60	80	
60 kg/ha	16.86	19.22	19.61	P value, <0.001 SED, 0.516 CV, 6.0%
100 kg/ha	16.85	17.33	16.96	
140 kg/ha	15.71	16.23	15.29	

Outer leaf number

The effect of nitrogen was prominent on outer leaf number. 60 kg N/ha and without nitrogen treatments produced the significantly higher number of outer leaves. By excluding the control plots, effect of interaction and phosphorus was not significantly different but nitrogen was significant ($P < 0.001$). The lower level of nitrogen had the highest (7.9) leaf number.

Upper ground biomass

The effect of chemical fertilizers was significant at 0.001% level. The control treatment yielded the lowest biomass of 35.4 t/ha. The total upper ground biomass production of 60:80:50 N:P:K kg/ha (74.6 t/ha) was statistically higher than that of rest of the treatments except 100:80:50 N:P:K kg/ha (60.3 t/ha). While analyzing the data without using the control, interaction and phosphorus failed to demonstrate difference statistically. However, weak evidence ($P < 0.05$) was recorded for nitrogen. 60 kg/ha produced the statistically highest (62.5 t/ha) biomass.

Diseases and insects

Alternaria leaf spot, Sclerotinia rot and Downey mildew were the three diseases recorded from the experimental plots. Disease scoring just before harvest found 0-20% attacked by Alternaria leaf spot, 0-28% disease severity of Downey mildew and 0-12% attack by Sclerotinia rot. There was not a very definite trend of these diseases along with the treatments. Attack of cutworms was severe during the establishment phase of the transplanted plants, where up to 10% damage was recorded within a week of transplanting in a plot. Similarly, attack of red ants was also severe. In nursery stage, attack of damping off disease and flea beetles insect were recorded.

Major nutrients exhaustion

Nitrogen, phosphorus and potash levels in the experiment plots were 0.224%, 45.16ppm and 195.9 ppm respectively before the establishment of the experiment. Similarly, organic matter content and soil pH were 1.76% and 5.8 respectively. Analysis of variance revealed that the NPK content in different treatments was not significant due to application of different dose of nitrogen and phosphorus. None of the combination among the nutrients before and after experiment along with soil pH showed a correlation. Failure to get positive correlation indicates that nitrogen might have been leached and the phosphorus might have been absorbed by the plants.

The result has indicated an interesting area of nutrient management in the context of expanding summer season cabbage cultivation in the hills. The effect of phosphorus was found very prominent in the soil having more than pH 5.5. Failure to show encouraging result by increasing levels of nitrogen in rainy season meant to alter the current practice of nitrogen application. Further splitting the dose of nitrogen and using slow releasing approach has to be looked in the future.

ACKNOWLEDGEMENTS

We are grateful to Hill Agriculture Research Project (HARP) for the financial support. Our sincere gratitude goes to Messrs RC Munakarmy, DB Subba, DP Dhakal, S Baidhya, ASR Bajracharya and YP Sah for their professional supports. We heartily appreciate the help provided by Messrs JB Basnet, BP Chaudhary and JL Mandal for trial execution, data recording and data compilation. Last but not the least, Dr DP Serchan deserves special thanks for his suggestions to improve the manuscript.

REFERENCES

- Acharya GP and BP Tripathi. 2001. Assessment of strip cropping practice against soil and soil fertility loss through run off in sloping crop fields in the hills of western development region of Nepal. *Lumle Working Paper No. 2002/1*. Agriculture Research Station, Lumle, Kaski, Nepal.

- Chaudhary SL. 1993. *A handbook of manures and fertilizers on vegetable crops*. Vegetable Development Division, Khumaltar.
- Gregory PG. 1997. *A soil fertility research strategy for Pakhribas Agricultural Centre, Nepal: Report of a consultancy visit*. The University of Reading, United Kingdom.
- Gurung GB and Resham KC. 1993. Review of climatological information of Pakhribas Agricultural Centre its importance and implications in agriculture. *PAC Working Paper No. 67*. Pakhribas Agricultural Centre, Dhankuta, Nepal.
- Khatriwada PP. 2000. Plant spacing: A key husbandry practice for rainy season cabbage production. *J. Nepal Agric. Res.* 4:48-55.
- Lal G. 1996. Effect of nitrogen and spacings on yield and quality of cabbage (*Brassica oleracea* var capitata). *Annals of Biology* (Ludiana). 12(2):242-244.
- Man KS and BS Shadu. 1995. On the nitrogen requirement of cabbage. *Indian J Hort.* Vol. XII, 4:188-195.
- PAC. 1990. *Madhya Pahadi Chhetrama Barshaibhari Banda Kopi Utpadan* (Year round cabbage production in mid hills-in Nepali). *PAC Technical Bulletin*. Pakhribas Agricultural Centre, Dhankuta, Nepal.
- Shrestha TN and NP Ghimire. 1996. Fresh Vegetable Production in Nepal. **In:** *Proceedings on the National Seminar on Vegetable Development* 11-12 June 1996. Vegetable Development Division and FAO Fresh vegetable and Vegetable Seed Production Project, Kathmandu, Nepal. Pp.1-16.
- Subba JR. 1991. *Sikkim ka sag sabji* (Vegetables in Sikkim-in Nepali). Department of Agriculture, Government of Sikkim, Gangtok.
- Tandon HLS. 1987. *Fertilizer recommendation for horticultural crops in India - A guide book*. Fertilizer Development and Consultation Organization, New Delhi, India.
- Thapa MP, PP Khatriwada, SR Gautam, G Neupane and BH Baral. 1997. Provisional recommendation for horticultural crop production in the Eastern hills of Nepal: Based on research at Pakhribas Agricultural Centre (1988-1996). *PAC Working Paper No. 216*. Pakhribas Agricultural Centre, Dhankuta, Nepal.
- VDD. 1990. *Nepal Ma Tarkari Kheti* (Vegetable cultivation in Nepal-in Nepali). Vegetable Development Division, Khumaltar, Lalitpur, Nepal.

Response of Red Creole Onion Sets to Different Planting Dates on Off-Season Production under the Mid-Hill Condition of Dailekh

Tul B Poon¹ and Hom N Regmi²

¹ Agriculture Research Station, Dailekh, Mid Western Nepal

² Horticulture Research Division, Khumaltar

ABSTRACT

This experiment was carried out at Agriculture Research Station (Horticulture), Dailekh during the years 2001 and 2002. The objective of this study was to identify the appropriate planting date of Red Creole onion sets for maximum yield of both biomass and bulb during off-season. Onion seeds were sown in the individual nursery beds in the last week of January. They were lifted in the first week of June and were selected and stored well until the planting weekly intervals on July 26, August 3, 10, 17, 24 and 31 in the main field. Planting dates significantly influenced the plant population, biomass and bulb yield. These yield components decreased with the earlier planting in rainy season. Onion sets planted on August 31 produced the highest pooled plant population (5, 45,776/ha) followed by August 24 (5, 29,444/ha). August 24 set-planting Produced the highest pooled biomass yield (51,266 kg/ha) and fresh bulb yield (35,127kg/ha). However, the set-planting of July 26 gave the lowest pooled plant population (3, 65,000/ha), biomass yield (14,480 kg/ha) and fresh bulb yield (7,978 kg/ha). The results of the study indicated that the second fortnight of August set-planting is the most suitable planting date of all tested planting dates under the mid-hilly condition of Dailekh and similar areas in mid and possibly even far-western regions of Nepal.

Key words: *Allium cepa*, biomass yield, bulb, components, planting date

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetables in Nepal. It is enriched with starch, protein, carotene, Vitamin B and C. Although they are consumed in rather small quantities by most families, they are used in many houses almost daily primarily as a seasoning for wide variety of dishes. Many virtues are contributed to the onion: they have diuretic properties and are beneficial to the digestive tract, they are good for eyes, act as heart stimulant and are useful as anti-rheumatic remedies (as cited by Shanmugavelu 1989).

Common onion bulbs are produced during summer season by raising seedlings in the nursery during early winter season. Most of the onion bulbs are rotten in open stores during rainy season which lead to the shortage of onion bulbs as well as their rise-price in autumn and winter seasons. A huge amount of onion bulbs are imported to our country from India from October to May. In order to meet the demands of onion bulbs during these lean seasons, the techniques of off-season onion production through the use of sets has already been generated (Pun and Karmacharya 1993). Middle of August planting sets are preferred in Maharastra, India to get an early crop of better quality for fetching a high price (AAD 1982). Rainy season planting of sets has been commonly recommended for the general cultivation throughout the mid-hills of the country (Pun and Karmacharya 1993). Howsoever, no regionally authenticated information is available on the time of planting sets for the mid-hills of mid-west and far west of the country. This paper describes the response of planting dates of Red Creole onion sets to biomass yield, fresh bulb yield and yield contributing other phonological characters.

MATERIALS AND METHODS

This investigation was carried out in the field of Agriculture Research Station; Dailekh located an altitude of 1300 meters during 2001/002 and 2002/003. The soil was sandy loam retaining 1.74% organic matter, 0.09 % total N, 72 and 198 kg/ha available P and K respectively, with pH 6.20. Seeds of Red Creole onion were sown in the individual nursery beds of 2 meters length and 1- meter breadth during the last week of January. Onion sets were lifted in the first week of June. Sets with average diameter of 1.5- 2.0 cm were selected, tied in bunches and hanged in an airy storeroom until the planting of sets in the main field. The six different planting dates (i.e. July 26, August 3, August 10, August 17, August 24, and August 31) were tested in onion variety Red Creole respectively during 2001/002 and 2002/003. The individual unit plot area of 2.25m² was laid out in a randomized complete block design with four replications. A total of 150 sets were planted in the intra-rows and inter rows of 10 × 15 cm in the individual plot. Well-decomposed farmyard manure @ 20 mt /ha was incorporated into the soils prior to planting of sets. Nitrogen (60 kg), Phosphorus (100 kg) and Potash (100 kg)/ ha were applied in the last land preparation. The rest of the Nitrogen (60 kg) was top-dressed in two equal split doses, the first 25 days after and the second 50 days after planting of sets. The other cultural practices such as weeding, irrigation and plant protection measures were followed as per needed. Bolting was not allowed by plucking off the flower stalks during late growing bout of the crop. The crops were harvested in 98- 106 days accordingly after planting. Observations were made on days to harvest, plant population, biomass yield, fresh bulb yield, individual bulb diameter, and individual bulb weight.

RESULTS AND DISCUSSION

The plant population, biomass yield and fresh bulb yield were recorded highly significant ($P<0.01$) from the sets planted in different dates of rainy season in 2001. However, the plant population was recorded as non-significant from the sets planted in the same dates during the same season in the year 2002 (Table 1). An individual bulb diameter was not significantly influenced ($P>0.05$) by different dates of sets planting during rainy seasons of both the years 2001 and 2002. The individual bulb weight was significantly different ($P<0.05$) in the years 2001 and 2002 (Table 2). The response of onion sets to rainy season planting dates on yield components and yield-contributing characters are cited and discussed accordingly.

Plant population

Planting dates significantly contributed to the pooled plant population of two years, which was the highest (5, 45,776/ha) on Bhadra 15/ August 31 followed by Bhadra 8/ August 24 (5, 29,444/ha) and Bhadra 1/August 17 (5, 01,111/ha). All the same, the pooled plant population/ha in these planting dates were statistically on par. Sets planting of Shrawan10/ July 26, conversely, imparted the lowest pooled plant population (3, 65,000/ha) (Table 1). The earlier the planting dates, the fewer the number of plant population was noted that is presumably due to the existent of growth retardant substances (ABA) in the earlier planting sets and somewhat unfavorable environmental condition for the uninformed sprouting and subsequently, poor growth of sets rather than those in the later planting sets.

Biomass yield

Planting dates highly had a significant influence on the pooled biomass yields of both the years, as the highest pooled biomass yield (51,266 kg /ha) was on Bhadra 8/August 24 followed by Bhadra 15/August 31 (51,080 kg/ha) and Bhadra 1/ August 17 (46,944 kg/ha). The pooled biomass yields in the planting dates inclusive of Shrawan 18/August 3 (34,355 kg/ha) were, nevertheless statistically, on par. Sets planting of Shrawan 10/July 26, on the contrary, imparted the lowest pooled biomass yield (14,480 kg/ha) (Table 1). The later the planting dates the higher the pooled biomass yields could probably be due to the non-existent of growth retardants in the sets coupled by favorable environmental factors during the later season than the earlier season that might be leading to enhance the biomass yield.

Fresh bulb yield

Planting dates highly had a significant contribution to the pooled bulb yields of two years, as the highest pooled bulb yield Bhadra 8/August 24 (35,127 kg/ha) followed by Bhadra 15/ August 31 (32,963 kg/ha) and Bhadra 1/August 17 (29,762 kg/ha). The pooled bulb yields in these planting dates were, all the same statistically, on par but Sets planting of Shrawan 10/ July 26, statistically, imparted the lowest pooled bulb yield (7,978 kg/ha)(Table 1). The higher pooled bulb yields were noted in lines with the later planting dates, which could presumably be due to the favorable environmental factors and the highest Pooled plant population of onion.

The present finding of the study more or less contradicts with the results reported by Pun in 1986-1987 in Kathmandu valley of Nepal, and Regional Agricultural Research Station (RARS), Nepalgunj (2001). For the former author recorded the highest bulb yield (19670 kg/ha) from the last day of July set-planting. Latter, RARS, Nepalgunj (2001) reported the highest bulb yield of variety Nasik Red (17600 kg/ha) from the set-planting on September 6, in Banke, Nepal. The results of these two studies for the respective region, up to some extent, do not agree with the results obtained in the mid-hill environment of Dailekh, lying in the mid-western region of the country. This is because of variations in geophysical and climatic conditions of all these regions.

Table 1. Effect of planting dates of onion sets on yield components at ARS, Dailekh during 2001/002-2002/003

Planting date	Plant population/ ha			Total biomass yield, kg/ ha			Total fresh bulb yield, kg/ha		
	2001	2002	Pooled	2001	2002	Pooled	2001	2002	Pooled
Shrawan 10 (July 26)	2,97,778	4,32,222	3,65,000	8,560	20,400	14,480	5,978	9,978	7,978
Shrawan 18 (August 3)	3,64,444	4,23,333	3,93,888	18,000	50,711	34,355	12,000	24,333	18,166
Shrawan 25 (August 10)	5,34,444	4,63,333	4,98,888	41,489	36,444	38,966	31,244	19,631	25,437
Bhadra 1 (August 17)	5,21,111	4,81,111	5,01,111	44,289	49,600	46,944	31,689	27,835	29,762
Bhadra 8 (August 24)	5,75,555	4,83,333	5,29,444	51,644	50,889	51,266	43,644	26,609	35,127
Bhadra 15 (August 31)	5,37,107	5,54,444	5,45,776	49,938	52,222	51,080	34,250	31,675	32,963
Grand mean	4,71,740	4,72,963	4,72,351	35,653	43,378	39,516	26,468	23,343	24,906
CV, %	18.19	16.50	17.34	14.71	23.89	19.30	53.13	21.40	37.26
LSD _{0.05}	-	-	1,64,152	-	-	-	-	-	-
LSD _{0.01}	1,70,490	-	-	18,622	21,932	20,277	9,013	1,0413	9,713
P-value	<0.01	>0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Bulb diameter and weight

Planting dates did not influence the pooled diameter of an individual bulb, which was not significantly different at all. However, the pooled weight of the individual bulb was statistically significant, as Bhadra 8/ August 24 had the heaviest pooled weight of individual bulb (54 g) followed by Bhadra 15/August 31(53 gm) and Bhadra 1/August 17 (51 gm). Besides the individual bulb weight produced by Shrawan 10/July 26 set-planting, this yield contributing components of five planting dates are, statistically, on par.

Table 2. Effect of planting dates of onion sets on yield contributing phenological characters at ARS, Dailekh during 2001/002 - 2002/003

Planting date	Days to harvest			Diameter of individual bulb, mm			Weight of individual bulb, g		
	2001	2002	Pooled	2001	2002	Pooled	2001	2001	Pooled
Shrawan 10 (July 26)	100	106	103	35	33	34	29	34	32
Shrawan 18 (August 3)	100	104	102	39	36	39	33	41	37
Shrawan 25 (August 10)	100	102	101	43	39	44	47	45	46
Bhadra 1 (August 17)	100	100	100	43	40	44	50	52	51
Bhadra 8 (August 24)	100	98	99	46	49	48	66	42	54
Bhadra 15 (August 31)	100	96	98	46	44	45	54	52	53
Grand Mean	100	101	101	42	40	42	47	44	46
CV, %	-	-	-	7.86	19.46	13.66	24.83	30.95	27.89
LSD _{0.05}	-	-	-	-	-	-	17.20	-	19
P value	-	-	-	>0.05	>0.05	>0.05	<0.05	>0.05	<0.05

CONCLUSION

For off-season onion production, onion sets of Red Creole variety can be planted from Shrawan 25/ August 10 to Bhadra 15/ August 31 under the mid-hill conditions of Dailekh as well as the similar conditions of mid-western and possibly even the far-western tracts of the country. The first fortnight of Bhadra/ the second fortnight of August plantings are particularly recommended to get both the high biomass and bulb yield. However, there were no effects of planting dates on the individual bulb weight and diameter. Besides the achievements made in recently accomplished trial, different planting dates will need to be tested and verified further, depending upon the additional promising onion varieties such as Nasik-53, Pusa Red, Nasik Red, Agrifoud Dark Red, Agrifound Light Red, Anmol-51, Black Beauty and Giant Red Globe etc for off-season onion production through sets.

ACKNOWLEDGEMENTS

The authors whole-heartedly acknowledges all the staffs of Agriculture Research Station, Dailekh, who overtly contributed to the research work even in a critical situation. We are profoundly grateful to Mr. Raghunath Sapkota, Executive Director, Dr. Ram Partap Shah, Crop and Horticulture Director, Dr Surya Parsad Pandey, Planning Director, Mr Govinda Parsad Koirala, Finance Director and Dr Nanda Prasad Shrestha, Administrative Director of NARC, for their cooperation and encouragement. Constructive suggestions from Dr. Kedar Budhathoki, Chief of Horticulture Research Division, are also indebtedly appreciated.

REFERENCES

- AAD. 1982. Annual report. Associated Agricultural Development, New Delhi.
- Pun L and BB Karmacharya. 1993. *Vegetable crops trainer's manual, manpower development agriculture project* (MDAP). Kathmandu. Pp.247-256
- Pun L. 1986-1987. Studies on onion bulbs production by sets during off-season. **In:** *Technical report on variety evaluation, seed production and agronomic studies* (L Pun and SS Chatterjee, eds). VDD, Khumaltar. Pp.34-36.
- RARS 2001. Off- season onion bulb production through sets. **In:** *Annual reports*. Regional Agricultural Research Station, Nepalgunj. 57p.
- Shanmugavelu KG. 1989. *Production technologies of vegetable crops*. Oxford and IBH Publishing Co. PVT. LTD. New Delhi. Pp.444-520.

Role of Sucrose on Vase Life of Cut Spike of Gladiolus cv Pacifica

Hom N Regmi¹ and Gopi Upreti²

¹ Horticulture Research Division, Khumaltar

² Institute of Agriculture and Animal Science, Rampur, Chitwan

ABSTRACT

An experiment was conducted to access the suitability of different concentration of sucrose solution in vase life of cut spike of gladiolus during 1999/2000 in Horticulture laboratory, IAAS. Results of experiment on the effect of different concentration of sucrose in the vase life behavior of cut-spikes under normal room temperature demonstrated that 12% sucrose solution gave maximum number of florets open at 6 and 9 days of vase life. The numbers of shaded florets were minimum with 12% sucrose at 6 and 9 days of vase life. 12% sucrose was the most effective substrate in prolonging the vase life (11.3 days) of the cut-spikes with the opening of largest size florets (10.2 cm in diameter).

Key words: Cut spikes, gladiolus, sucrose, vase life

INTRODUCTION

Gladiolus flower spikes last for 6-7 days when they are placed in normal vase water. Extended vase life of cut spikes depends on their water relations and the rate of senescence, which can be reduced by using certain chemicals. Water alone cannot sustain the long life of cut spikes in normal room temperature.

Sucrose plays an important role on the vase life of cut flower. According to Hellebust (1976) the uptake of sucrose by rapidly expanding cells and its conversion to reducing sugars by the active invertase associated with these cells appears to be important in maintaining turgor during expansion growth. Primary physiological features of deterioration in cut flowers are exhaustion of carbohydrates and proteolysis. Sucrose substitutes for the naturally depleting carbohydrate in cut flowers, reducing or preventing proteolysis. The proteolytic phenomenon is the primary function for bluing of red rose petals (Marousky 1972).

At present, no effects have been made towards prolonging the post harvest life of cut spikes in Nepal. Due to the lack of knowledge regarding the post-harvest life of cut spikes, consumers could not enjoy the elegance of cut spike of gladiolus for longer period in the vase. The objective of this experiment was to verify the actual concentration of sucrose in vase water, which could be able to prolong vase life of cut spike of gladiolus effectively in normal room condition.

MATERIALS AND METHODS

An experiment was conducted in a completely randomized experimental design (CRD) to access the suitability of different concentration of sucrose solution in vase life of cut spike of gladiolus. Three concentrations of sucrose (4%, 8% and 12% sucrose in vase solution) were taken and compared with control as distilled water only. Sucrose solution of all concentration was made with distilled water. 250 ml of different concentration of sucrose solutions were made and poured in glass jar. In each jar 4 spikes of uniform length (87 cm) with equal number of florets were placed representing one spike per replication and plugged by cotton to check the evaporation of water from jar. Slanting cut was given to the lower portion of the spike to ensure the maximum exposure of vascular components to the solution. Spikes were retained with two bract leaves.

Observations were recorded on vase life characteristics viz diameter of first floret, vase life of floret, number of florets completely opened at 3, 6 and 9 days, number of completely shaded floret at 6 and 9 days of vase life, total vase life of spike (days) and water relations. Water relations of the cut spike in vase were established as described by Godwa and Murthy (1994). Total water uptake, loss and loss/uptake ratio were calculated at 9 days after vase life and average uptake, loss and loss/uptake for each spike was obtained.

RESULTS AND DISCUSSION

Various traits observed in the experiment were statistically significant (Table 1).

Table 1. Mean square of various traits measured vase life behaviour of cut spikes of gladiolus cv Pacifica during 1999/2000 in Rampur

Source of variation	df	Number of fully opened florets at			No of completely shaded florets at		Floret life	Vase life	Diameter of floret, cm
		3rd day	6th day	9th day	6th day	9th day			
Within sucrose concentration	3	0.75 ^{ns}	3.33	2.17**	0.73 ^{ns}	1.5**	0.83*	4.06*	3.88**
Between sucrose concentration	12	0.29	0.5	0.38	0.23	0.38	0.21	0.9	0.45

*, ** Significant at 5% and 1% level. ns, Non-significant.

Number of fully opened florets

Figure 1 shows the response of cut spikes of gladiolus to different concentration of sucrose in regard to the number of completely opened floret at different days after vase life. No significant result was observed at 3 days after vase life. But critical differences were observed for 6 and 9 days. 12% sucrose gave the maximum number of florets opened at a time (4.5 at 6 days and 5.0 at 9 days) followed by 8% sucrose (4.0 at 6 days and 4.8 at 9 days) whereas control opened least numbers of floret (2.5 at 6 days and 3.5 at 9 days) during these periods.

The highest percentage sucrose solution in vase water resulted the greater number of floret opened at a time. Opening of floret in cut spike is directly related to the water balance and of the spike and the availability of the respiratory substrate in the growing parts. Optimum water balance helps to maintain the freshness of the florets and the opening is influenced by the sucrose content. Similar result has been reported by Mayak et al (1973). According to them, the improved water balance that is achieved by the sugar solutions resulted in the increased number of open florets.

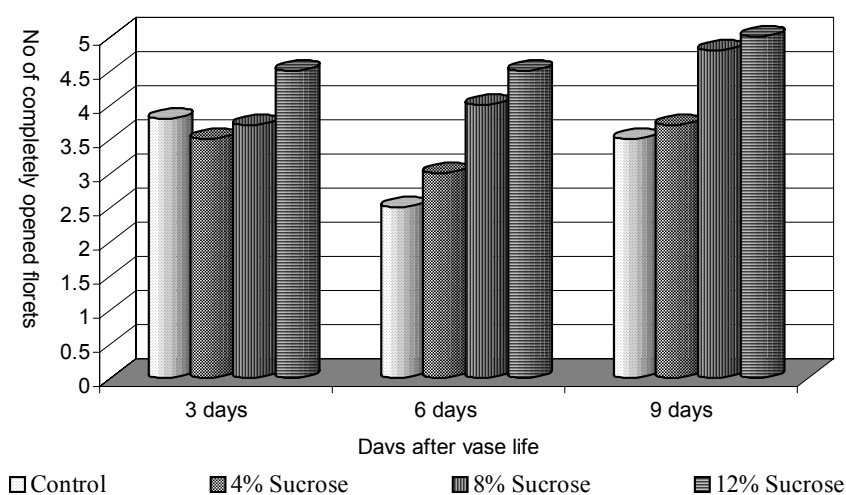


Figure 1. Influence of different concentration of sucrose on number of completely opened florets at different days of vase.

Number of completely shaded floret

Figure 2 shows the effect of sucrose concentrations on number of completely shaded floret at different days of vase life. No significant difference was found at 6 days of vase life for this parameter, whereas difference was detected critically at 9 days of vase life of cut spike. Control showed the maximum number of completely shaded floret (6.0) followed by 12% sucrose concentration. 4% and 8% sucrose concentration again showed lowest number of florets (4.8 each) shaded at 9 days of vase life.

The maximum number of floret completely shaded in control was due to the higher water loss uptake ratio. This rapid expense of water indicates the rapid respiratory loss of substrate, which can not maintain the longevity of the life of the individual floret as well as can't maintained the water balance to keep the turgidity of the floret. According to Murali (1990) the loss of water balance may encourage the increase in endogenous ABA levels and therefore accelerates the senescence.

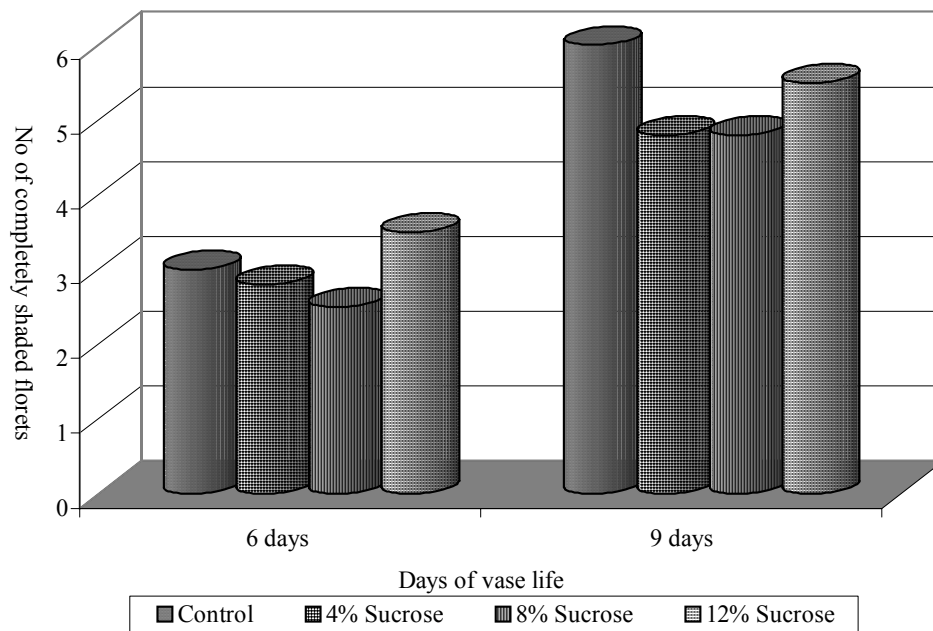


Figure 2. Influence of different concentration of Sucrose on number of completely shaded florets at different days of vase.

Diameter of floret

Figure 3 highlights the influence of different concentration of sucrose solution on size of floret regarding diameter of floret. A significant difference was found for this parameter. 12% sucrose bloomed the largest sized floret (10.2 cm) followed by 8% sucrose (9.4 cm) and control (8.7 cm). 4% sucrose solution opened the smallest sized floret (7.9 cm) among the tested concentration of sucrose.

The highest concentration of sucrose (12%) produced the largest size flower in vase. The supply of sucrose to the newly developed floret is in optimum level as compared to the lower concentration of sucrose, which alters the size of floret in vase. Also the water balance in spike plays a role in the size of the floret. Mayak et al (1973) reported that spike held continuously in sucrose solution caused better improvement in flower opening rather than short pretreatment with 7.5% sucrose solution and the improved water balance that is achieved by the sugar solutions resulted in the greater floret size.

Floret life

The life of individual floret was affected by concentrations. 12% sucrose gave the longest life of floret (3.7 days) followed by 8% sucrose (3.5 days) and 4% sucrose (3.0 days). Control gave the shortest life (2.8 days) of floret (Figure 3).

12% sucrose was responsible for longer floret life. The availability of respiratory substrate at an optimum level and optimum water level due to low rate of transpiration is responsible for the longer life of floret in higher concentration of sucrose. It was reported that sucrose increased the sugar content of the floret and plays the role of anti-desiccant, which provides the nutrition to the floret (Marousky 1971). Primary physiological features of deterioration in cut flowers are exhaustion of carbohydrates and proteolysis. Sucrose substitutes for the naturally depleting carbohydrate in cut flowers, reducing or preventing proteolysis (Marousky 1972).

Vase life

Sucrose treatments markedly improved the vase life of cut spikes (Figure 3). The longest spike life (11.3 days) was obtained with 12% sucrose concentration followed by 8% (10.5 days) and 4% sucrose concentration (9.5 days). Control gave the lowest number of days in vase (9.0 days).

The role of sucrose in vase life has already been discussed. Over all optimum water balance due to low rate of transpiration and continuous supply of nutrition through sucrose influenced positively to the vase life of cut spike in 12% sucrose solution. The optimum water balance may also prevent the amount of ABA and keep the freshness of the floret as well as spike, which ultimately hastened the vase life of cut spike of gladiolus. Mayak et al (1973) found that spike held continuously in sucrose solution provided better flower opening and vase life rather than short pretreatment with 7.5% sucrose solution. Larson and Frolich (1969) compared the vase life of cut carnation by placing into sucrose solution and observed delaying of the climacteric peak of ethylene and concluded that sucrose provided an oxidizing substrate, delaying senescence.

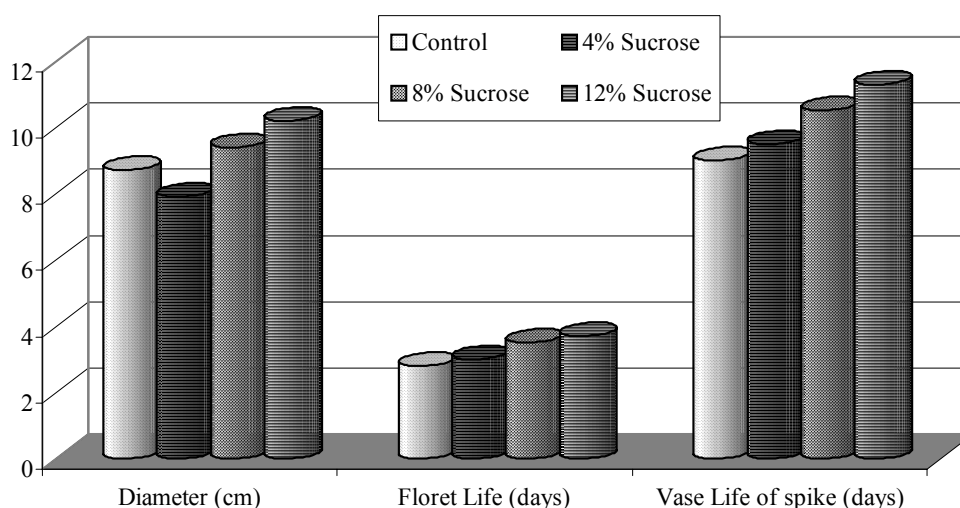


Figure 3. Influence of sucrose concentration on floret size, floret life and vase life of cut spike of gladiolus cv Pacifica.

Water relation

Water relations of cut spike with respect to water uptake, water loss and water loss uptake ratio were studied (Table 2). Water uptake by the spike was maximum from the plain vase water until 9 days of vase life followed by 8% and 4% sucrose concentration respectively. 12% sucrose caused the least amount of water until 9 days of vase life. Maximum amount of water was expended by control followed by 8% and 4% sucrose solution respectively. Least amount of water was expended by 12% sucrose concentration until 9 days of vase life. Maximum loss:uptake ratio was exhibited by spike with 12% sucrose followed by 4% with 8% sucrose and 4% sucrose respectively. Lowest ratio of loss:uptake was maintained by spike with control treatment.

Table 2. Effect of sucrose concentration on water relations by the cut spikes of gladiolus cv Pacifica during vase life

Treatment	Water loss, g	Water uptake, g	Loss/uptake ratio
Control	77.86	86.02	0.91
4% sucrose	38.9	62.93	0.62
8% sucrose	47.77	78.49	0.61
12% sucrose	36.77	64	0.57

The highest ratio of water loss:uptake ratio was exhibited by highest sucrose concentration (12%) in vase water, whereas lowest rate was observed in control. According to Marousky (1969) sucrose, in keeping solution, greatly decreased the amount of water absorbed, apparently due to its high osmotic potential. He observed that the respiratory rate was almost double by sucrose as compared to control. The higher rate of respiration is responsible for the higher rate of energy release, which helps to upgrade the quality of vase life of cut spike. These findings suggest that the role of sucrose in floral preservations is not only a respiratory substrate but also an anti-desiccant. The maintenance of fresh weight was due to the stomatal closure, exerted by the sucrose that prevented transpiration and weight loss. Kuoper et al (1995) found that opening of rose bud has been induced by an aqueous solution containing 45 mM sucrose. According to them, sucrose meets the requirement of organic matter, which flows from source tissue to the flower as main sink, which implies that a considerable amount of the added sucrose is claimed for osmoregulation. The lower water loss:uptake ratio in lower concentration sucrose in vase water may be responsible for the loss of fresh weight of spike and net water content of the spike and leads to the senescence by the greater activity of ABA (Murali and Reddy 1993, Murali 1990).

REFERENCES

- Godwa, JVN and GMA Murthy. 1994. Effect of aluminum, calcium and sucrose on post harvest life of gladiolus. **In:** *Floriculture, Technology, Trades and Trends* (J Prakash and KR Bhandary, eds). Oxford and IBH Publishing Co. Pvt. Ltd. India. Pp.492-495.
- Hellebust JA. 1976. Osmoregulation. *Annual review of plant physiology* 27:485-505.
- Kuoper D, S Ribot, HS VanReenen, N Marissen and HSV Reenen. 1995. The effect of sucrose on the flower bud opening of "Madelon" cut roses. *Scientia-Horticulture* 60:325-336.
- Larson FE and M Frolich 1969. The influence of 8-hydroxyquiniline citrate, N-dimethylamino succinic acid and sucrose on respiration and water flow in "Red Slim" cut carnations in relation to flower senescence. *J. American Society of Horticultural Science* 94:289-292.
- Marousky FJ. 1969. Vascular blockage, water absorption, stomatal opening and respiration of cut "Better Times" roses treated with 8-hydroxyquiniline citrate and sucrose. *J. American Society of Horticultural Science* 94:223-226.
- Marousky FJ. 1971. Inhibition of vascular blockage and increased moisture retention in cut roses induced by pH, 8-hydroxyquiniline citrate and sucrose. *J. American Society of Horticultural Science* 96:38-41.
- Marousky FJ. 1972. Water relations, effects of floral preservatives on bud opening and keeping quality of cut flowers. *Hort. Science* 7:114-116.
- Mayak S, B Bravdo, A Gvilli and AH Halevy. 1973. Improvement of opening of cut gladioli flowers by pretreatment with high sugar concentration. *Science Horticulturae* 1:357-365.
- Murali TP and TV Reddy. 1993. Postharvest life of gladiolus as influenced by sucrose and metal salts. *Acta Horticultutae* 343:313-320.
- Murali TP. 1990. Mode of action of metal salt and sucrose extending the vase life of cut gladioli. *Acta Horticulturæ* 266:307-316.

Buckwheat Diversity in Nepal in the Context of Morphological, Biochemical and Molecular Analysis

Hari P Bimb

Biotechnology Unit, NARC, Khumaltar

ABSTRACT

Landraces and wild relative of crop species are regarded as the indispensable gene sources for future genetic improvement. For effective conservation of genetic variation, it is necessary to identify the target population based on its genetic variation and sustainability in its habitat. Buckwheat (*Fagopyrum* spp) being grown in wide geographic variations of Nepal is especially important source of food for marginal farmers of hills and mountains. Due to its nutritional and medicinal values, buckwheat has recently been recognized as one of the valuable crops for commercial importance. This paper outlines the buckwheat diversity in the context of morphological, biochemical and molecular analysis. Exploration and collecting of *Fagopyrum* species was conducted in several districts of Nepal. Common buckwheat (*F. esculentum*) and tartary buckwheat (*F. cymosum*) were commonly cultivated in surveyed areas. Wild and weed forms of tartary buckwheat revealed more morphological, biochemical and molecular variation. So is the case with wild form (*F. cymosum*). Results on genetic diversity studies of Nepalese buckwheat with isozyme and random amplified polymorphic DNA (RAPD) markers are discussed.

Key words: Biochemical, buckwheat, diversity, molecular analysis, morphology, Nepal

Embryo Culture for Interspecific Hybridization in the Genus *Oryza*: A Simplified Technique of Hardening Improves the Field Plant Establishment

Raj KNiroula¹, Lakshmi P Subedi², Ram C Sharma² and Madhusudan P Upadhyay³

¹ Faculty of life science, Purbanchal University, Biratnagar, Nepal

² Institute of Agriculture and Animal Science Rampur, Chitwan, Nepal

³ Nepal Agriculture Research Council Khumaltar, Kathmandu, Nepal

ABSTRACT

Embryo culture is an efficient plant breeding tool to accomplish wide hybridization in the genus *Oryza*. Successful plant regeneration from embryo culture is affected by several factors such as age of embryo, medium composition, light hours, temperature and humidity during culture and technique of hardening. Six hybrids (Kalanamak/*O. nivara*, Kalanamak/*O. rufipogon*, Kalanamak/*O. officinalis*, Manshara/*O. officinalis*, IR 64/*O. nivara*, and IR 72/*O. granulata*), two improved parents viz IR72 and *O. granulata* were subjected to five different media and four techniques of hardening to determine the efficiency of these media for germination and techniques for seedlings hardening, after removal from the culture tube at IAAS during 2001-2002. The present study revealed that the effective plants establishment in the field vary with the nutrient composition of medium and technique for hardening the seedlings employed. It is suggested that effective plants regeneration through embryo rescue could be enhanced by selecting and improving the nutrient composition of medium and technique for hardening.

Key words: Embryo culture hardening techniques, media composition, regeneration, wild species

INTRODUCTION

Wide hybridization and embryo rescue are two important complementary techniques to accomplish introgressive hybridization in the genus *Oryza*. Introgressive hybridization including wide arrays of, but related, wild germplasms is necessary to widen the present gene pool of rice (Brar and Khush 1995). Some crops attained commercial status only with genetic background of their wild species (Harlan 1976). At the international Rice Research Institute (IRRI), a series of hybrids and monosomic alien addition lines (MAALs) have been produced following these techniques. To date more than a dozen of economic genes have been transferred into elite *indica* background (Brar and Khush 1997). However, production of wide cross hybrids is very difficult due to several pre and post fertilization barriers. They occur in interspecific hybridization as a result of either sexual incompatibility or hybrid inviability (Willims et al 1987). In such a situation *in vitro* culture of hybrid embryo in appropriate sterile nutritional medium is very useful to recover novel gene combination from interspecific or intergeneric hybridization (Nandan 1997).

The credit of embryo culture goes to Laibach (1929) and Skirm (1942) for demonstrating the important application of the embryo culture technique to overcome interspecific incompatibility in *Linum* and *Prunus*, respectively. In the genus *Oryza*, Niles (1951) used this technique for the first time to raise intraspecific rice hybrids. Since then rapid advancements in embryo rescue in rice have been made, particularly in nutritional and cultural condition. Nutritional requirements for the effective differentiation of the plantlets from embryos of different species and their hybrid vary, therefore, a wide range of cultural media differing in their chemical compositions have been formulated and are being used. Several investigators used wide range of media for *in vitro* rice embryo culture for example, White's basic medium (Yie and Liaw 1975, Amemiya et al 1956a, 1956b), SR (Ko et al 1983), Bouharmont (Bouharmont 1991, 1961), Nistch's and White's (Iyer and Govila 1964) and ¼ MS (Jena and Khush 1984, de Guzman 1983). However, most of the reports showed that any medium can successfully be employed with minor modifications depending on the parental genotypes used in crossing.

Almost all research institutes have been used their own standardized cultural technique and medium, but in Nepal no such standardised technique has been made yet. Therefore, it is crucial to standardize the cultural conditions and nutritional requirements in each research laboratory because successful rescue of embryos in rice needs complete medium and success will be depend on the choice of media (Niroula 2003). Similarly effective plant establishment in the field is highly influenced by the technique of hardening. Niroula et al (2002) documented that plant regeneration in the field condition was more difficult than the culture of immature hybrid embryos in the laboratory. The present study was carried out to determine the efficiency of five different media, used by earlier investigators and to improve the transferring survival rate through the appropriate procedure of seedlings hardening after removal from agar medium prior to transplant into the soil.

MATERIALS AND METHODS

The experiment was conducted taking five different sterile media viz. Nistch's (1969), White's (1953), $\frac{1}{4}$ MS (Murashige and Skoog 1962), SR (Ko et al 1983) and Bouharmont (1991) in which 7-10 day old immature embryos were subjected (White 1953, Nistch 1969 adopted from Razdan 2001, Ko et al 1983, Murashige and Skoog 1962, Bouharmont 1991). Each medium was supplemented with 10% coconut milk.

Subjected embryos were further divided into three categories: three sets of intragenomic hybrid embryos (IR 64/*O. nivara*, Kalanamak/*O. nivara*, Kalanamak/*O. rufipogon*), three types of intersectional hybrids (Manshara/*O. officinalis*, Kalanamak/*O. officinalis*, and IR 72/*O. granulata*) and embryos from two parents (IR72 and *O. granulata*). Each individual set consisted of 7 embryos, in totality 56 embryos were inoculated on each medium. Hybrid embryos were produced by crossing green house grown wild species as male and cultivated forms as female parent. During hybridization hand pollinated spikelets of distant crosses were sprayed by GA₃ and NAA @ 75 ppm (1:1) once a day regularly up to five days after pollination. Aseptic excision and inoculation of the embryo was carried out by adopting the procedure suggested by Ko et al (1983). Excision, excised ovaries were sterilized in freshly prepared solution of sodium hypochlorite (1%) for 15 minutes. After sterilization, through washed for three times. Embryos then excised from the sterile ovaries were inoculated into already prepared culture tube containing nutrient solutions at an appropriate pH and 0.7% agar. Cultures were maintained in a controlled chamber at 25±1°C under dark until germination and then under continuous light (110 foot candles) up to 2-4 weeks. Regenerated seedlings were removed out from the culture tubes at three-leaf stage. The roots of the seedlings were thoroughly washed to remove agar in the tap water and finally washed with sterilized distilled water. Hardening of seedlings was done following the four methods: 1) direct transfer, 2) petridish method, 3) Iyer and Govila (1964) method, and 4) sand-soil-nutrient solution method, to enhance rooting and to make plants hardened in external environment. First method is the direct transfer of seedlings obtained after embryo rescue. Second approach was hardening of seedlings in the moist filter paper over the petridish as suggested by Bouharmont (1961). Third method consisted of hardening in the nutrient solution in a temperature controlled chamber as reported by Iyer and Govila (1964).

The fourth method was the new one that was developed during this experimentation. The newly developed hardening medium and procedures consist of sterilized 2:1 sand and soil (300 g in each 13- × 10-cm plastic bag) floated with a nutrient solution (Karim and Vlamis 1962) up to 1.5 cm above the mixture surface in the bags, in which the molybdenum source (H₂MoO₄) was modified to sodium molybdate (Na₂MoO₄ · 2H₂O). Stock solution of each of the chemicals was made and finally complete nutrient solution was prepared (Table 1). The whole small plastic bags with fragile seedlings were kept in plastic bucket. Then these were covered by large white plastic bag with the aid of stakes to maintain appropriate humidity. The covered plastic bags were removed every day for 1-2 hours for three consecutive days after 6-7 days of hardening and finally whole plastic bags were removed and seedlings left for two more days in the same medium. This hardening activity was undertaken in a well-illuminated room as well as in an open field. Finally hardened seedlings were planted to plastic buckets filled with well-fertilized sterilized soil and grown in the glasshouse of IAAS during winter season in 2001-2002.

Media efficiency was at first determined and then different hardening schemes were attempted. Percentages regarding the germination, tube attacked by micro-organisms, seedling died after germination and well grown seedlings and success rate of hardenings were calculated in proportion of the total number of embryos cultured and total seedlings hardened.

RESULTS

Hybrid as well as two selected parental embryos subjected to different cultural media showed variation in germination and other observations depending on the composition of media employed (Table 2). Although the parental embryos germinated within two days irrespective of the media used, significant variations were observed in days required for the germination (5-13 days) and growth of intergenomic hybrids depending on the media compositions. The germination in selected media varied from 58.92-83.92% and was highest in Bouharmont (83.92%) and $\frac{1}{4}$ MS (82.14%) media. The low germination (ie 58.92%) was recorded in White's medium. Highest % of germination was observed in Bouharmont (1991) medium, even though it had high contamination (16.07%). The % of contamination varied from 12.5-16.07%. Attack of micro-organism was quite low in SR, White and Nistch, but % of seedling mortality was high in these media (ie 22.85-30.30%). In these respect, $\frac{1}{4}$ MS and Bouharmont (1991) was superior (Figure 1). In overall observation, the percentage of well grown seedling during culture was highest in Bouharmont (1991) and $\frac{1}{4}$ MS media (62.55%), though none of the media was able to foster the growth of the complex intersectional hybrids (*O. sativa* cv IR72/*O. ranulata*). Similarly, among four methods adapted to hardening of the seedlings, new technique (sand-soil-nutrient solution) developed during this experimentation resulted in highest transplant survival rate (96%) than the others (Table 3).

Table 1. Composition of the nutrient solution (Karim and Vlamis 1962) employed to prepare hardening solution

Nutrient (molar concentration)							
KNO ₃	”	”	...	...	...	...	1 ml/ l
Ca (NO ₃) ₂	”	”	...	...	...	...	1 ml/ l
KH ₂ PO ₄	”	”	...	...	...	...	2 ml/ l
MgSO ₄	”	”	...	...	...	...	4 ml/ l
FeSO ₄	1.112 g / l	”	...	...	...	...	1 ml/ l
Johnson's Micronutrient solution	...	...	...	...	...	...	1 ml/ l
KCL	...	...	...	1.77	ppm	...	...
H ₃ BO ₃	...	...	...	0.27	ppm	...	...
MnSO ₄ . H ₂ O	...	...	...	0.274	ppm	...	...
ZnSO ₄ . 7 H ₂ O	...	...	...	0.131	ppm	...	...
CuSO ₄ . 5 H ₂ O	...	...	...	0.032	ppm	...	...
H ₂ MoO ₄ [†]	...	...	...	0.0096	ppm	...	...

[†] H₂MoO₄ was modified by Na₂MoO₄. 2H₂O.

DISCUSSION

Different media used by different investigators resulted in variation in germination and other observations. By using $\frac{1}{4}$ MS variation was observed in germination of hybrid embryos in three set of cross combinations. We obtained 31-80% germination of hybrid embryos depending on the genotype of parental species. Sitch et al (1989) obtained similar observations in $\frac{1}{4}$ MS medium and recorded 0-80% germination. In the past White's medium was commonly adopted to accomplish effective germination of embryo *in vitro* (Iyer and Govila 1964, Li et al 1961, Nakajima and Morishima 1958, Amemiya et al 1956a, 1956b). Although Nakajima and Morishima (1958) reported that the germination of embryos in White's medium was ranged from 16-100%. Iyer and Govila (1964) studied comparative efficiency of White's and Nistch's media and found that Nistch's was more effective for younger embryos. They reported 52-62.22% germination of intersectional hybrid rice embryos.

Similarly, others like Bouharmont (1991), Ko et al (1983), Yie and Liaw (1975) obtained good response of cultures in media adopted by them ie Bouharmont (1991), SR and White's, respectively, but they did not mention any developmental patterns from germination to field plant establishment. In this study, however, the medium proposed by Bouharmont (1991) and $\frac{1}{4}$ MS were potential than others. Other observations regarding the number of embryos died after germination and numbers of tubes attacked by microorganisms were similar to observations made by Nakajima and Morishima (1958).



Figure 1. 1. Showing germination of 8 days old hybrid embryo (*O. sativa* cv Manshara/*O. officinalis*) on Bouharmont (1991) medium. 2-4. Sequential steps of new technique of hardening.

Table 2. Comparative results of embryo culture on five different sterile media

Hybrid combination	No. of embryo culture	No. of embryos germinated	No. of embryos not germinated	No. of tube attacked by Micro-organisms	No. of seedlings died after germination	No. of seedlings well grown
Bouharmont (1991)						
IR 64 / <i>O. nivara</i>	7	7	-	1	1	5
Manshara / <i>O. officinalis</i>	7	6	-	1	-	6
Kalanamak / <i>O. officinalis</i>	7	5	1	1	-	5
Kalanamak / <i>O. nivara</i>	7	6	1	-	-	6
Kalanamak / <i>O. rufipogon</i>	7	5	-	2	1	4
IR 72 / <i>O. granulata</i>	7	4	3	1	3	-
IR 72	7	7	-	2	-	5
<i>O. granulata</i>	7	7	-	1	-	6
Total (%)	56	47 (83.92)	9 (16.07)	5(10.6)		35 (62.5)
SR (Ko et al 1983)						
IR 64 / <i>O. nivara</i>	7	5	-	2	2	3
Manshara / <i>O. officinalis</i>	7	3	2	1	3	-
Kalanamak / <i>O. officinalis</i>	7	4	3	-	2	2
Kalanamak / <i>O. nivara</i>	7	4	3	-	1	3
Kalanamak / <i>O. rufipogon</i>	7	6	1	-	-	6
IR 72 / <i>O. granulata</i>	7	2	5	2	-	-
IR 72	7	6	1	2	-	4
<i>O. granulata</i>	7	5	2	-	1	4
Total (%)	56	35 (62.5)	17 (30.35)	7 (12.5)	9 (25.71)	22 (39.28)
White (1953)						
IR 64 / <i>O. nivara</i>	7	5	2	-	2	3
Manshara / <i>O. officinalis</i>	7	4	3	1	2	1
Kalanamak / <i>O. officinalis</i>	7	2	4	1	2	-
Kalanamak / <i>O. nivara</i>	7	4	3	-	-	4
Kalanamak / <i>O. rufipogon</i>	7	3	4	-	-	4
IR 72 / <i>O. granulata</i>	7	1	6	-	1	-
IR 72	7	7	-	2	2	3
<i>O. granulata</i>	7	7	-	3	1	3
Total (Percentage)	56	33 (58.92)	22(39.28)	7 (12.5)	10 (30.30)	18 (32.14)
Nistch (1969)						
IR 64 / <i>O. nivara</i>	7	4	3	1	-	3
Manshara / <i>O. officinalis</i>	7	1	4	2	-	1
Kalanamak / <i>O. officinalis</i>	6	3	4	-	2	1
Kalanamak / <i>O. nivara</i>	7	6	1	-	1	5
Kalanamak / <i>O. rufipogon</i>	7	5	2	-	-	5

IR 72 / <i>O. granulata</i>	7	3	4	2	2	-
IR 72	7	7	-	2	1	4
<i>O. granulata</i>	7	6	1	-	2	4
Total (Percentage)	55	35 (63.63)	19 (32.54)	7 (12.72)	8 (22.85)	23 (41.81)
¼ MS (1962)						
IR 64 / <i>O. nivara</i>	7	7	-	1	-	6
Manshara / <i>O. officinalis</i>	7	5	2	2	1	2
Kalanamak / <i>O. officinalis</i>	7	4	3	1	-	4
Kalanamak / <i>O. nivara</i>	7	7	-	2	-	5
Kalanamak / <i>O. rufipogon</i>	7	7	-	-	-	7
IR 72 / <i>O. granulata</i>	7	2	5	-	2	-
IR 72	7	7	-	1	-	6
<i>O. granulata</i>	7	7	1	1	-	5
Total (%)	56	46 (82.14)	11 (19.64)	8 (14.28)	3 (6.52)	35 (62.5)

Table 3. Comparative results of different attempts employed to established hybrids plants in the field from embryo culture regenerated seedlings

Cross combination and success rate, %	Total seedlings hardened	Direct transfer	Bouharmont (1961) method	Iyer and Govila (1964) method	Present method
IR 64/ <i>O. nivara</i>	19	7	4	5	3
Success rate		0.0	25.0	60.0	100.0
Kalanamak/ <i>O. officinalis</i>	12	6	2	2	2
Success rate		0.0	0.0	100.0	100.0
Kalanamak/ <i>O. nivara</i>	24	6	5	8	5
Success rate		0.0	20.0	50.0	80.0
Kalanamak/ <i>O. rufipogon</i>	26	5	7	8	6
Success rate		0.0	0.0	75.0	100.0
Manshara/ <i>O. officinalis</i>	11	3	3	3	2
Success rate		0.0	0.0	66.67	100.0
Total	92	27	21	26	18
Mean success rate		0.0	9.0	70.33	96.0

It is a universally accepted factor that the culture could not be 100% free from microorganisms. In the present study, the best response of ¼ MS and Bouharmont (1991) might be partly due to superiority of these media and partly to genotypic differences of plant materials. The requirement of chemical compositions of media may vary in accord with genotypic constitution of the embryos. One interesting observation is that the hybrid embryo obtained from *O. sativa* cv IR 72/*O. granulata* did not grow well after germination, mostly died after germination, and hence no hybrid was obtained. This suggests that the more complex the hybrid, the more complex the media is required to foster the better germination and vigorous growth. The observed variations in germination and subsequent growth in the media employed suggest that complex hybrid embryos need complete media, as the normal endosperm supplied. Similar results were presented by several researchers (Singh et al 1990, de Guzman 1983, Hadley and Openshaw 1982). It is found that successful rescue of embryo needs complete medium and success will be dependent on the choice of media. However, cultural conditions may also affect the germination and subsequent growth and development of the seedlings (Ko et al 1983, Amemiya et al 1956a, 1956b) and it may also vary from laboratory to laboratory depending on the researchers expertise in handling of the materials (Razdan 2001).

A large numbers of reports have been published concerning the field plant establishment of embryo rescue regenerated plants, however, only limited workers described it in details. Jena and Khush (1984) obtained good field plant establishment through culture in nutrient solution for 10 days, but they did not mention about the media used by them. Nowick (1986), Iyer and Govila (1964) and Nandan (1997) described techniques of hardening. Iyer and Govila (1964) reported petridish method resulted in 50% survival rate in contrast to 10% in the present study. In the second attempt, they devised a technique in which Iyer and Govila (1964) obtained nearly 100% survival rate. In this study, however, their method resulted in only 70% success. Therefore, we were tried to improve the technique of hardening by sand-soil- nutrient solution, which resulted nearly 100% survival rate even in an open field. It does not require environmental chamber as used by Iyer and Govila (1964). Thus the results obtained here clearly indicate that the success of the embryo rescue for obtaining the interspecific hybrids in the genus *Oryza* more frequently depends on the choice of appropriate medium and

technique of hardening. It is, therefore, concluded that the better cultural media and technique of hardening can significantly improve the production of wide cross hybrids.

ACKNOWLEDGEMENT

IPGRI is highly appreciated for partial financial support.

REFERENCES

- Amemiya A, H Akemine and K Toriyama. 1956a. Cultural conditions and growth of immature embryo in rice plant. Studies on the embryo culture in rice plant I. *Bot. Bul. Acad. Sinica, Tokyo, Ser. D.* 6:1-40.
- Amemiya A, H Akemine and K Toriyama. 1956b. The first germinative stage and varietal differences in growth response of cultured embryo in rice plant. Studies on the embryo culture in rice plant II. *Bot. Bul. Acad. Sinica, Tokyo, Ser. D.* 6:59-60.
- Bouharmont J. 1961. Embryo culture of rice on sterile medium. *Euphytica*, 10:283-293.
- Bouharmont J. 1991. Embryo culture for wide hybridization in rice. **In:** *Biotechnology in agriculture and forestry*. Vol. 14. Rice (YPS Bajaj, ed). Springer-verlag, Berlin Heidelberg. Pp.95-104.
- Brar DS and GS Khush. 1995. Wide hybridization for enhancing resistance to biotic and abiotic stresses in rainfed lowland rice. **In:** *Proceedings of the International Rice Research Conference*, 13-17 Feb 1995. Fragile lives in fragile eco-systems. IRRI, Manila, Philippines. Pp.901-910.
- Brar DS and GS Khush. 1997. Alien introgression in rice. *Plant Mol. Bio.* 35:35-47.
- de Guzman EV. 1983. Recent progress in rice embryo culture at IRRI. **In:** *Cell and tissue culture techniques for cereal crop improvement*. Proceedings of a workshop consponsored by the institute of genetics, academia, sinica and IRRI. Science Press Beijing, China, IRRI, Manila Philippines. Pp.215-228.
- Hadley HH and SJ Openshaw. 1982. Interspecific and intergeneric hybridization. **In:** *Hybridization of crop plants* (WR Fehr and HH Hadley, eds). The American Society of Agronomy, Inc. and The Crop Science Society of America, Inc. Pp.131-142.
- Harlan JR. 1976. Genetics resources in wild relatives of crops. *Crop Science* 16:329-333.
- Iyer RD and OP Govila. 1964. Embryo culture of interspecific hybrids in the genus *Oryza*. *Indian J. Gent. and Plant breed.* 24(2):116-121.
- Jena KK and GS Khush. 1984. Embryo rescue of interspecific hybrids and its scope in rice improvement. *RGN* 1:133-134.
- Karim AQ, MB and J Vlamis. 1962. Micronutrient deficiency symptoms of rice grown in nutrient culture solutions. *Plant and Soil* 16:347-360.
- Ko SW, CK Wong and SC Woo. 1983. A simplified method of embryo culture in rice of *Oryza sativa* L. *Bo. Bull. Acad. Sinica* 24:97-101.
- Laibach F. 1929. Ecogenesis in plants: methods and genetic possibilities of propagating embryos otherwise dying in the seed. *J. Heredit* 20: 201-208.
- Li HW, TS Weng, CC Chen and WH Wang. 1961. Cytogenetical studies of *Oryza sativa* L. and its related species. *Bo. Bull. Acad. Sinica* 2: 79-86.
- Murashige T and F Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Plant Physio.* 39: 375-383.
- Nakajima T and H Morishima. 1958. Studies on embryo culture in plants II. Embryo culture of interspecific hybrids in *Oryza*. *Japan J. Breed.* 8:105-110.
- Nandan JS. 1997. Manual on rice breeding. Kalyani publishers New Delhi, India. Pp.114-120.
- Niles JJ. 1951. Hybridization methods with paddy. *Tropical Agriculturist* 107:25-29.
- Niroula RK. 2003. Cytogenetic relationship between cultivated and Nepalese wild species of rice. *M.Sc Thesis*. Tribhuvan University. Pp.54-56.
- Niroula RK, LP Subedi, RC Sharma, MP Pandey and NR Adhikari. 2002. Embryo culture for interspecific hybridization in the genus *Oryza*. **In:** *Abstract of International Conference on Wild Rice* (SP Yadav, ed), 21-27 October 2002 GEM/Nepal, Anam Nagar, PO Box 10647, Kathmandu, Nepal. P.33.
- Nowick EM. 1986. Chromosome pairing in *Oryza sativa* L. x *O. latifolia* Desv. hybrids. *Canadian J. Genet. Cytol.* 28:278-285.
- Razdan MK. 2001. *An introduction to plant tissue culture*. Oxford and IBH publishing company private Limited. P.36.
- Singh AK, JP. Moss and J Smartt. 1990. Ploidy manipulations for interspecific gene transfer. *Adv. Agronomy* 43:194-224.
- Sitch LA, RD Dalmacio and GO Romero. 1989. Crossability of wild *Oryza* species and their potential use for improvement of cultivated rice. *RGN* 6:58-60.
- Skirm GW. 1942. Embryo culture as an aid to plant breeding. *J. Heredit* 33:211-215.
- Williams EG, G Maheswaran and JE Hutchinson. 1987. Embryo culture and ovule culture in crop improvement. *Plant Breed. Rev.* 5:181-235.
- Yie ST and SI Liaw. 1975. Studies on the growth and development of excised embryos of different varieties of rice. *Bot. Bull. Acad. Sinica* 16:149-158.

Study on *Xiphinema americanum* Group by DNA Fingerprinting

Kishwor K Bhattarai and M Maurice

Ghent University, Belgium

ABSTRACT

Xiphinema ameraicnum group is economically important as some of the species are efficient vectors of nepovirus and are quarantine concern in many countries. In recent years, this group is under dispute regarding the number of valid species. The fast and accurate species identification on the basis of morphology and morphometric differences is difficult as most of the characters overlap. Modified DNA amplification fingerprinting (DAF) technique was used to study the genetic diversity among the 16 selected species within this group. The genetic distance inferred by maximum parsimony clustered species into 7 sub-group, though are not in agreement with the other current findings. In the mean time, it was found that some unique species specific bands, which could be squeezed and studied to develop species-specific makers. From this study, it cab be stated That the DAF technique with added degenerate oligonucleotide primed polymerase chain reaction (DOP-PCR) has potentiality to reveal genetic variation among nematodes and can be used to find molecular makers too.

Key words: DNA, finger printing, nematode

Transgenic Plants: A Source for Edible Vaccines

Hari K Prasai

Regional Agricultural Research Station, Lumle, Kaski

ABSTRACT

Vaccines and antibodies play a key role in health care. However, each year, infectious diseases kill about 17 million people worldwide. Approximately, 80% of the world's children are capable to receive vaccines against infectious diseases and 20 % still remain unvaccinated which leads to about 2 million children of the world potentially avoidable death each year. This problem is especially prevalent in the developing countries and in the remote parts of the world. Various reasons are involved in affecting the efficient distribution and utilization of the vaccines. Expression of the pathogens in transgenic plants is a convenient and inexpensive source for these immunotherapeutic molecules. Various antigens have already been expressed successfully in plants. Edible plant vaccines against diarrhea expressed in potato is already in preclinical human trials. Attempts are being made to express many proteins of immunotherapeutic use at high level in plants and to use them as bioreactors of modern era.

Key words: Antigens, antibodies, edible vaccine, immunity, infectious diseases, transgenic plants

INTRODUCTION

Millions of people die from the infectious diseases, especially in the developing countries, due to nonexistent, unreliable or too expensive of the immunization. In 1990, researchers proposed that certain food could be genetically engineered to produce vaccines to solve the problems with vaccine administration, which could be eaten when inoculations are required. The experiment raw potatoes were genetically engineered to produce the part of toxin secreted by *Escherichia coli* was carried out under the direction of Carol O. Tacket to demonstrate that an edible vaccine could stimulate immune response in human (Dopel 2000)

In the past century, the development of vaccine has helped to wipeout the infectious diseases. They have eliminated small pox disease. Scientists and physicians hope now to get rid the world of six more diseases: diphtheria, pertusis, polio, measles, tetanus and tuberculosis. Currently, 80 percent of the world's children receive these vaccines but 20 percent still go unvaccinated. This leads to about 2 million avoidable death each year. This problem is especially prevalent in developing countries and in the remote parts of the world. There are number of reasons why the vaccinations do not go to these individuals. This includes high cost of syringes, the need of refrigeration for transport and storage, necessity of a qualified work force and expensive facilities, often given in multiple doses and small isolated villages hard to reach and the need for importing vaccines from other locations (McGinley 2002).

Norwalk virus is a common virus which often causes diarrhea (Diarrhea is responsible for death of about 3 million people in a year, mainly in the developing countries). In the recent trials at the University of Maryland, 19 of 20 study participants developed an immune response to Norwalk virus. In the study, healthy adult volunteers received two to three doses of the genetically altered potato or three doses of unaltered potato. Not all of the volunteers showed the same immune response but 95 percent did develop some immunity (McGinley 2002). However, recent studies using new diagnostic assay developed with recombinant Norwalk virus (rNV) particles or using reverse transcription-polymerase chain reaction have shown that the epidemiological significance of NV infection has been greatly underestimated (Tacket 2000).

The development of enabling technologies such as detoxification methodologies, the use of a variety of tissue culture systems to propagate microbes and the new biotechnology of the last quarter of the 20th century, particularly that of recombinant DNA, has driven the evaluation in the field of vaccinology (Fauci 2001). The possibility of inserting the desired genes into the plant has already been proved by plant biologist by producing transgenic plants. To construct the NV-transgenic potatoes, pNV 140, a binary vector that contains expression cassettes for NVcp and Kanamycin is an antibiotic used in the treatment of certain diseases. It is non-toxic to the host. The transformed potatoes were called NV140-13 potatoes and were identified by the pNV 140 tDNA (transfer DNA) that is located in its DNA

NECESSITY OF EDIBLE VACCINES

The edible vaccines are the vaccines, which are made by inserting the genes for the vaccines into the plant. The edible part of the transgenic plant has the vaccine inside of it and simply has to be eaten. An antigenic material that produces specific immunity by stimulating an immune response is termed a vaccine. Different kinds of vaccines have already been developed to induce passive and active immunization for producing resistance to many diseases.

About 200 years after the discovery of vaccine against the small-pox by the Physician E Jenner, the World Health Organization (WHO) designed the small-pox eradication campaign worldwide. The WHO proudly announced the eradication of the small-pox disease from the world within a very short period i.e. about after 13 years of implementing the small-pox eradication campaign. Because, humans were the only host of this pathogen and the pathogen cannot survive outside of host etc. Unfortunately, the eradication of pathogens is not always as easy as it was with small-pox or polio. Many dangerous pathogenic agents still infect millions of people each year (Table 1).

Table 1. Some diseases for which effective vaccines are not yet available

Disease	Annual mortality	Annual incidence
Malaria	1500000	150000000
Schistosomiasis	330333	10000000
Worm infestation	50000	4900000000
Tuberculosis	3000000	10000000
Diarrhea diseases	4300000	28000000
HIV	100000	750000

Adapted from Janeway and Travers 1996.

Various researches are being carried out at finding vaccines in order to limit the death toll associated with these conditions. Numbers of reasons are responsible for not reaching the dramatic impact of modern vaccines in the developing world, where it is the most needed (Martin 1999). Now the researchers are agreed that the best hope for protecting the world from infectious diseases may reside in the edible vaccines. Because, the edible vaccines are less expensive, can be produced locally and do not require refrigeration. They could also potentially be produced indefinitely without growers having to purchase more seeds and plants each year. Also, because the vaccine eliminates the need for syringes, there is less risk of infection after contamination (McGinley 2002).

Many infectious agents colonize by invading epithelial membranes. Vaccines that are effective against these infections must stimulate the mucosal immune system to produce secretory immunoglobulin-A (Ig-A) at mucosal surfaces such as the gut respiratory epithelia (McGhee et al 1993, Castro et al 1993). Most Ig-A is synthesized locally by plasma cells in mammary and salivary glands, and along the respiratory, gastrointestinal and genitourinary tracts. It is then transported through epithelial cells to the lumen. This antibody is a first line of defense against microbial invaders at mucosal surfaces. Secretory Ig-A serves as an important effector function at mucous membrane surfaces, which are the main entry sites for most of the pathogenic organisms. Secretory Ig-A can cross link large antigens with epitopes. Binding of secretory Ig-A to bacterial and viral antigens prevents attachment of the pathogens to the mucosal cells. Once attachment is blocked, viral infections and bacterial colonization are inhibited. Complexes of secretory Ig-A and antigens are easily entrapped in mucus and then eliminated by the ciliated epithelial cells of the respiratory tract. Secretory Ig-A has been shown to provide an important line of defense against bacteria such as *Salmonella*, *Vibrio cholerae* and

Neisseria gonorrhoeae and viruses such as polio, influenza and reovirus. In general, a mucosal immune response is more effectively achieved by oral rather than parenteral antigen delivery. Injected vaccines initially bypass mucous membranes and typically do a poor job of stimulating mucosal immune response (Estes 2000). But edible vaccines come into contact with the lining of the digestive tract. Transgenic plants that express antigens in their edible tissue might be used as an inexpensive oral vaccine production and delivery system (Arntzen et al 1994) through consumption of an “edible vaccine”.

INSERTION OF FOREIGN GENE INTO THE PLANT

The capacity to introduce and express diverse foreign genes in plants was first described in tobacco by *Agrobacterium* mediated (Horsch et al 1984, de Block et al 1984) and vectorless approach (Paszowski et al 1984). The strategy for transgene expression in plants is pretty straightforward: the foreign gene must be integrated in a stable fashion into the plant's genome either by using *Agrobacterium* T-DNA (Transfer DNA) vectors or by direct means including microprojectile bombardment.

The intermediate vector (IV) containing foreign DNA in the transfer region (T-region) can be transferred to *Agrobacterium tumefaciens* by conjugation. Since the IV is conjugation deficient, conjugation must be mediated by the presence in the donor *Escherichia coli* (*E. coli*) of a helper, conjugation-proficient plasmid which can mobilize the IV. Suitable helper plasmids are pRK 2013 (Ditta et al 1980), which consists of the transfer genes from the naturally occurring plasmid pRK2 cloned into ColE1 replicon or pRN3 (Shaw et al 1983). These transfers are conveniently brought about by triparental mating.

Complete tumor inducing (Ti) plasmid DNA is not found in plant tumor cells but a small, specific segment of the plasmid about 23 kb in size, is found integrated in the plant nuclear DNA (Chilton et al 1977). This DNA segment is called T-DNA. Thomashow et al (1980) and Zambryski et al (1980) demonstrated that the integration of the T-DNA can occur at many different, apparently random, sites in the plant nuclear DNA. T-DNA transfer and processing require products of *vir* genes (*virA*, -B, -G, -C, -D and -E), which are located outside the T-DNA region. The expression of *virB*, -C, -D and -E is positively regulated at the transcriptional level by plant signal molecules which are exuded from wounded or actively growing cells (Stachel et al 1985).

The *virA* and *virG* genes control the plant induced activation of other *vir* genes, whereas *virA* protein acts as a receptor for the phenolic and monosaccharides signals (Stachel and Zambryski 1986). In response to the activating signal molecule, an endonuclease encoded by *virD* makes two nicks in the T-DNA in the small strand at its border sequence in the Ti-plasmid. The T-DNA single strand is transferred with the right border leading (Stachel et al 1986). The T-DNA enters the plant cell in single-stranded form and that complementary strand is synthesized by plant cell enzymes (Tinland et al 1992).

The biolistic technique is used to stably transfect nuclear DNA in a variety of cell types in dicotyledonous and monocotyledonous species (Svab et al 1990, Staub and Maliga 1992). In the procedure of gene transfer using a high velocity microprojectile to deliver nucleic acids into living cells was described by Klein et al (1987) and Sanford et al (1991). The DNA bearing tungsten or gold particles (1-3 μm in diameter) are carried by a microprojectile and is accelerated into living plant cells.

EDIBLE VACCINES PRODUCTION

Cramer et al (1996) successfully expressed various foreign proteins including serum albumin, human α – interferon, human erythropoietin and murine immunoglobulin G and A in plants. Tacket et al (1998) made several attempts to produce various antigens and antibody in plants. The route by which vaccines are administered affects both the magnitude and type of immune response elicited. Antigens or antibodies expressed in plants can be administered orally as any edible part of the plant or by parenteral route (such as intramuscular or intravenous infection) after isolation and purification from the plant tissue.

Agrobacterium mediated transformation of gene into the plants has become the popular method for dicots. However, the biolistics methods of transformation including monocots have come into the existence (Birch and Christian 1997). Haq et al (1995) demonstrated the use of strong and organo-specific plant promoters for expression of foreign genes into plants. Though promoters of genes, like maize ubiquitin and rice actin, have

been reported to direct high level of expression in monocots, the 35S promoter of cauliflower mosaic virus remains the promoter of choice for dicots (Schledzowski et al 1994). Haq et al (1995) observed the increased expression levels of the recombinant protein with the retention of the heat labile *E. coli* enterotoxin in endoplasmic reticulum of potato by using endoplasmic reticulum retention signal. Two different strategies for transgene expression in plants have been evaluated (Figure 1) which includes either: i) Stable genomic integration, with foreign DNA introduced either by *Agrobacterium* T-DNA vector or by direct means including microprojectile bombardment, ii) transient expression using viral vector. Stable expression affords the advantage of the subsequent generation of large number of transgenic plants either by vegetative or sexual means and the opportunity to introduce more than one gene for possible multicomponent vaccination production. One way of generating edible vaccines relies on the bacterium *Agrobacterium tumefaciens* to deliver into plant cells the genetic blueprints for viral or bacterial “antigens” – proteins that elicit a targeted immune response in the recipient. The following chart (Figure 2) illustrates the production of vaccines potatoes.

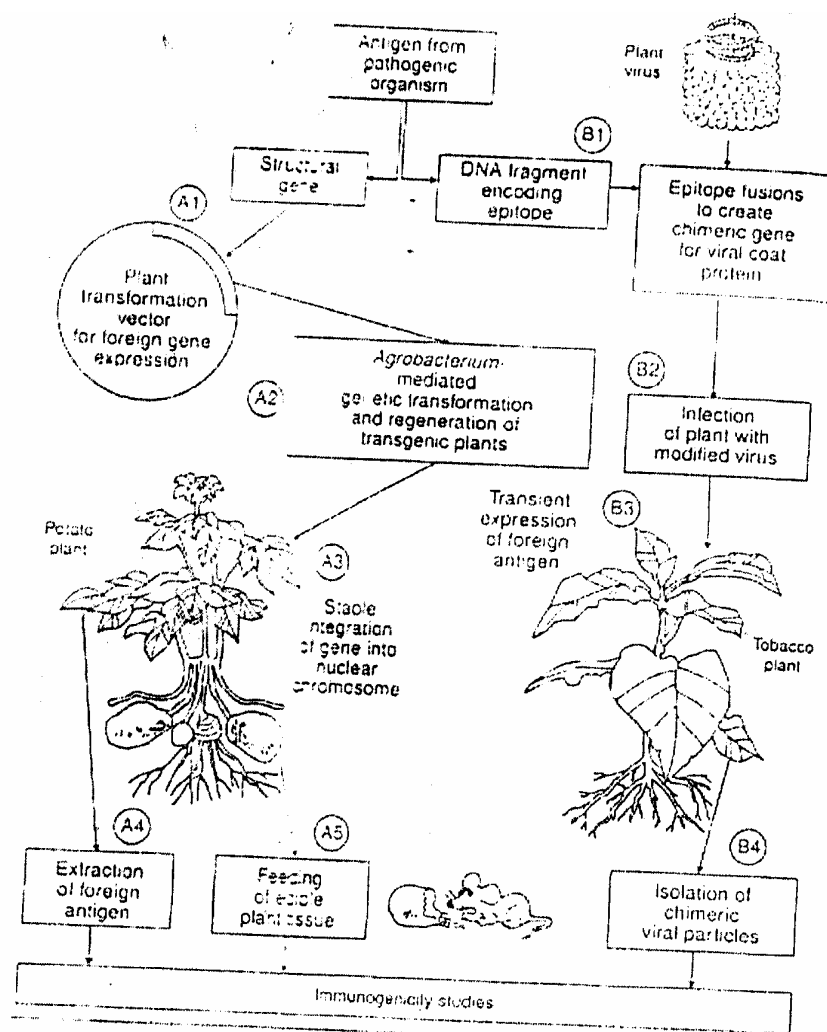


Figure 1. Strategies for expression of antigens in plants (Adapted from Mason and Arntzen 1995).

While plant system may have the capability of producing any vaccine in large amounts and in a less expensive manner, purification of the product may require the use of existing or even more cumbersome procedure. Attention therefore has been paid to mainly those antigens that stimulate mucosal immune system to produce secretory IgA (S-IgA) at mucosal surfaces, such as gut and respiratory epithelia. In general, a mucosal response is achieved more effectively by oral instead of parenteral delivery of the antigen. Thus, an antigen produced in the edible part of a plant can serve as a vaccine against several infectious agents, which invade epithelial membranes. Subsequently a number of attempts were made to express various antigen in plants (Table 2).

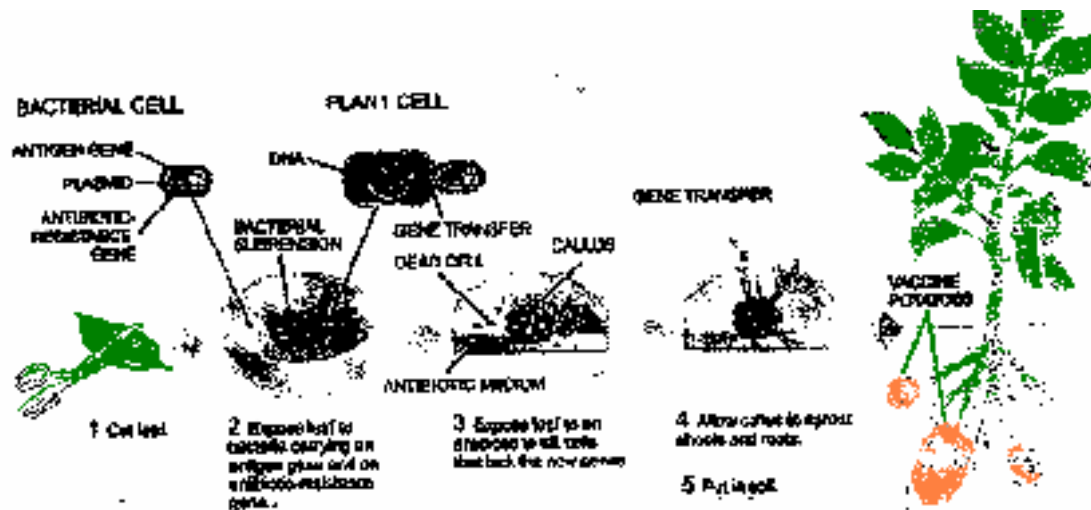


Figure 2. Procedure to make an edible vaccine.

Table 2. Antigen produced in transgenic plants

SN	Protein	Plant	Reference
1.	Hepatitis B surface antigen	Tobacco	Mason et al 1992
2.	Rabies virus glycoprotein	Tomato	McGarvey et a. 1995
3.	Norwalk virus capsid protein	Tobacco	Mason et al 1996
4.	E. coli heat-labile enterotoxin B subunit	Potato	Haq et al 1996
5.	Cholera toxin B subunit	Potato, tobacco	Hein et al 1996
6.	Mouse glutamate decarboxylase	Potato	Ma et al 1997
7.	Insulin	Potato	Arakawa et al 1998

One of the alternative strategies of producing a plant based vaccine is to infect the plants with recombinant viruses carrying the desired antigen that is fused to viral coat protein. The infected plants have been reported to produce the desired fusion protein in large amounts in a short time. The technique involved either placing the gene downstream a subgenomic promoter, or fusing the gene with capsid protein that coat the virus (Table 3). Modelska et al (1997) have shown that immunization of mice intraperitoneally or orally by gastric incubation or by feeding of plants infected with the recombinant alfalfa mosaic virus carrying rabies peptide CPDrg 24 mounted local as well as systematic immune response. Oral administration could stimulate both serum IgG as well as Ig A synthesis. After immunization, 40% of the mice were protected against the challenge with a lethal dose of virus.

Table 3. Transient production of antigens in plants after infection with plant viruses expressing a recombinant gene

SN	Protein	Plant	Carrier	Reference
1.	Influenza antigen	Tobacco	TMV	Beachy et al 1996
2.	Rabies antigen	Spinach	AIMV	Modelska et al 1997
3.	HIV-1 antigen	Tobacco	AIMV	Yusibov et al 1997
4.	Colon cancer antigen	Tobacco	TMV	Vetch et al 1998

TMV = Tobacco mosaic virus, AIMV = Alfalfa mosaic virus.

EXPRESSION AND ASSEMBLY OF ANTIBODIES IN PLANTS

Transgenic plants are also being looked upon as a source for producing large-scale antibodies which can serve the purpose of passive immunization by direct application, in addition to providing a tool for drug targeting or interactive inactivation of undesirable molecules (Hiatt et al 1993). Gene technology has provided great impetus to the utility of antibodies, since antibody genes can be altered to order.

Thus not only genes coding for both the light and heavy chains have been expressed, but modified genes capable of expressing only Fab (assembled light chains and shortened heavy chains) or ScFV (single peptide chains where variable domains of heavy and light chains are covalently linked by a short flexible peptide) have also been expressed in bacteria and mammalian cells (Duving et al 1990, Benvenuto et al 1991, Ma et al 1997)

Transgenic plants not only provide the means to express antibodies but also enable the glycosylation and entry into secretory pathway which allow assembly of complete antibodies and Fab fragments. Variable fragments (Fv) can be produced in cytosol and fused with protein such as protein A and phosphatase to improve the detection and purification of single chain Fv (scFv). In plants, antibody production (1-5% of total plant protein) has been achieved by cross-pollination of individual transformed plants expressing light or heavy chain (Mason et al 1995).

Aiming at therapeutic treatments, Ma et al (1995) have succeeded in producing multimeric secretory IgA (SigA) molecules in plants, which represent the predominant form of immuno- globulin in mucosal secretions. SigA not only contains heavy and light chains but it is also dimerized by a fourth polypeptide, the SC. Production of such antibodies in mammalian cells is very complex because of the requirement of B cell as well as gut epithelial cells for the formation of the SigA. Thus, four transgenic engineering which produced a murine monoclonal antibody light K chain, the hybrid IgA-G antibody heavy chain, murine J chain. A series of sexual crosses was carried out to allow expression of all the four proteins simultaneously. The progeny produced functional secretory immunoglobulins very efficiently. This demonstrated the potential of plants in assembly of antibody.

CONCLUSION

The greatest triumphs of modern immunology have come from vaccination, which has eradicated or virtually eliminated several human diseases. It is the single most successful manipulation of the immune system to date because it takes advantages of its natural specificity and inducibility. Nevertheless, there remains much work to do. There are no affordable vaccines against a variety of important infectious diseases, existing vaccines need to be safer and more effective, and the speed of the process of generating vaccines for newly emerging pathogens must be increased. The growing understanding of microbiology and immunology, together with power of molecular biology and recent advances in biotechnology, have already made it possible to develop new approaches to vaccine development. The elaboration of edible vaccines made from transgenic plants is one of many very promising new approaches. It is now proven that plant-derived antigens delivered orally to humans can stimulate the production of humoral and mucosal antibody responses.

REFERENCES

- Arakawa T, DKX Chong, JL Merritt and WHR Langridge. 1997. *Transgenic Res.* 6:403-413.
- Arakawa T, J Ya, DKX Chang, PC Hough Engen and WHR Langridge. 1998. *Nature Biotechnol.* 16:934-938.
- Arntzen, CJ Mason, HS Shi, Ji Haq, TA Esten MK and JD Clements. 1994. Modern approaches to new vaccines including prevention of AIDS. Cold Spring Harbor Laboratory Press.
- Beachy RN, HJ Fitchen and MB Hein. 1996. *Ann. NY Acad. Sci.* 792:43-49.
- Benvenuto E, RJ Ordus, R Tavazza, G Ancora, S Binocca and P Galeffi. 1991. *Plant Mo. Biol.* 17:865-874.
- Birch RJ. 1997. *Anna Rev. Plant Physi Mol. Biol.* 48:297-326.
- Castro G and CJ Arntzen. 1993. *Am J Physiol.* 165:599-610.
- Chitton MD, M Drummond, CJ Merlo, D Sciaky, AL Montoya, MP Gordon, and EW Mester. 1977. Stable incorporation of plasmid DNA into higher plant cells, the molecular basis o F crown gall tumorigenesis. *Cell* 11:263-271.
- Chrispeels MJ and BW Tague. 1991. *In Res. Cytol.* 125:1-45.
- Christon P. 1997. *Plant Mol Biol*, 35:197-203.
- Cramer CL, DL Weissenborn, KK Oishi, EA Grabau, S Bennett, E Ponce, GA Grabowski and DM Radin. 1996. *Ann. NY Acad. Sci.* 792:62-71.
- DeBlock M, L Herrera-Estrella, M van Montagu, J Schell and P Zambrybid. 1984. Expression of foreign genes in regenerated plants and their progeny. *EMBO J.* 3:1681-1689.
- Ditta G, S Stanfield, D Corbin and DR Helinski. 1980. Broad host range DNA cloning system for gram negative bacteria. Construction of gene bank of *Rhizobium meliloti* Proc. Natl. Acad. Sci. USA 77:7347-7351.
- Doepel LK. 2000. First human test shows that an edible vaccine is feasible. Available at <http://www.naid.njh.gov/newsroom/ediblevccc.htm>.
- Duving K, S Hippe, F Kreuzaler, and J Schell. 1990. *Plant Mol. Biol.* 15:281-293.

- Estes MK. 2000. Norwalk Virus vaccines: Challenges and progress. Vol. 181. Available at <http://www.journals.Uchicago.edu/JID>.
- Fauci AS. 2001. Infectious diseases: consideration for the 21st century. 32:675-685. Available at <http://www.journals.Uchicago.edu/CID>.
- Haq TA, HS Mason, JD Clements and CJ Arntzen. 1995. *Science* 268:714-715.
- Hein MB, TC Yeo, F Wang and A Sturtevant. 1996. *Ann. NY Acad. Sci.*, 792:51-56.
- Hiatt A and K Mostov. 1993. In: (AJ Hiatt, D Marcel, eds). Inc. New York. Pp.221-237.
- Horsch RB, RT Fraley, SG Rogers, PR Sanders A Lioyd and N Hoffman. 1984. Inheritance of functional foreign gene in plants. *Science* 223:496-498.
- Janeway CA and P Travers. 1996. Immunobiology, 2nd ed. Current Biology/Garland.
- Klein TM, ED Wolf, R Wu and JC Sanford. 1987. High velocity microprojectiles for delivering nucleic acids into living cells. *Nature* 327:70-73.
- Ma SW, QL Zhao, ZQ Yin, R Mukherjee, B Ssngh, HY Quin, CR Stiller and AM Jevnikar. 1997. *Nature Med.* 3:793-796.
- Martin D. 1999. Edible vaccine presented to Professor Roger Prichard, <martinduport@hotmail.com>.
- Mason HS and CJ Arntzen. 1995. *Trends Biotechnol.* 13:388-392.
- Mason HS, JM Ball, JJ Shi, X Jiang, MK Estes and CJ Arntzen. 1996. *Proc. Natl. Acad. Sci. USA* 93:5335-5340.
- Mason HS, DM Lam and CJ Arntzen. 1992. *Proc. Natl. Acad. Sci. USA* 89:11745-11749.
- McGhee JR and H Kiyono. 1993. *Infect. Agents Disease* 2:55-73.
- McGinley LJ. 2002. Potato vaccine: Healthy for life from the eyewitness news Newsroom, University of Maryland. Available at www.meginley@som.unmaryland.edu.
- McGravey PB, J Hammond, MM Dienelt and FH Michaels. 1995. *Biotechnology* 13:1484-1487.
- Modelska A, B Dietzschold, N Sleysh and V Yusibov. 1997. *Proc. Natl. Acad. Sci. USA* 95:2481-2485.
- NAID. 1988. *Net News*. National Institute of Allergy and Infectious Diseases. Potato vaccine development.
- Paszowski J, RD Shillito, M Saul, V Mandak AND T Hohn. 1984. Direct gene transfer to plants. *EMBO. J.* 3:2712-2722
- Sanford JC, MJ Devit, JA Russell, FD Smith, PR Harpending, MK Roy and SA Johnston. 1991. An improved helium driven biolistic device. *Technique* 3:3-16.
- Schledzowski K and RR Dendel. 1994. *Transgenic Res.* 3:249-255.
- Shaw CH, J Leemans, M Van Montagu and J Schell. 1983. A general method for transfer of cloned genes to plant cells. *Gene* 23:315-330.
- Stachel SF, E Messens, M Van Montagu and P Zambryski. 1985. Identification of the single molecules produced by wounded plant cells that activate T-DNA transfer in *Agrobacterium tumefaciens*. *Nature* 318:624-629.
- Stachel SE, B Timmerman, and P Zambryski. 1986. Generation of single stranded T-DNA molecules during the initial stages of T-DNA transfer from *Agrobacterium tumefaciens* to plant cells. *Nature* 322:706-711.
- Stachel SF and P Zambryski. 1986. VirA and VirG control the plant-induced activation of the T-DNA transfer process in *Agrobacterium tumefaciens*. *Cell* 46:325-333.
- Staub J and P Maliga. 1992. Long regions of homologous DNA are incorporated into the tobacco plastids genome transformation. *Plant Cell* 4:39-45.
- Svab Z, P Hajdukiewicz and P Maliga. 1990. Stable transformation of plastids in higher plants. *Proc. Natl. Acad. Sci. USA* 87:8526-8530.
- Svennerholm AM, M Jertborn, L Gothefors, AMMM Karim, DA Sack and J Holmgren. 1984. *J. Infect. Dis.* 149:884-893.
- Tacket CO, HS Mason, G Losonsky, JD Clements, MM Levine and CJ Arntzen. 1998. *Nature Med.* 4:607-609.
- Tacket CO. 2000. Human immune responses to a novel Norwalk Virus vaccine delivered in transgenic potatoes. Available at <http://www.journals.Uchicago.edu/JID>.
- Thanavala Y, YF Yang, P Lyons, HS Mason and C Arntzen. 1995. *Proc. Natl. Acad. Sci. USA*, 92 : 3358-3361.
- Thomashow, MF, R Nutter, AL Montoya, MP Gordon and EW Nester. 1980. Integration and organization of Ti plasmid sequences in crown gall tumors. *Cell* 19:729-739.
- Tinland B, Z Koukolikova-Nicola, MN Hall and B Hohn. 1992. The T-DNA-linked virD2 protein contains two distinct functional nuclear localization signals. *Proc. Natl. Acad. Sci. USA* 89:744-7446.
- Vetch T, V Yusibov and H Koprowski. 1998. *J. Immunol. Methods* 220:60-75.
- Yusibov V, A Modelska, K Stepkowski and H Koprowski. 1997. *Proc. Natl. Acad. Sci. USA* 94:5784-5788.
- Zambryski P, M Holsters, K Kvuger, A Depicker, J Schell, M Van Montagu and H Goodman. 1980. Tumor DNA structure in plant cells transformation by *A. tumefaciens*. *Science* 209:1385-1391.

Comparative Toxicity of some Botanical Products against Corn Grain Weevil, *Sitophilus zeamais* (Mostch) under Storage Condition

Yamuna P Sah

ARS, NARC, Pakhribas

ABSTRACT

The experiment was conducted under laboratory condition (15.06 to 23.85°C and 84.43% RH). The objectives of the study were to prevent stored corn grain damage using different botanical insecticides against *Sitophilus zeamais* and determine the effective rates and duration of efficacy. The test plants were *Acorus calamus*, *Azadirachta indica*, *Artemisia vulgaris*, *Swertia chirata* and *Melia azedarach* in processed form. All the test plants were effective against *Sitophilus zeamais* but differed in efficacy depending on the rates and duration of storage. The most effective up to 360 days storage is *Acorus calamus* stolen powder either, at 5 to 30 g. Under this treatment no corn grains were damaged, there was no weight loss, and there was an acceptable percentage of seed germination. *Azadirachta indica* kernel powder at 15 to 30 g, *Artemisia vulgaris* leaf and twig chips at 15 to 30 g, and *Swertia chirata* leaf and twig chips at 15 g were effective up to 90 days and *Artemisia vulgaris* at 5 g and *Melia azedarach* at 15 g were effective only up to 60 days. The degree of damage was unacceptable, since it reached 25% with significant decrease in grain weight and seed germination if storage was prolonged in these treatments. *Acorus calamus* is recommended. It is effective up to one year, affordable (22.7 kg fresh rhizome equal to 5 kg powder is needed per ton of corn), abundant in the wilderness, and easy to prepare. A follow-up study may be conducted on the efficacy of the other plant parts, and in various preparations and storage techniques. Conservation/planting of these botanical insecticides should be encouraged as natural sources of pesticides.

INTRODUCTION

At present, one of the major concerns is the increasing demand of corn for food consumption in home and in agro-based industries. But certain biological elements such as insect pests, diseases, weeds and rodents limit its yield. In this light, the adoption of plant protection measures in raising crops assumes increasing importance in developing countries where about 25% of the populations suffer from malnutrition.

One contributory factor on high weevil damage in Nepal is that the majority of hill farmers store their ears in a Kunio (corn ears stored inside house) storage pattern up to 3 months before placing them in tangro (a traditional storage pattern where corn ears hanged on wooden or bamboo anchorage installed outside the house). Weevil contamination while storing starts right in kunio. Further, corn is stored throughout the year so there is a continuous presence of insect in the storage area. But the benefit of this type of storage is conditioning grains to remove excess moisture so to enhance pest protection. The corn weevil (*Sitophilus zeamais*) is an important pest in stored corn grain, especially in the tropical and subtropical world. They live and breed in grain debris near the threshing floors before moving to granaries.

The use and promotion of biological control has been successful in regulating pest population but often at levels that are above, the economic threshold. Chemical control works and is most effective for shelled grains protection. However, it can impose health hazard not only to those applying insecticides but also to consumers. Farmers often do not follow proper safety precaution, a situation, which puts them and their families at risk

during the treatment process (Manandhar et al 2000). Champ and Dyte (1976) reported that *Sitophilus* sp is the major stored pests of the majority of common cereals worldwide.

Reality available renewable resources if plant protection materials like indigenous botanicals may induce farmer to relict using synthetic insecticides against stored insects. In addition, the use of botanical products would bring back the traditional values and customs of the Nepalese farmers. Such revival is in harmony with modern scientific knowledge concerning pest management. Thus, the findings of the study could be easily adapted to the local norms and ecology and hence easily acceptable to farmers.

On the other hand, the preparation and use of botanical products entails less expense. The farmers could save a lot of money, as the expenses for the use of botanical products are more or less half the supposed price of commercial pesticides. Furthermore, the practice could increase more market demand because consumers would tend to prefer more farm products produced out of the use of botanicals than use synthetic pesticides. In addition, the practice of using botanical pesticides could encourage farmers to make use of locally available resources rather than those that have to be imported. Finally, the findings of the study would also provide information on how farmers in Nepal manage *Sitophilus zeamais* in stored grains. Thus the study provides a background on the comparative study on the management of corn weevils.

MATERIALS AND METHODS

The botanicals were collected from varying altitudes ranging from 1500 to 2400 m in eastern Nepal. Fresh rhizomes of sweet flag of (*Acorus calamus*) were collected and cleaned with fresh water. Root hairs were removed and rewashed with clean water. The rhizomes were chopped into small pieces of about 1 cubic cm and shed dried for one week. They were eventually powdered in a flourmill. Mature dry kernels of neem (*Azadirachta indica*) were collected from a low land area Tarai about 159 m in the central region of Nepal. Mug-worts (*Artemisia vulgaris*) were collected from eastern mid-hills of Nepal. Their fresh leaves with thin stems were chopped into small pieces, shed-dried up to one week and then chopped into smaller pieces.

Table 1. Initial observations on experiment materials

SN	Description	Moisture content, %			1000-grain wt, g	% infestation
		Fresh	Dried	Processed material		
1	<i>Acorus calamus</i>	77.5	5.5*	7.6 ⁺	-	-
2	<i>Azadirachta indica</i>	-	-	8.2 ⁺	-	-
3	<i>Artemisia vulgaris</i> L.	-	-	8.6*	-	-
4	<i>Swertia chirata</i>	-	-	8.3*	-	-
5	<i>Melia azedarach</i>	-	-	7.9*	-	-
6	Corn grain (<i>Zea mays</i>)		14.2		324	0.0

+ powder * chips.

Table 2. Plant test materials and corresponding dosages

Treatment	Plant material	Dosage, g/kg corn grain
T ₁	<i>Acorus calamus</i>	5
T ₂	<i>Ac. calamus</i>	15
T ₃	<i>Ac. calamus</i>	30
T ₄	<i>Azadirachta indica</i>	5
T ₅	<i>Az. indica</i>	15
T ₆	<i>Az. indica</i>	30
T ₇	<i>Ar. vulgaris</i> L	5
T ₈	<i>Ar. vulgaris</i> L	15
T ₉	<i>Ar. vulgaris</i> L	30
T ₁₀	<i>Swertia chirata</i>	15
T ₁₁	<i>Melia azedarach</i> L	15
T ₁₂₅	Control	0

Fresh leaves Chirata (*Swertia chirata*) with thin stems were collected from the Agricultural Research Station, Pakhribas. Dhankuta (2200 masl) in Nepal. The collected materials were chopped into small pieces and shed-

dried up to one week and again chopped into smaller pieces. Fresh leaves of Chinaberry (*Melia azedarach*) were collected from the ARS Pakhribas, Dhankuta eastern high hills (2200 masl) in Nepal. The collected materials were chopped into small pieces, shed-dried up to one week and again chopped into smaller pieces. *S. zeumais* weevils were mass reared in a room temperature ranging from 21⁰C to 26⁰C and RH of 78.5 to 96%. The weevils were reared for two months to meet their requirement for experiment. There were 12 treatments (included control) and three replications, which made a total experimental unit of 36.

Acorus calamus (stolen powder), *Azadirachta indica* (kernel powder), *Artemisia vulgaris* (stem + leaf chips) *Swertia chirata* (stem + leaf chips), *Melia azedarach* (leaf chips). The powder form of *Ac. calamus* and *Az.indica* were mixed thoroughly with grains whereas the chips form was placed in three layers in corn (bottom, middle and top). Immediately 40 pairs (males and females of weevils of zeamaïs were introduced in each of treatments. The covers of the buckets were fully sealed with masking tape. The treatments were arranged in a complete randomized design. The buckets were opened and repacked every month for a duration of 12 months to collect data. For the whole expennncutal period maximum and minimum room temperature and relative humidity data were recorded.

Data analysis

Percentage of degree of damage: This was computed using the following formula.

$$\% \text{ damage of grain} = \frac{\text{Number of damaged grains}}{\text{Number of observed grain}} \times 100$$

The moisture content MC of the grains was assessed according to ISTS (1985) rules. Grain moisture was adjusted at 12% using the following formula.

$$\text{Adjusted (MC)} = \frac{100 - \text{sample moisture content}}{100 - 12} \times \text{sample weight}$$

The percentage grain weight loss was calculated by using the following equation of Boxal (1986).

$$\text{Weight loss (\%)} = \frac{\text{Initial TGM} - \text{Sample TGM}}{\text{Initial TGM}} \times 100$$

Where, TGM = thousand total mass on weight loss analysis.

Before analysis the data were transferred to arcsine values.

RESULTS AND DISCUSSION

Effect of treatment on grain damage

At 180 days of storage, the *Acorus* rhizome powder treatments at 5 g, 15 g, and 30 g remained effective against *Sitophilus zeamaïs* weevil on corn. No corn grain was damaged in all these treatments. The other botanical products tested were not effective up to 180 days. The degree of damages in the fifth month continued to increase ranging from 72 to almost 90%, but all the corn grains in the untreated were damaged (100%).

In view of this, the experiment was terminated on *Azadirachta indica*, *Artemisia vulgaris vulgaris*, *Swertia chirata* and *Melia azedarach*. In the *Acorus calamus* treatment, corn weevils (*Sitophilus zemaïs*) were reintroduced to determine further if the materials used were still effective. At 360 days of storage, the corn grains in all the *Acorus rhizome* treatments that were reintroduced with 40 pairs of male and female *Sitophilus* weevils at 180 days after treatment remained sound.

The *Acorus calamus* at 5 g, 15 g, and 30 g are still effective even if the corn grains were reinfested with corn weevil. The result clearly indicates that *Acorus* powder is a superior botanical plant material for the control of *Sitophilus* weevil on corn grain that will be stored for a year shown in Table 3.

Table 3. Monthly percentage of corn grains damaged by corn weevil on storage for 6 months (Aug 2001-Jan 2002)

Treatment	Dosage, g/kg	No. of days after treatment					
		30	60	90	120	150	180
<i>Ac. calamus</i>	5	0.00 ^d	0.00 ^f	0.00 ^h	0.00 ^f	0.00 ^e	0.00 ^f
<i>Ac. calamus</i>	15	0.00 ^d	0.00 ^f	0.00 ^h	0.00 ^f	0.00 ^e	0.00 ^f
<i>Ac. calamus</i>	30	0.00 ^d	0.00 ^f	0.00 ^h	0.00 ^f	0.00 ^e	0.00 ^f
<i>Az. indica</i>	5	1.77 ^c	6.37 ^c	18.13 ^{cd}	46.63 ^{bc}	67.20 ^{bc}	86.13 ^{bcd}
<i>Az. indica</i>	15	0.00 ^d	2.40 ^e	9.47 ^{fg}	31.43 ^{de}	58.13 ^{cd}	72.37 ^e
<i>Az. indica</i>	30	0.00 ^d	2.17 ^e	8.50 ^g	28.37 ^e	63.10 ^{bcd}	75.07 ^e
<i>Ar. vulgaris</i>	5	2.90 ^b	9.73 ^b	23.63 ^b	54.63 ^b	72.60 ^b	89.77 ^{bc}
<i>Ar. vulgaris</i>	15	0.00 ^d	3.80 ^d	12.50 ^{ef}	38.57 ^{cd}	61.40 ^{cd}	79.63 ^{de}
<i>Ar. vulgaris</i>	30	0.00 ^d	2.93 ^{de}	14.83 ^{de}	42.93 ^c	65.87 ^{bc}	82.13 ^{de}
<i>S. chirata</i>	15	0.00 ^d	2.20 ^e	8.90 ^{fg}	29.70 ^{de}	53.90 ^d	74.10 ^e
<i>M. azedarach</i>	15	1.43 ^c	6.53 ^c	21.20 ^{bc}	45.60 ^{bc}	73.10 ^b	92.87 ^b
Control	0	9.63 ^a	21.33 ^a	40.13 ^a	74.67 ^a	91.73 ^a	100 ^a

Means followed by the same letters in a column is not significantly different at 0.05% level using DMRT.

Table 4. Percentage of grains weight loss by corn weevil on storage for 6 months (Aug 2001 Jan 2002)

Treatment	Dosage, g/kg	No. of days after treatment					
		30	60	90	120	150	180
<i>Ac. calamus</i>	5	0.00 ^d	0.00 ^d	0.00 ^e	0.00 ^e	0.00 ^e	0.00 ^e
<i>Ac. calamus</i>	15	0.00 ^d	0.00 ^d	0.00 ^e	0.00 ^e	0.00 ^e	0.00 ^e
<i>Ac. calamus</i>	30	0.00 ^d	0.00 ^d	0.00 ^e	0.00 ^e	0.00 ^e	0.00 ^e
<i>Az. indica</i>	5	0.48 ^c	1.76 ^b	5.28 ^{bc}	13.81 ^{bc}	19.37 ^{abc}	25.47 ^{abc}
<i>Az. indica</i>	15	0.00 ^d	0.70 ^{cd}	2.63 ^d	9.15 ^d	17.69 ^{bc}	21.34 ^d
<i>Az. indica</i>	30	0.00 ^d	0.63 ^{cd}	2.48 ^d	8.29 ^d	18.79 ^{bc}	22.18 ^{cd}
<i>Az. indica</i>	5	0.80 ^b	2.84 ^b	6.98 ^b	16.18 ^{ab}	21.25 ^{ab}	26.48 ^{ab}
<i>Az. indica</i>	15	0.00 ^d	1.10 ^c	3.64 ^d	11.27 ^{cd}	18.40 ^{bc}	23.07 ^{cd}
<i>Az. indica</i>	30	0.00 ^d	0.90 ^c	4.35 ^{cd}	12.79 ^{cd}	19.17 ^{bc}	24.22 ^{bcd}
<i>S. chirata</i>	15	0.00 ^d	0.63 ^{cd}	2.59 ^d	8.65 ^d	15.73 ^c	21.51 ^d
<i>M. azedarach</i>	15	0.37 ^c	1.91 ^b	6.14 ^b	13.44 ^{bc}	20.49 ^{ab}	27.64 ^a
Control	Untreated	2.85 ^a	6.31 ^a	11.76 ^a	22.08 ^a	26.42 ^a	29.66 ^a

Means followed by the same letters in a column is not significantly at 0.05% level using DMRT.

Effect of treatment on grain weight

The grain weight loss after 180 days after treatment application in the storage is presented in Table 4. The treatments of *Acorus* powder in all rates at 5, 15 and 30 g were observed more effective than the other tested botanical insecticides. There was a noted 0% grain weight loss at 180 days after treatment application. *Azadirachta* at 15 g effected 21.34% grain weight loss but was more effective than *Azadirachta* at 30 g and 5 g; *Swertia* at 15 g and *Artemisia* and *Melia* at 15 g. *Swertia chirata* effected 21.51% weight loss but was better than *Azadirachta* at 30 g and all three rates of *Artemisia* and *Melia* at 15 g 180 days after treatment application.

Azadirachta at 30 g showed better effect than *Artemisia* at 15 g in terms of grain weight loss, which was 22.18% and 23.07%, respectively. The 30 g and 5 g rate of *Artemisia* and *Azadirachta* at 5 g effected weight losses of 24.22%, 26.48% and 25.47%, respectively. The performance of *Melia* at 15 g was poor in terms of reducing grain weight loss. It effected 27.64% weight loss, which was close to the 29.66% of untreated control.

Based on the foregoing results, all the treatments of *Acorus* powder performed superior in preventing weight loss. They were effective against *Sitophilus* weevils that cause damage on the corn grain in comparison with the other botanical treatments. The rate of *Azadirachta* kernel powder at 15 g was more effective than the 30 g and 5 g. Similarly, *Artemisia* at 15 g rate was also better than 30 g and 5 g in preventing grain weight loss. *Swertia* at 15 g in was more effective than other tested botanical plant materials except *Acorus* powder and *Azadirachta* kernel powder at 15 g/kg. Similar results were found by Paneru et al (1996, 1997) and Neupane (1989).

Table 5. Initial and final percentage of germination of corn grains storage from (Aug 2001 to July 2002)

Treatment	Grain germination, %		
	Initial (0 days)	After 180 days	After 360 days
<i>Ac. calamus</i>	92	88	84
<i>Ac. calamus</i>	92	85	81
<i>Ac. calamus</i>	92	87	82
<i>Az. indica</i>	92	8	Terminated *
<i>Az. indica</i>	92	19	Terminated *
<i>Az. indica</i>	92	14	Terminated *
<i>Ar. vulgaris</i>	92	5	Terminated *
<i>Ar. vulgaris</i>	92	12	Terminated *
<i>Ar. vulgaris</i>	92	10	Terminated *
<i>S. chirata</i>	92	16	Terminated *
<i>M. azedarach</i>	92	2	Terminated *
Control	92	0	Terminated *

* These treatments were terminated after 180 days of storage.

Table 6. Mean metrological data July 2001 to July 2002

Month	Mean room temperature, °C		Mean RH, %
	Maximum	Minimum	
July 2001	23.09	15.92	89.77
August 2001	24.18	16.382	89.74
September 2001	23.07	16.14	91.17
October 2001	24.83	15.79	85.48
November 2001	23.65	14.52	81.37
December 2001	23.75	12.83	82.19
January 2002	23.09	11.56	79.19
February 2002	22.97	12.05	78.82
March 2002	24.49	14.12	78.55
April 2002	25.51	15.03	80.37
May 2002	25.12	16.25	85.06
June 2002	24.15	16.77	89.07
July 2002	22.21	17.29	89.77
Total Annual	310.11	195.09	1097.55
Man Annual	23.85	15.06	84.43

The result of the statistical analysis of variance indicates that the different treatments markedly differ from the untreated control, and that the treatment factor was the principal factor in determining the percentage grain weight losses caused by *Sitophilus* weevil. As presented, there was no weight loss recorded in all the rates of *Acorus*. This means that the *Sitophilus* weevils had not damaged the corn grains. It is recommended, therefore, that the *Acorus calamus* either at 5, 15 and 30 g/kg of corn grain be used to prevent *Sitophilus* weevil infestation on corn grain that will be stored for one year. In one experiment in Nepal 100% mortality of *Sitophilus* weevil was observed within 5 days after treatment application with *Acorus* rhizomes powder. Similar result was recorded in Nepal, Entomology division (1999). The statistical result of the analysis of variance clearly indicates that treatment factor is highly significant as compared with the untreated control.

Effect of treatment on seed germination

The initial percentage of germination of the corn grains was 92, indicating that the corn grains used are viable for planting. Germination test was repeated after 180 days of storage, and the germination result decreased significantly from 92% to 0%. It was in the *Acorus* rhizomes powder treatments where the percentage of seed germination was high-, it ranged from 85 to 88%. This value is highly accepted compared to the other treatments with botanical insecticides, which ranged from 2% (*Melia azedarach* at 15 g) to 19% (*Azadirachta indica* at 15 g). There was no significant difference also among the *Acorus calamus* treatments. *Acorus calamus* at 5 to 30 g is good protectant against corn weevil and a preserver of the viability of corn grains.

The low viability of seeds in the other treatments with botanical insecticides, however, is not due to the direct effect of the treatments inhibiting germination. Table 6 shows that germination effect is due to the extent of grain damage in these treatments. In the *Azadirachta indica* treatments, for instance, only about 25% not damaged

with a corresponding seed germination of 15% on the average. A similar case is noted in *Artemisia vulgaris*. The lowest 2% of germination came from treatment of *Melia azedarach*, which was due to grain damage of more than 90%. All the corn grains in the untreated did not germinate due to the total (100%) destruction of the corn grains by *Sitophilus* weevil.

The findings corroborate the study conducted in Nepal by Paneru et al (1996), who noted that *Acorus rhizome* in powder form reduces corn grain infestation by F, progeny of corn weevil. The *Acorus rhizome* powder used was at 50 g/kg corn grains and was effective up to 225 days storage period without the effect on germination.

CONCLUSION

All the tested botanical insecticides were effective in controlling *Sitophilus zeamais* weevil infestation on the stored corn grains. However, they vary in efficacy depending on the duration of storage. All the rates (5, 15 and 30 g) of *Acorus calamus* were effective up to one year storage. No corn grains were damaged up to 360 days even if reinfested with adult weevils at 180 days. This result to an acceptable percentage of seed germination of 85 to 88% at 180 days after storage and zero grain weight loss up to 360 days.

All the rates (5, 15 and 30 g) of *Azadirachta indica* were also effective but only up to 90 days storage. The same observation was noted on the higher rates (15 and 30 g) of *Artemisia vulgaris* and *Swertia chirata* at 15 g. On the other hand, the lowest rate (5 g) of *Artemisia vulgaris* and the 15 g *Melia azedarach* were effective only for 60 days in preventing *Sitophilus* weevil infestation. The corn grains in these treatments significantly lost weight with unacceptable percentage of germination rate ranging from 2 to 19% after 180 days from treatment application. All the tested botanical insecticides are effective against *Sitophilus zemaia* weevil infestation on corn grains but effectiveness depends on the duration of storage.

The most effective among the test insecticides is *Acorus calamus* stolens rhizomes in powder form at 5 to 30 g/kg corn grain. It can provide 100% protection to corn grains that will be stored up to one year resulting to 0% weight loss and high rate (85 to 88%) viability of the corn seeds. The other botanical insecticides are less effective and with shorter efficacy. The *Azadirachta indica* kernels in powder form at 5 to 30 g, *Artemisia vulgaris* leaves and twigs in chips at 15 to 30 g, and *Swertia chirata* leaves and twigs in chips at 15 g are effective up to 90 days. The least effective are the lowest rate (5 g) of *Artemisia vulgaris* and *Melia azedarach* leaves and twigs chips at 15 gm; their efficacy will last only for 60 days. The degree of damage in these treatments if storage is prolonged reached an unacceptable value of 25%. Weight loss on corn grains and germination rate also significantly decrease if storage is further prolonged.

Corn grains stored without protection from *Sitophilus zemaia* infestation before storing deteriorate in quality in 30 days. A 5-kg corn infested with 40 pairs (males and females) can cause more than 25% damage in 60 days and 100% damage in 180 days. Grain weight decreases significantly the percentage of germination.

RECOMMENDATION

All the tested botanical insecticides can be used to control *Sitophilus zemaia* weevil infestation on corn grains. Selection, however, should be based on the duration of storage that is desired as follows:

- For 360 days storage *Acorus calamus* rhizomes powder either at 5 to 30 g is recommended.
- For 90 days storage, to be used may be either *Azadirachta indica* kernel powder at 15 to 30 g, *Artemisia vulgaris* leaf and twig chips at 15 to 30 or *Swertia chirata* leaf and twig chips at 15 g and for 60 day storage, the lower rate of *Artemisia vulgaris* at 5 g or *Melia azedarach* at 15 g.
- *Acorus calamus* is recommended than the other test plant. The amount of rhizomes needed to treat one ton of corn grains is 22.7 kg, equivalent to 5 kg powder form. This amount is affordable to small farmers who store less than 1/4 t corn grains. This plant is also abundant in the wilderness and can be planted in marginal marshy areas common in Asian countries. The preparation of rhizome powder is easy, and the leaves, after taking off the rhizomes, can be used for other purposes.

- A follow-up study may be conducted on the efficacy of the other plant parts and in various preparations and storage techniques. It is also recommended that conservation/planting of these botanical insecticides should be encouraged in view of their potential as natural source of pesticides.

REFERENCES

- ARSP. 1998/1999. *Annual report*. Agricultural Research Station, Pakhribas, Dhankuta, Nepal. Pp.53, 76-78.
- Boxall RA. 1986. A critical review of the methodology for assessing farm level grain losses harvest. *Trop Development Research Institute*. O.D.A. 139p.
- Calboso FM. 1990. The corn weevil *Sitophilus zeamais* (Motsch.), Coleoptera Curculionidae, A population model. *MSc Thesis*. The Faculty of the Graduate School, UPLB.
- CBS. 1998. *Statistical pocket book*. His Majesty's Government National Planning Commission Secretariat. Central Bureau of Statistics, Thapathali, Ramshah Path, Kathmandu, Nepal. 63p.
- Champ BR and CE Dyte. 1976. Report of the FAO global survey of pesticide susceptibility of stored grain pests. *FAO, plant production and protection series no. 5*. FAO, Rome. 297p.
- ED. 1999. *Annual report*. Entomology Division, Nepal Agricultural Research Council, Khumaltar, Lahtpur, Kathmandu, Nepal. Pp. 14-17.
- ED. 2000. *Annual report*. Entomology Division, Nepal Agricultural Research Council, Khumaltar, Lahtpur, Kathmandu, Nepal. Pp.50-52.
- Grainge M and S Ahmed. 1988. *Handbook of plants with pest-control properties*. New York, USA, Wiley & Sons.
- Gyawali BK, GP Shibakoti, CB Karki, RR Sharma, TP Pokhrel and JD Ranjit. 1996. Current status and future research strategies of IPM in NARC. *Paper Presented at Workshop on IPM CRSP*. NARC, Conference Hall, Khumaltar, Lahtpur, Kathmandu, Nepal, Feb 5-6, 1996.
- Gyawali BK. 1996. Driving IPM approach in outreach research. *Paper presented at the third National Outreach Research Workshop*, Pakhribas Agriculture Research Center, Dhankuta from May 21-23, 1996.
- Joshi SL, BB Karmacharya and BR Khadge. 1991. *Plant protection*. Manpower Development, Agriculture Project, Kathmandu, Nepal. Trainer's Manual No. 16. Pp.1-2, 70-71, 324-325, 331-338.
- KC G. 2000. Post-harvest losses in maize: Review of the finding of the Rural Save Grain Project. *Proceedings of a working Group Meeting of the Hill Maize Research Project*, Khumaltar Lalitpur, Kathmandu, Nepal. 25-27 Sept 2000. Pp.47-49.
- Khadka RJ, BD Gurung, TP Tiwari, GB Gurung, RP Ghimire, KB Adhikari and DN Shrestha. 1994. A study on Chirata (*Swertia Chirata*): The high altitude cash crop of the eastern hills of Nepal. Pakhribas Agricultural center, Dhankuta, Koshi zone, Nepal. *PAC Work. Paper. no.* 107.
- Manandhar DN and DM Suakya. 1996. *Climate and crops of Nepal*. Nepal Agricultural Research Council, Swiss Agency for Development and Cooperation, Nepal. Pp.13, 19, 21, 28, 47, 49 and 51.
- Manandhar DN, JK Ransom and NP Rajbhandari. 2000. Developing and disseminating technology to reduce post-harvest losses in maize. *Proceedings of a working group meeting of the hill maize research project* Khumaltar, Lalitpur, Nepal 25-27 Sept 2000.
- Morallo-Rejesus B, RS Rejesus. 2001. *Biology and management of stored product and post-harvest insect pests*. Department of Entomology UPLB, College, Laguna, Philippines 4031. Pp.44-48, 132-159.
- Neupane FP. 1989. *Ball Biruwa Ka Shatru Ra Tinka Roktham*. ShaJha Prakasan Chhapakhana, Pulchaul, Lalitpur, Kathmandu, Nepal. Chap. 14; Pp. 394-405.
- Neupane FP. 1999. *Jaributi Dwara Kira Niyantrayan*. SaJha Prakasan Chhapakhana, Pulchaul, Lalitpur, Kathmandu, Nepal. Pp. 46 and 95-109.
- Paneru RB, VR Duwadi and MR Bhattarai. 1993. Second year of testing locally available plant materials against weevil in stored wheat. Pakhribas Agriculture Center, Dhankuta, Nepal c/o BAPSO, P O Box 106 Kathmandu, Nepal. *PAC Work. Pap. No.* 44.
- Paneru RB, VR Duwadi, R Khanal and MR Bhattarai. 1996. Testing of the efficacy of some local materials against weevil in stored maize. Pakhribas Agriculture Center, Dhankuta, Nepal c/o BAPSO PO Box 106 Kathmandu, Nepal. *PAC Work. Pap. No.* 139.
- Paneru RB, VR Duwadi, R Khanal. 1997. Study on the effect of different doses of Bojo (*Acorus calamus*) rhizome dust against weevil on stored wheat grains. Pakhribas Agriculture Center, Dhankuta, Nepal c/o BAPSO PO Box 106 Kathmandu, Nepal. *PAC Tech.Pap.*173.
- Paneru RB, YP Sab. 2000. Botanical and other indigenous knowledge system for the control of post harvest insect of maize. *Proceedings of a working Group Meeting of the Hill Maize Research Project*, Khumaltar Lalitpur, Kathmandu, Nepal. 25-27 Sept 2000. Pp.23-29.
- Paneru RB. 1996. Study on the effect of temperature, wheat moisture content, maturity and harvested altitude of rhizome on the toxicity of *Acorus calamus* (L.) powder to *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.) mortality and their progeny emergence. *MSc Thesis*. Imperial College of Science and Technology, Ascot, Berkshire, SL57py England.
- Sah YP. 1999. Minimizing the losses in stored maize under farmer's storage condition in the eastern hills of Nepal, ARSP. Agricultural Research Station, Pakhribas, Dhankuta, Nepal. *Tech. Pap. No.* 188

- Shibakoti GP and DN Manandhar. 2000. An overview of post-harvest losses in maize in Nepal. *Paper presented in working Group Meeting*, Khumaltar Lalitpur, Kathmandu, Nepal. 25-27 Sept 2000. Pp.6-9.
- Shibakoti GP. 1984. Post harvest losses at storage due to stored grain pests of maize under different storage structure. *The Eleventh Summer Crop Workshop*, Parwanipur Agricultural station, Parwanipur. Jan 30 - Feb 2 1984. Pp.28-39.

Effect of Different Doses of Bojo (*Acorus calamus* L.) Rhizome Dust against Weevil on Stored Wheat Grains

Ram B Paneru¹, Vrigu R Duwadi², Rajendra Khanal² and Yagya P Giri¹

¹Entomology Division, Khumaltar

²Pakhribas Agricultural Centre, Dhankuta

ABSTRACT

This study was carried out to determine an optimum dose of sweet flag (*Acorus calamus* L.) stolen dust in order to reduce the weevil infestation (*Sitophilus oryzae* L.) in stored wheat. The stolen dust was evaluated at rates of 0, 5, 10, 20, 30, 40, 50 and 60 g per kg wheat grains. The performance of dust in both years indicated that a dose of 20 g or > 20 g per kg grains was highly effective to reduce the weevil infestation. The dose rate of 20 g dust per kg wheat is determined as an optimum dose to reduce weevil damage to a negligible level.

INTRODUCTION

In eastern hills of Nepal, wheat (*Triticum aestivum*) is a major cereal crop in term of area cultivated and production in the winter season. It ranks fourth in area coverage after rice, maize and finger millet, and third in production (DFAMS, 1992; Tiwari, 1992). Wheat is a major cereal crop cultivated during the winter season in the eastern hills. Wheat grown in main season is normally harvested on May/June. It remains in store about six months for domestic consumption and until the coming year for cultivation. In general, farmers store wheat on upper floor of the house in the locally made containers such as bamboo baskets (*Dhaki*), big mud pots (*Ghyampo*), etc. which allow air circulation. There are many insect pests, which cause significant loss both of quantity and quality of wheat in storage. It was observed during field visit and treks in the eastern hills that an important contributor to losses of stored wheat is the weevil (*Sitophilus oryzae* L.). Damage of up to 33.3% of grains has been reported by Paneru et al. (1993) under farmers' condition in the eastern hills. Weevil not only causes grain loss but also reduces the quality of stored wheat. Furthermore, infested wheat does not germinate and is unhygienic for human consumption.

Pesticides (eg almunium phosphide, malathion) have been recommended to protect wheat grains from weevil infestation. These pesticides have some potential in practice depending upon storage characteristics and socio-economic factors of users. But, chemical pesticides are either expensive or un-available to eastern hill farmers, and are not friendly to the environment. In such a situation, use of effective indigenous plant materials instead of chemical pesticides is highly desirable.

Sweet flag is a member of Araceae family. It is herbaceous and aromatic perennial plant. It has long, erect, narrow leaves with underground stolen. It is distributed worldwide and has medicinal value (Motley 1994). It grows well in swamps and marshy land up to an altitude of 2000 m. The stolen and fragrant oils have been used medicinally and it is used as a flavouring agent (Motley 1994). It has known insecticidal properties and is effective against numerous pests, including weevils (Stoll 1988). Tiwari (1993) (quoting anonymous report) reported that incorporation of *A. calamus* dust in food is non-toxic to humans. The active insecticidal and anti-feedant ingredients are α and β asarone, major constituents of oil of *calamus* (Hasheminejad and Caldwell 1994). There are some reports indicating that the active ingredient of Sweet flag (β -asarone) is unsafe to admix in food and should be restricted to 1 ppm in alcoholic beverages. Plants contain different levels of α and β asarone depending upon growing location.

The crop protection programme of Pakhribas Agricultural Centre, Nepal, to promote the use of locally available indigenous plant materials in order to reduce weevil infestation, carried out a study. Among the tested materials, Sweet flag stolen dust was reported to be an effective plant material to protect wheat grain from weevil infestation at a rate of 50 g dust mixed with one kg of wheat (Paneru et al 1993). However, the dose 50 g dust per kg wheat was considered too high volume where larger quantities of wheat are to be treated. On the same line, there was some indication that a rate of 5 g dust mixed with one kg wheat had also given considerable reduction to weevil infestation. With this background the present work was designed to determine the most effective low dose in the range between @ 5 and 60 g dust per kg wheat.

MATERIALS AND METHODS

The experiment was conducted during normal wheat storage period for farmers in a field store similar to farmers' stores. The experiment was carried out during 1991/92 and repeated during 1992/1993, both between July and February, 150 - 180 days being the normal storage period under farmer conditions. Wheat variety RR 21 was used in the experiment.

Prior to mixing dust with wheat, moisture content and germination level of wheat were assessed using International Seed Testing Association (ISTA) rules 1985. The initial wheat moisture content was recorded 12.5 and 11.1 per cent, with germination levels of 92 and 99 per cent, for the years 1991/92 and 1992/93 respectively. Five kg of wheat were used for each treatment application. There were a total of eight dose levels in each of four replications (blocks). The wheat was thoroughly mixed with each dose of sweet flag stolen dust. Untreated seed was used as a control treatment. The treated wheat of each replication was placed in a bamboo basket (Dhaki) of 8 kg capacity. The baskets were plastered with a mixture of mud and cow dung and well dried in sun light prior to grain filling as a normal farmers' practice. These baskets were placed on the floor arranged in randomised complete blocks.

Stolen of sweet flags were uprooted. They were washed and chopped into small pieces. These pieces were dried under shade to avoid loss of volatile aroma of the stolen. These well-dried pieces were ground into dust using local practice (crushed by Dhikki). The moisture content of dust was maintained not more than 14 per cent. This moisture level is preferable so as to be comparable with the usual moisture content of stored wheat. In general 7 kg of fresh sweet flags stolen require producing one kg dust.

Treatments

1. Sweet flag stolen dust thoroughly mixed @ 5 g per kg wheat grains.
2. Sweet flag stolen dust thoroughly mixed @ 10 g per kg wheat grains.
3. Sweet flag stolen dust thoroughly mixed @ 20 g per kg wheat grains.
4. Sweet flag stolen dust thoroughly mixed @ 30 g per kg wheat grains.
5. Sweet flag stolen dust thoroughly mixed @ 40 g per kg wheat grains.
6. Sweet flag stolen dust thoroughly mixed @ 50 g per kg wheat grains.
7. Sweet flag stolen dust thoroughly mixed @ 60 g per kg wheat grains.
8. Grains without addition of any material added.

The percentage of grains bored by weevil was recorded after 60, 120, 150 and 180 days by inspecting 1000 randomly selected wheat grains from samples of each replication. The thousand grain mass (TGM) was recorded from the random sample taken prior to treatment and from samples at 150 and 180 days. The percentage grain weight loss was calculated at 150 and 180 days using the following equation,

$$\text{Weight loss, \%} = \frac{\text{Initial TGM} - \text{Sample TGM}}{\text{Initial TGM}} \times 100$$

These weight loss were adjusted to a standard moisture content to ensure uniformity on weight loss analysis. At the time of each observation, moisture content of grains was also assessed according to ISTA rules, 1985. Analyses of variance were calculated after transforming the bored percentage values into arcsine values.

RESULTS AND DISCUSSION

The grains were free from weevil damage at the beginning of this experiment. The mean percentage of bored grains and grain weight losses at different times are presented in the Tables 1 and 2 for the year 1991/92 and 1992/93 respectively. Analysis of variance showed significant differences on the per cent grains bored values between dose rates.

Table 1. Mean percentage of grains bored by weevils and grain weight loss during 1991/92

Treatment	Grains bored, %				Grain wt loss, %	
	60 days	120 days	150 days	180 days	150days	180 days
T1 (5 g)	5.4 AB	11.3 B	16.0 B	19.6 B	3.0	5.1
T2 (10 g)	4.3 AB	7.3 BC	8.4 BC	7.4 C	4.6	5.2
T3 (20 g)	3.8 B	5.0 BC	3.4 C	3.4 CD	3.4	5.0
T4 (30g)	2.1 B	4.1 BC	4.6 C	2.8 D	2.2	3.7
T5 (40 g)	2.7 B	2.6 C	4.5 C	2.9 D	1.1	3.1
T6 (50 g)	1.8 B	2.1 C	4.1 C	3.0 D	4.3	1.5
T7 (60 g)	1.9 B	2.1 C	4.0 C	2.0 D	2.4	1.7
T8 (control)	9.4 A	54.6 A	63.8 A	73.1 A	8.7	11.1
F test	***	***	***	***	NA	NA
CV, %	28.62	28.16	24.76	15.75	NA	NA
LSD (0.01)	1.035	9.352	9.404	5.85	NA	NA
SE±	0.2	2.3	2.4	1.6	NA	NA

NA, Not analysed.

Weevils in the control treatment bored the highest percentages of grains. At 60 days, the percentage grains bored by weevils were statistically significant different among the treatments. Bored grain percentage values recorded from untreated control treatment and treatments with the grains mixed with sweet flag stolen dust @ 20 g and more than 20 g per kg grains were significant different. However, there was no significant difference between treatments at @ 20 or more than 20 g dust per kg grains. The observation recorded at 120 days showed that all the doses of sweet flag were effective to manage weevil infestation if a 11% bored grains is acceptable against 54.6 per cent in untreated control.

When grains were observed at 150 days of storage, there were 16 and 8 per cent grains bored by weevils in the treatment of @ 5 g and 10 g per kg grains respectively. These treatment were significant different with control treatment and other treatments at 20 g and > 20 g dust per kg wheat. The percentage bored grains in the treatment of @ 20 g and more than 20 g per kg grains were statistically non significant different. Similarly, at 180 days bored grains increased to 19.6 and 7.4 per cent at 5 and 10 g per kg grains respectively. The bored grain percentage was lower in treatments at @ 20 g and more than 20 g per kg grains as compare to other treatments. However, they are statistically not significant. The highest grain weight losses 8.7 and 11.1 percent have been recorded in the control treatment during the observation recorded on 150 and 180 days respectively. There was less than 5.0 per cent grain weight loss in the grain mixed with different doses of sweet flag stolen dust.

Table 2. Mean percentage of grains bored by weevils and grain weight loss during 1992/93 (NA, Not analysed)

Treatment	Grains bored, %				Grain wt loss, %	
	60 days	120 days	150 days	180 days	150 Days	180 Days
T1 (5 g)	0.8 B	8.4 B	8.0 B	9.0 B	4.1	6.2
T2 (10 g)	0.7 B	2.2 BC	2.1 BC	2.5 BC	4.9	5.4
T3 (20 g)	0.2 B	0.6 C	0.5 BC	1.1 C	4.3	4.9
T4 (30 g)	0.2 B	0.4 C	0.3 C	0.4 C	3.1	3.0
T5 (40 g)	0.4 B	0.3 C	0.5 C	0.5 C	3.3	3.8
T6 (50 g)	0.3 B	0.2 C	0.1 C	0.4 C	3.3	4.0
T7 (60 g)	0.3 B	0.5 C	0.2 C	0.4 C	3.4	2.5
T8 (control)	43.3 A	78.5 A	82.6 A	89.9 A	21.2	22.0
F test	***	***	***	***	NA	NA
CV, %	38.16	30.29	37.49	31.07	NA	NA
LSD (0.01)	6.231	7.803	9.638	9.231	NA	NA
SE±	1.6	1.9	2.4	2.3	NA	NA

As in previous year, the percentage grains bored by weevils was the highest in control treatment this year (1992/93). Bored grains percentage values were statistically significant different among the treatments control and grains mixed with different doses of sweet flag stolen dust in all observations.

The observation recorded at 60 days indicated that there were statistically significant different on percentage grains bored by weevil between the treatments control and sweet flag treated treatments. All the doses of sweet flag dust were found effective to reduce weevil attack in the grains. However, the dose levels of sweet flag were not significantly different. The bored grain percentage recorded at 120 days indicated that sweet flag dust treatments at 5 and 10 g per kg grains were statistically significant different with doses @ 20 and more than 20 g per kg grains. Percentage grains bored by weevils was lower in the grains mixed with sweet flag dust at the rate of 20 and more than 20 g per kg grains.

The bored grain percentages recorded at 150 and 180 days indicated that the treatments are statistically significant different. The treatments at the rate of 5, 10 and 15 g were statistically significant different with treatment at 20 and more than 20 g per kg grains during the observation at 150 days. Similarly, the treatments at the rate of 5 and 10 g were statistically significant different with treatment at 20 and more than 20 g per kg grains during the observation at 180 days. As far as the effectiveness of sweet flag stolen dust is concerned, the bored grain percentages were lower in the grains mixed with dust at the rate of 20 and more than 20 g per kg grains. The dose levels at the rate of 20 or more than 20 g per kg grains were not significantly different to reduce weevil attack for the period up to 180 days.

The highest grain weight losses 21.18 and 22.04 percent have been recorded in the control treatment during the observation recorded on 150 and 180 days respectively. There was less than 6.25 per cent grain weight loss in the grain mixed with different doses of sweet flag stolen dust.

CONCLUSION

Experimental results during the year 1991/92 and 1992/93 indicated that a dose rate of 20 g or more than 20 g sweet flag dust per kg grains have similar performance to protect the grains from weevil infestation for the period 180 days of storage. A dose rate of 20 g reduced grain boring by weevil from 73.1 to 3.4 and 89.9 to 1.1 per cent as compared with untreated control during the years 1991/92 and 1992/93 respectively. From both years it is clear that a dose rate of 20 g or more sweet flag stolen dust is effective to protect one kg wheat from weevil infestation. Thus, this study concluded that application of sweet flag stolen dust @ 20 g per kg wheat grains is able to protect the wheat grains from weevil damage as an optimum dose for the storage period of 180 days.

ACKNOWLEDGEMENT

The authors are grateful to FE Tollervey, PAC for supporting the work. Grateful thanks are also due to Mrs B Rai (Paudel) for germination and moisture content evaluation Messrs BN Devkota, B Khadka and L Shrestha are also acknowledged for their valuable assistance in sampling and the evaluation of weevil damage.

REFERENCES

- DFAMS. 1992. *Agricultural statistics of Nepal*. Department of Food and Agricultural Marketing Services (DFAMS), Agricultural Statistics Division, Lalitpur, Nepal.
- Hasheminejad G and J Caldwell. 1994. Genotoxicity of the alkenylbenzenes alpha-asarone and Beta asarone, myristicin and elmicin as determined by the UDS assay in cultural rat hepatocytes. *Journal of Food and Chemical Toxicology* 32(3):223-231.
- Motley TJ. 1994. The ethnobotany of sweet flag, *Acorus calamus* (L.). *Economic Botany* 48(4):397 – 412.
- Paneru RB, VR Duwadi and MR Bhattarai. 1993. Second year of testing locally available plant materials against Weevil (*Sitophilus oryzae* L.) PAC Working Paper No. 44. Pakhribas Agricultural Centre, c/o BAPSO, PO Box 106, Kathmandu.

- Stoll G. 1988. Natural crop protection based on local farm resources in the tropics and sub tropics. *AGRECOL* Buhleingasse 2. D-7609, Hoihburg 1 FR.
- Tiwari SN. 1993. Efficacy of some plant products as grain protectants against *Sitophilus oryzae* (L). *J. Insect Science* 6:158 – 160.
- Tiwari TP. 1992. Sterility problems of Nepalese wheat. *MSc Thesis*. University of London. Wye College UK.

Monitoring Field Status of Naturally Occurring Egg Parasitoids of Citrus Green Stink Bug, *Rhynchocoris humeralis* Thunberg and Their Identifications

Roshan Manandhar, Parma N Sharma and Salik R Devkota

Regional Agriculture Research Station, Lumle, Kaski

ABSTRACT

The naturally occurring parasitoids of citrus green stinkbug were monitored at Bandipur (1000 masl), Bachegaon (660 masl) and Lohi (450 masl) in Tanahun district; Karendada (940 masl), Syangja district and Pokhara (850 masl), Kaski district in 2000 and 2001. The results revealed that the egg parasitoids namely *Anastatus* sp, *Trissolcus latisculus* Crawford and *Ooencyrtus utittheisae* Risbec are widely distributed in this region. *O. utittheisae* was the most prevalent species followed by *Anastatus* sp and *T. latisculus*. The average ratio of parasitoid- pest was found to be 1:1.87.

INTRODUCTION

Citrus green stink bug (CGSB), *Rhynchocoris humeralis* Thunberg (Hemiptera: Heteroptera: Pentatomidae) was identified as one of the major causes of premature fruit drop in mandarin orange (*Citrus reticulata*, Blanco), especially in the lower hills (600 to 1000 masl.). Occurrences of adult bugs in mandarin tree commenced in May and later, both adults and nymphs fed upon developing fruits. Fruit drops were more severe when fruits were smaller in size during June to August, but endured their attack thereafter (Pandey and Rana 1993). The extent of fruit drop ranged from 92-100% under forced feeding condition until middle of August and then drop decreased to about 50% and 25% in the first and second half of September respectively. However, natural fruit drop was 20% in which CGSB appeared to be responsible for 50% of this loss (Pandey and Rana 1993).

The eggs of bugs were found parasitised by the egg parasitoid, *Trissolcus* nr. *priapus* in the field cage experiments conducted at Lohi village, Tanahun during 1991-92 (Pandey and Rana 1992). Monitoring of parasitoids at Lohi village and Horticultural Research Station (HRS), Malepatan in 1993 and 1994 and Lohi village, HRS, Malepatan, Yampaphant and Keware Bhanjyang in 1995 revealed that *Trissolcus latisculus* Crawford (Scelionidae), *Anastatus* sp (Eupelmidae) and *Ooencyrtus utittheisae* Risbec (Encyrtidae) being egg parasitoids of bugs. The former two species occurred in higher rate in the western development region of Nepal. (Pandey et al 1995, 1997). Based on the previous developed information on the occurrences of egg parasitoids of CGSB in citrus growing areas of western development regions of the country, a further monitoring work was carried out in order to find out the intensity of parasitoids in nature regulating the population of CGSB.

MATERIALS AND METHODS

Monitoring of CGSB egg parasitoids was carried out at Bandipur (1000 masl), Bachegaon (660 masl), Lohi (450 masl), in Tanahun; Karendada (940 masl) Syangja district and Pokhara valley (850 masl), Kaski district during May to October 2000 and 2001. Unlike previous methodologies (Pandey et al 1995, 1997), eggs of CGSB laid on plant parts of citrus tree in the natural condition were collected in the monthly interval from May to October during 2000 and 2001. Two to three orchards were visited at each location and CGSB eggs were collected

within a period of one hour. Minimum of 5 sets of eggs ie 80 CGSB eggs was targeted to collect from each location.

Collected eggs were brought to Agricultural Research Station (ARS), Lumle and incubated at room temperature (average minimum and maximum temperatures being 16.15°C and 22.75°C respectively). Types of parasitoids emerged were recorded daily. The emerged parasitoids were identified with reference to identified parasitoid specimens by International Institute of Entomology, London, UK preserved in the laboratory, ARS, Lumle.

RESULTS AND DISCUSSION

CGSB laid eggs both on the upper and lower surfaces of leaves in a batch of 14 in number. Eggs were mostly concentrated on the outer surface of lower half canopy of the mandarin tree. Eggs were parasitised in all or a few in a batch and those parasitised eggs were black in colour. Freshly parasitised white eggs, which gradually turned black during incubation period hatched into parasitoids in 13-15 days. The fresh unparasitised white eggs hatch into nymphs within 5 days.

CGSB eggs were found in the mandarin tree from early July to late September. The egg parasitoids were also active during the period with peak activity in August. It was also noted that the pest- parasitoid activity was comparatively lower in 2001 as compared to 2000 (Table 1, 2).

Table 1. Monitoring of naturally occurring parasitoids of citrus green stink bug, 2000

Month	Number of collected eggs	Emerg ed parasitoids			Number of CGSB nymphs	Number of unhatched eggs
		<i>Anastatus</i> sp.	<i>Trissolcus laticulcus</i>	<i>Ooencyrtus utitheisae</i>		
Bandipur						
May	0	0	0	0	0	0
June	14	0	0	13	1	3
July	17	0	0	12	5	5
August	70	13	2	27	28	4
September	32	7	2	0	23	0
October	0	0	0	0	0	0
Total	133	20	4	52	57	12
Bachegaon						
May	0	0	0	0	0	0
June	14	0	0	0	14	0
July	68	15	5	0	48	0
August	70	3	2	14	42	16
September	27	2	10	15	0	9
October	0	0	0	0	0	0
Total	179	20	17	29	104	25
Lohi						
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	54	13	1	0	40	0
September	42	14	0	12	14	8
October	0	0	0	0	0	0
Total	96	27	1	12	54	8
Karendada						
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	68	25	6	0	37	0
August	62	18	10	0	34	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
Total	130	43	16	0	71	0
Pokhara						
May	0	0	0	0	0	0
June	0	0	0	0	0	0

Month	Number of collected eggs	Emergent parasitoids			Number of CGSB nymphs	Number of unhatched eggs
		<i>Anastatus</i> sp.	<i>Trissolcus laticulus</i>	<i>Ooencyrtus utitheisae</i>		
July	90	0	0	5	77	10
August	53	0	0	15	33	7
September	0	0	0	0	0	0
October	0	0	0	0	0	0
Total	143	0	0	20	110	17
Grand total	681	110	38	113	396	62

Table 2. Monitoring of naturally occurring parasitoids of citrus green stink bug, 2001

Month	Number of collected eggs	Emerged parasitoids			Number of CGSB nymphs	Number of unhatched eggs
		<i>Anastatus</i> sp.	<i>Trissolcus laticulus</i>	<i>Ooencyrtus utitheisae</i>		
Bandipur						
June	28	4	8	0	16	0
July	70	6	0	0	56	8
August	68	11	4	32	13	10
September	14	0	0	0	14	0
October	0	0	0	0	0	0
Total	180	21	12	32	99	18
Bachegaon						
June	0	0	0	0	0	0
July	28	0	0	6	22	3
August	70	0	0	0	70	0
September	28	0	0	0	28	0
October	0	0	0	0	0	0
Total	126	0	0	6	120	3
Lohi						
June	0	0	0	0	0	0
July	64	0	0	0	35	29
August	70	0	0	14	55	4
September	14	4	2	0	0	8
October	0	0	0	0	0	0
Total	148	4	2	14	90	41
Karendada						
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	28	0	0	0	28	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
Total	28	0	0	0	28	0
Pokhara						
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	65	0	9	6	37	16
September	64	2	9	33	0	20
October	0	0	0	0	0	0
Total	129	2	18	39	37	36
Grand total	611	27	32	91	374	98

Results of both the years indicated that all three Hymenopteran parasitoids namely *Anastatus* sp., *T. laticulus* and *O. utitheisae* were widely distributed in the western hills. *O. utitheisae* is the most prevalent species followed by *Anastatus* sp. and *T. laticulus*. Pandey et al (1995, 1997) reported that *T. laticulus* and *Anastatus* sp had higher rate of occurrence in this region. In Pokhara valley, only *O. utitheisae* was recorded in 2000 and so also the same species was found dominant in 2001. In Karendada, where *O. utitheisae* was not encountered *Anastatus* and *T. laticulus* were the main egg parasitoids in 2000. The pest population was found very low, when only 2 sets of eggs collected in August without any parasitisation, all emerging nymphs. Pandey et al

(1995) reported more than one *O. utitheidsae* emergence from a single host's egg (54 parasitoids from 14 eggs). This phenomenon had occurred in both years but the data were not recorded accordingly. The ratio of parasitoid:pest in the monitored locations was found to be 1:1.52 in 2000 and 1:2.49 in 2001, with average ratio of 1: 1.87 over two years. These parasitoids were considered as the most efficient natural enemies in this region and effectively parasitising the eggs of CGSB (ARS, Lumle, Unpublished 2001).

In the light of successfully regulation of pentatomid bugs by egg parasitoids in USA (Hoffman et al 1987 and 1991), in Australia (James 1993) and in Japan (Atsushi 1995, Kazuro 1999), the indigenous egg parasitoids, *Anastatus* sp, *T. laticulcus* and *O. utitheidsae* could be efficient natural enemies, regulating the population of CGSB in Nepal provided these parasitoids were conserved and augmented in this region. Efforts were made to multiply these egg parasitoids in eggs of eri-silkworm and also in mulberry silkworm, but without any success, unlike successful multiplication of *Anastatus* sp. in the eggs eri-silkworm and release against pentatomid bug in Thailand (Lekswadsi and Kumchu 1991)

The naturally occurring egg parasitoids of CGSB namely *Anastatus* sp, *T. laticulcus* and *O. utitheidsae* are widely distributed in the western hills of Nepal. *O. utitheidsae* is the most prevalent species, followed by *Anastatus* sp. and *T. laticulcus*. The parasitoids and CGSB in nature occur in an average ratio of 1:1.87 (parasitoid:pest). These parasitoids can be considered as effective egg parasitoids of CGSB. To enhance biological control of CGSB in this region by these indigenous egg parasitoids, their conservation and augmentation are essential.

ACKNOWLEDGEMENTS

Authors are grateful to Dr RP Sah, ARS, Lumle for his support to carry out this activity. Sincere thanks to Dr WS Jones, HARP for his guidance to implement this activity. Similarly, Mr D Pokhrel, Mr SP Dahal are very much thankful to their support during monitoring. We express sincerely our gratitude to Dr SL Joshi, Entomology Division, Khumaltar, Lalitpur for the painful reviewing of the manuscript and improving the text. Funding provided by HARP is highly acknowledged. Last but not the least thanks to Mr RR Adhikari and administrative staff for helping us in word processing and providing logistic support.

REFERENCES

- Atsushi K. 1995. Development of the parasitoid, *Telonomus triptus* (Hym., Scelionidae) on the eggs of six stink bugs. *Bulletin of the National Agriculture Research Center*. (24):67-74. Tokyo University of Agriculture, Tokyo, Japan.
- Hoffman MP, LT Wilson and FG Zalom. 1987. Control of stink bugs in tomatoes. *California Agriculture* 41(5, 6):4-6.
- Hoffman MP, NA Davidson, L Wilson, LE Ehler and WA Jones. 1991. Imported wasps helps to control Southern green stink bug. *California Agriculture* 45(3):20-23.
- James DG. 1993. Toxicity of endosulfan to spined citrus bug, *Biprolus bibax* and some of its egg parasitoids. *Plant Protection Quarterly* 8(2):54-56. Yanco Agriculture Institute, NSW Agriculture, Yanco, New South Wales 2703, Australia. (Abstract).
- Kazuro O. 1999. Brood guarding in *Trissolcus plautidae* (Watanabe) (Hymenoptera: Scelionidae), an egg parasitoid of brown winged green bug, *Plautia crossota* stali Scott (Heteroptera: Pentatomidae). *Entomological Science* 2(1):41-47. Department of Entomology and Plant pathology, Fukuoka Agricultural Research Center, Yoshiki 987, Chikushino, 818-8549, Japan.
- Leksawadsi P and C Kumchu. 1991. Mass rearing and releasing of the parasitoid *Anastatus* sp. Kasetsart. *Journal, Natural Science* 25(1):47-58.
- Pandey RR and RB Rana. 1992. Green stink bug (*Rhynchoscoris humeralis*) damage of mandarin fruits and its natural parasitisation by *Trissolcus* sp. *Journal of the Institute of Agriculture and Animal Sciences* 13:127-128.
- Pandey RR and RB Rana. 1993: Effect of time of feeding of Citrus green stink on mandarin (1991-92). *LARC Working Paper No. 93/27*. Lumle Agriculture Research Center, Kaski.
- Pandey RR, TB Gurung and HP Ghimire. 1995. Studies on Citrus green stink bug (*Rhynchoscoris humeralis*). *LARC Working Paper No. 95/4*. Lumle Agriculture Research Center, Kaski.
- Pandey RR, YD GC and AK Vaidya. 1997. Report on management of fruit fly, survey of egg parasites of citrus green stink bug and monitoring of pests of rice and maize, 1995-1996. *LARC Working Paper No. 97/25*. LARC, Kaski.

Population Dynamics of Citrus Psylla (*Diaphorina citri* Kuwayama) in the Western Hills of Nepal and Spread of Citrus Greening Disease

Roshan Manandhar, Subash Malla and Deep N Sah

Regional Agricultural Research Station, Lumle, Kaski

ABSTRACT

Monitoring of citrus psylla, *Diaphorina citri* Kuwayama, was carried out at Yampaphant (450 masl), Tanahun; Lohi (650 masl), Tanahun; Bandipur (1,050 masl), Tanahun; Agricultural Research Station, Malepatan (850 masl), Kaski; Hemja (1,050 masl), Kaski; Agricultural Research Station (ARS), Lumle (1,450 masl), Kaski and Bhakimli (1,300 masl), Myagdi. Bright yellow sticky trap was used for monitoring the psyllid from September 1999 to April 2001. Yellow sticky trap was replaced by mouth aspirator at Yampaphant, Lohi and ARS, Malepatan from May 2001 to July 2001. *D. citri* was found at Yampaphant, Lohi, Bandipur, ARS, Malepatan and Bhakimli. No psyllid was observed at ARS, Lumle and Hemja. The presence of psyllid at Bandipur and Bhakimli (above 1000 masl) indicated a need for reformulating the altitude for citrus nursery establishment. As *D. citri* has been reported to be a vector mainly responsible for spread of citrus greening disease (CGD) in the country, citrus nursery should be established only in areas free of citrus psylla, CGD, CTV and Phytophthora diseases. The highest psyllid population was detected in spring and before rainy season in low altitude areas (<1,000 masl), while in high altitude areas (>1,000 masl) high psyllid population was observed during rainy season (day temperature $\geq 20^{\circ}\text{C}$).

INTRODUCTION

Citrus is one of the major commercial fruits of Nepal. The crop is mainly grown from 450 masl to 1,300 masl since antiquity (Shrestha 1999, Roistacher 1996, Shah 1992). Citrus is also one of the high value priority crop in the hills (Ninth Five Year Plan 1998-99, APP 1995). In the western hills (comprise of 11 districts), area covered by total citrus trees, fruit bearing trees and production are 5,262.74 ha, 3,070 ha and 31,099 t respectively (ASD 2000).

The Asian citrus psylla, *Diaphorina citri* Kuwayama, is the main vector of citrus greening disease (CGD) in South-Asia, Arabian Sub-continent and Africa (Gavarrá and Mercado, 1988; Yuhua and Changfan 1988, Aubert 1986, Aubert and Quilici 1986, Bove and Garner 1984). Besides causing distortion and curling of leaves and production of honeydew by nymphal feeding, the adult psylla is a vector of citrus greening disease (CGD) (Gavarrá and Mercado 1988, Aubert 1986). The presence of greening disease was reported in the country since mid 1960's along with the presence of psylla vector (Knorr and Shah 1971, Catling 1970, Thrower 1968). Though, CGD is also graft transmissible, the disease is mainly spreads through *D. citri* as the citrus is predominantly grown from the seedlings in the country (Verma and Sharma 1993, Roistacher 1991, Regmi and Lama 1986). The disease is a major concern in the citrus production as it significantly reduces the yield and entire economic loss is incurred within 6 to 8 years of its infection (Regmi and Lama 1986, Aubert 1986). Therefore, proper assessment of psylla populations and spatial and temporal distribution are of paramount importance for the management of the citrus greening disease.

MATERIALS AND METHODS

Monitoring of citrus psylla, *Diaphorina citri*, was carried out from September 1999 to July 2001 except in Hemja where study was carried out from January 2001 to July 2001. The study was conducted at different altitudinal regions viz. Yampaphant (450 masl), Tanahun; Lohi (650 masl), Tanahun; Bandipur (1,050 masl), Tanahun; Agricultural Research Station (Citrus block), Malepatan (850 masl), Kaski; Hemja (1,050 masl), Kaski; Agricultural Research Station, Lumle (1,450 masl), Kaski; Bhakimli (1,300 masl), Myagdi. Monitoring was done by using yellow sticky traps (designed and supplied by Bio-Control Research Laboratories, India) as yellow surfaces reflecting in the wavelength 500-550 nm inhibit flight or walking and tend to bring these insects on yellow objects. Yellow sticky trap was later replaced by mouth aspirator at Yampaphant, Lohi, and ARS, Malepatan.

Bright yellow sticky traps were installed in all the sites for citrus psylla monitoring. However, at Lohi and Hemja fluorescent yellow and lemon yellow were also used in April 2001. The orchards having at least 25 bearing trees were selected for psylla monitoring through yellow sticky trap. Preference was also given to those orchards where insecticides were not applied during the recent years. Yellow sticky band (24.9- x 10.2- cm) was pasted on outside of plastic box and hanged in the tree. In every orchard, four traps were installed. Number of psyllids trapped per trap per week was recorded. Psyllids trapped on four traps were averaged and graph of mean number of psyllids per trap was drawn.

D. citri was collected directly from a mouth aspirator comprising a perforated vial and an aspirating tube allowing winged adults to be aspirated singly. Mouth aspirator method was operated at Yampaphant, Lohi and ARS, Malepatan where psyllids were observed visually. Monitoring by mouth aspirators was conducted from May 2001 to July 2001 at a weekly interval. Four trees were randomly selected for monitoring in every orchard. Within each tree, four twigs were selected from the four geographical quadrants. The number of insects caught in 5 min in each twig was noted. The collected psyllids in the mouth aspirator were later released in the same orchard. Graph of population dynamics of citrus psylla was plotted with mean values of psyllids collected at four trees. Meteorological data were collected from Yampaphant, ARS, Malepatan, ARS, Lumle and Bhakimli. The graphs of maximum, minimum and rainfall data have been shown in Figures 8 to 11.

RESULTS AND DISCUSSION

There were spatial and temporal variations in psyllid population in the monitored locations. Citrus psylla was found on yellow sticky trap at Yampaphant (450 masl), Lohi (650 masl), Bandipur (1,050 masl) and Bhakimli (1,300 masl) and by mouth aspirator at ARS, Malepatan (850 masl). The insect was found neither on yellow sticky trap nor by mouth aspirator at Hemja and ARS, Lumle.

The citrus psylla was found trapped on yellow sticky trap between Sept 1999 to July 2000 at Yampaphant (Figure 1). However, psyllid was not detected between Aug 2000 to April 2001. High number of peaks were recorded in this site indicating high population fluctuation. Middle of October 1999, end of February, middle of March and middle to end of April 2000 was the most favourable period when the highest population of psyllid was observed.

At Lohi, the psyllid was found on yellow sticky trap from the end of August 1999 to October 2000 (Figure 2). The psyllid was not trapped from November 2000 to April 2001. Population dynamics of the psyllid showed a high frequency of peaks in the site. The highest insect population was found by the end of August 1999, middle of April and first week of May 2000.

Likewise at Bandipur, the psyllid was found from the end of August 1999 to Dec 2000 except in the month of March, April and June 2000 (Figure 3). The population remained sustained from Sept 1999 to Feb 2000 followed by no insect activity in the months of March, April and May 2000. The psyllid population rose after June 2000 and remained constant until Dec 2000. The highest insect population was observed at the end of Aug 1999 and Sept

2000.

The psyllid activity was found low at Bhakimli as compared to above three sites (Figure 4). The psyllid was found sporadically in the month of Sept 1999 and no psyllid was found during winter season. The psyllid was observed only at the end of winter and in spring season, however quite low in number. A high psyllid population was observed during the rainy season and recorded the highest in the month of July 2000. Contrary to 1999, the insect was not detected during the autumn season of 2000 whereas there was a surge in the population in December 2000. The psyllid was also found in the spring season of 2001. High number of psyllid peaks were observed at lower altitude (<1000 masl) than at the higher altitude (>1000 masl). High number of peaks were indicative of higher number of flushes in the citrus trees at lower altitude than at higher altitude.

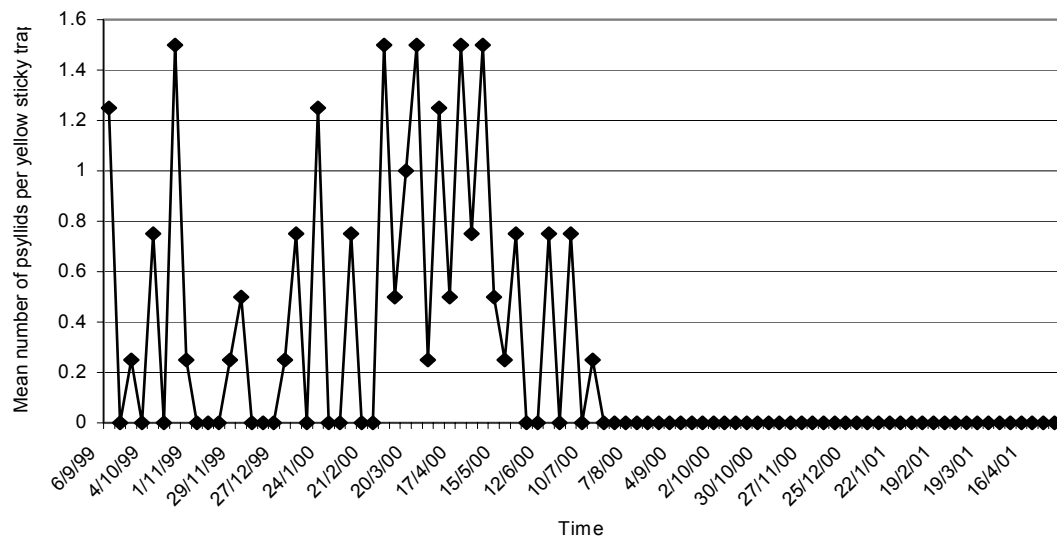


Figure 1. Population dynamics of citrus psylla trapped on yellow sticky trap at Yampaphant from Sept 1999 to April 2001.

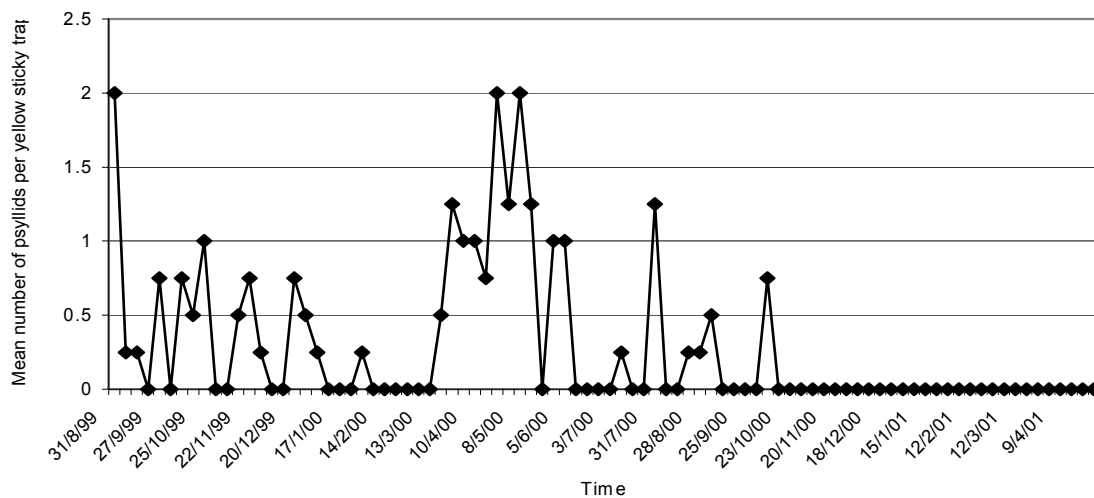


Figure 2. Population dynamics of citrus psylla trapped on yellow sticky trap at Lohi from August 1999 to April 2001.

The psyllid was not detected on the yellow sticky trap at ARS, Malepatan and Hemja during the initial period of recordings. Also, the insect was not observed at Lohi and Yampaphant from October 2000 to April 2001

and August 2000 to April 2001 respectively. The citrus psylla had been reported from ARS, Malepatan earlier (Lama et al 1986). No psyllid was observed on yellow sticky trap at ARS, Malepatan aroused suspicion about the efficacy of the bright yellow coloured trap. Therefore, effectiveness of fluorescent and lemon yellow traps was also tested in Lohi and Hemja in April 2000. In the new colour traps also no insect was trapped. The presence of the insect was searched through visual observation. Contrary to yellow sticky trap data, visual observation found the presence of psyllids in the orchards of Yampaphant, Lohi and ARS, Malepatan. Similar observation as yellow sticky trap was not so effective was described earlier (Gavarra and Mercado 1988, Aubert and Quilici 1986). Therefore, alternative method of mouth aspirator was applied for the study of population dynamics of the psylla at Yampaphant, Lohi and ARS, Malepatan from May 2001 to July 2001.

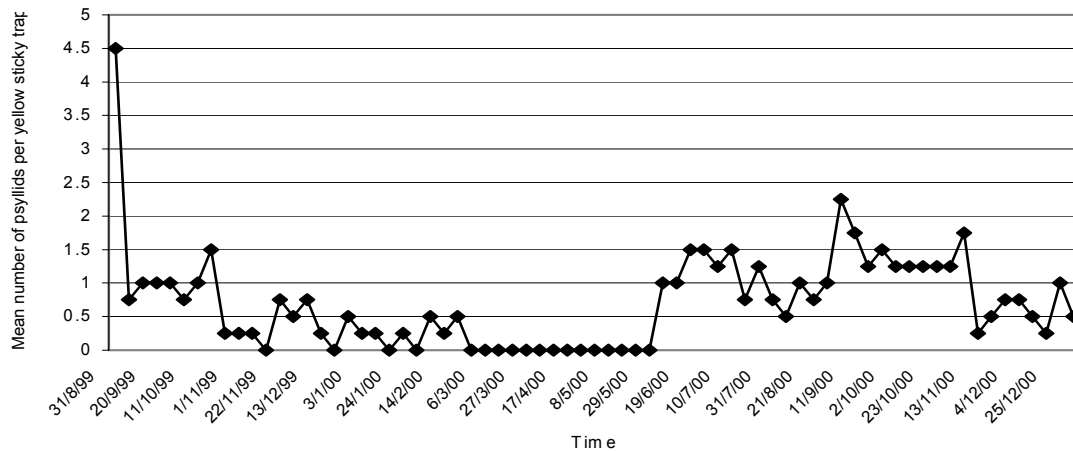


Figure 3. Population dynamics of citrus psylla trapped on yellow sticky trap at Bandipur from Aug 1999 to Dec. 2000

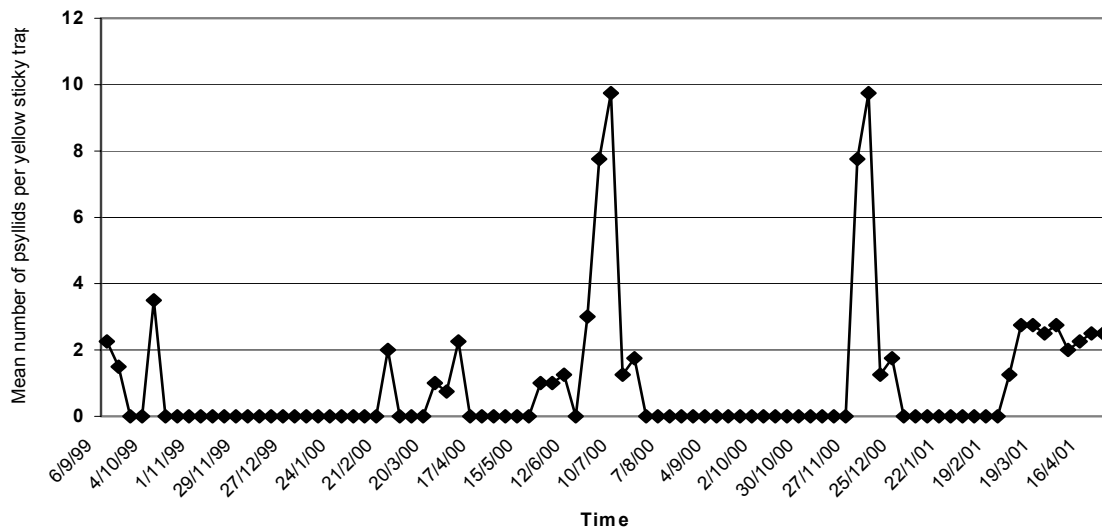


Figure 4. Population dynamics of citrus psylla trapped on yellow sticky trap at Bhakimli from Sept 1999 to April 2001.

Mouth aspirator data of Yampaphant site showed that psyllids were present in May and June 2001 while in July 2001 there was no insect (Figure 5). The highest population of the insect was found in the third week of May, which then declined. The psyllid rose slightly in the third week of June and no psyllid was found after fourth week of June.

The graph of mouth aspirator detection data showed a rise in psyllid population at Lohi (Figure 6). A high activity of psyllid was found in May and June 2001. The psyllid was not observed after the first week of July 2001. A high population of the insect was found on yellow sticky trap in May 2000 and also in May 2001 by mouth aspirator

confirmed that the psyllid population reached the highest during this month.

At ARS, Malepatan, the highest population was recorded in the first week of May 2001 (Figure 7). The population then declined until the second week of June from where the population remained sustained till the second week of July 2001. The psyllid was not found in the third week of July 2001.

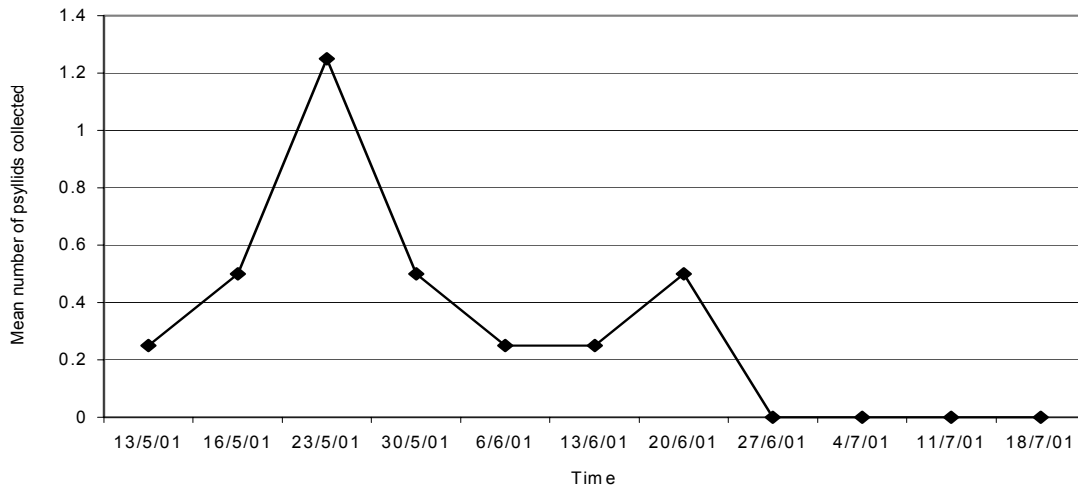


Figure 5. Population dynamics of citrus psylla collected with a mouth aspirator at Yampaphant from May to July 2001.

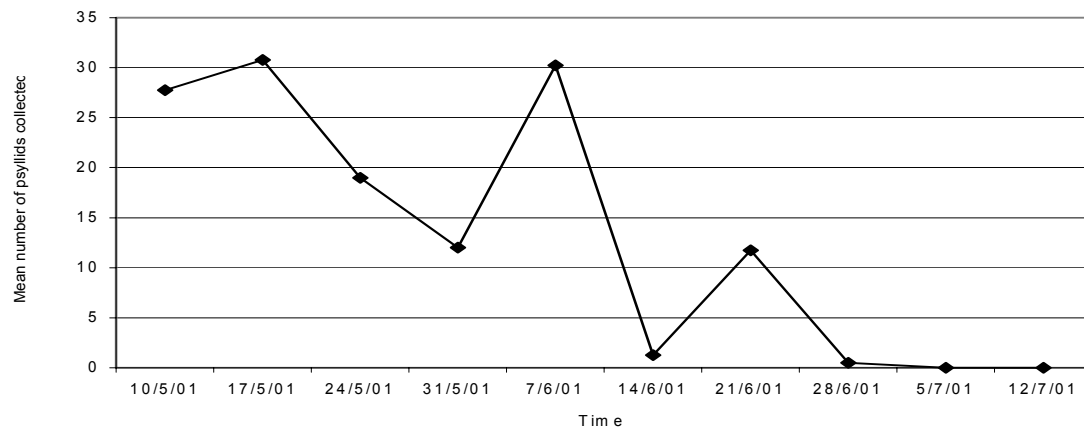


Figure 6. Population dynamics of citrus psylla collected with a mouth aspirator at Lohi from May to July 2001.

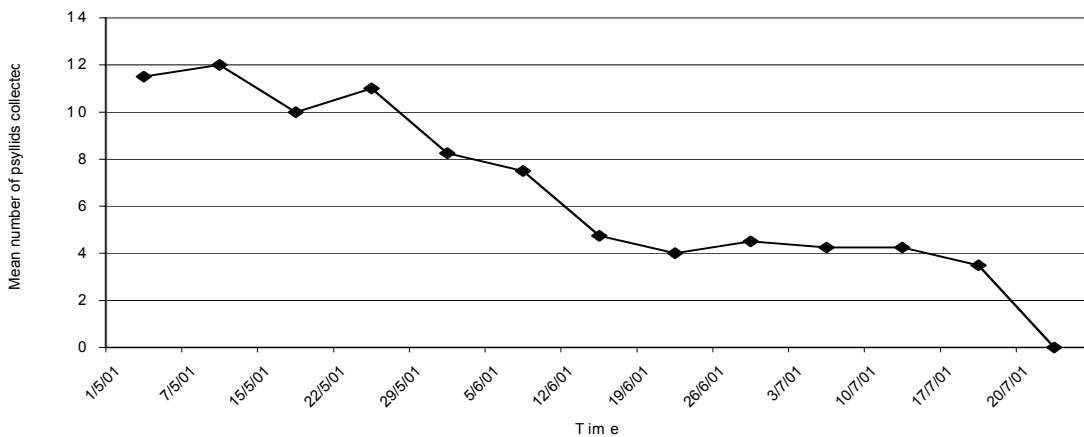


Figure 7. Population dynamics of citrus psylla collected with a mouth aspirator at ARS, Malepatan from May to July 2001.

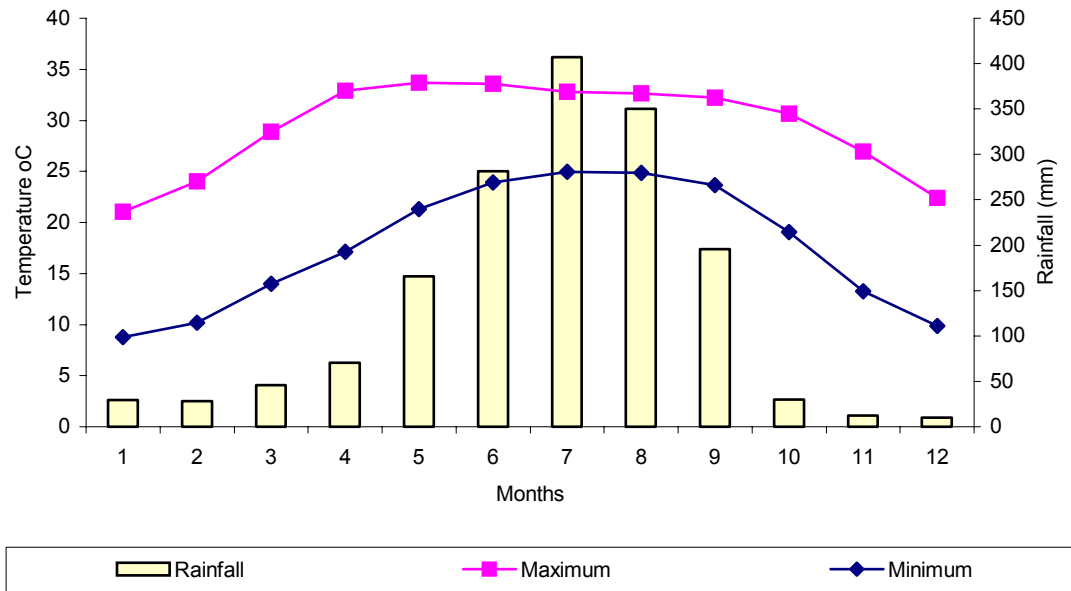


Figure 8. Meteorological data of Yampaphant.

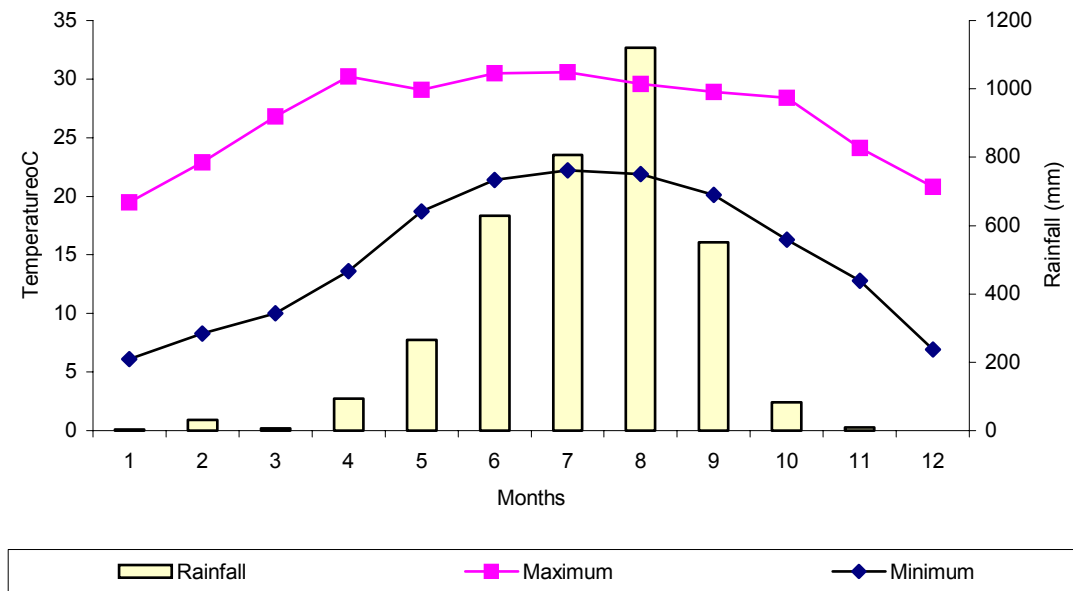


Figure 9. Meteorological data of ARS, Malepatan.

Correlating the insect population with meteorological data at different locations, the psyllid was detected in yellow sticky trap at low temperature during the winter season at Yampaphant, Lohi, Bandipur and Bhakimli. The insect is reported to be stедious and has been found surviving under a wide range of temperature extremes from 45°C to –7 to –8°C (Piehua et al 1988, Aubert 1988). The survival of psylla in cold winter of above locations indicates its wide adaptability.

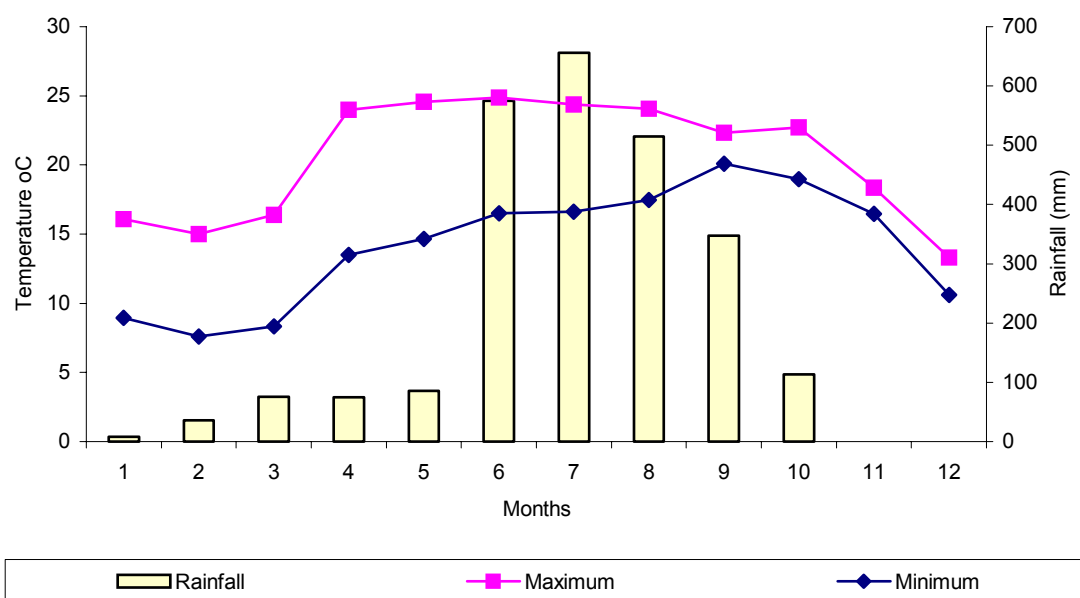


Figure 10. Meteorological data of Bhakimli.

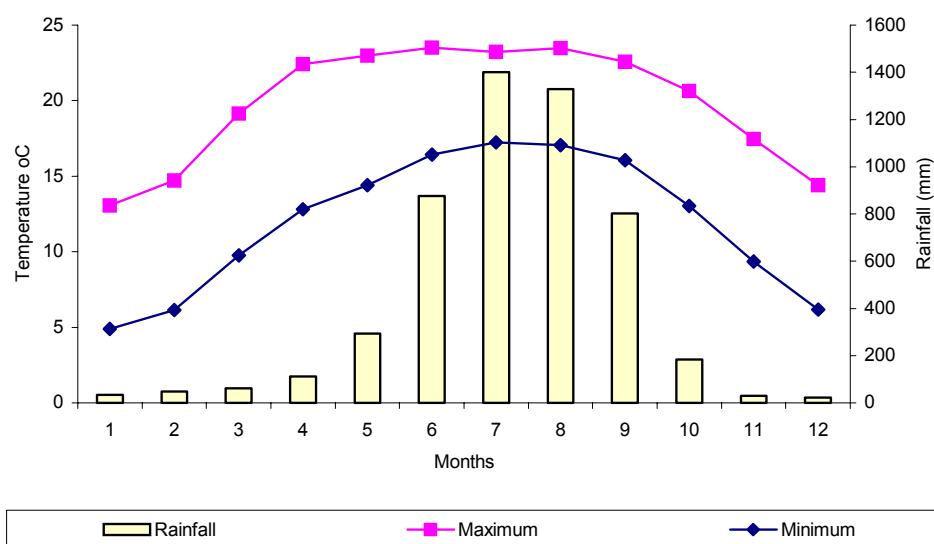


Figure 11. Meteorological data of ARS, Lumle.

D. citri thrives well under hot and dry conditions, but high rainfall and humidity adversely affect the psyllid (Quilici 1986, Aubert 1986). Population dynamics of Yampaphant, Lohi, Bandipur and ARS, Malepatan showed that highest population reached in dry, hot and less rainfall period. In low altitude area of Yampaphant, Lohi and ARS, Malepatan, highest population peaks were found during spring season supported the findings reported earlier (Aubert 1986). But, in high altitude area of Bandipur and Bhakimli, the highest population peaks were found during the high monthly temperature period of July and August. The highest population found in December 2000 at Bhakimli was an exceptional. Unlike Bhakimli, most of the monitored locations had higher insect population either before monsoon rainfall (Yampaphant, Lohi and Malepatan) or after monsoon (Bandipur). Rainfall seemed to have adverse effect on the *D. citri* population.

No psyllid population was observed at ARS, Lumle and Hemja. Characteristic high rainfall at ARS, Lumle might

be the cause for the unavailability of the psyllid in the area. Low mean monthly temperature of the location might be another cause for unsuitable condition for the psyllid multiplication. There has been a high rate of citrus decline in Hemja, but the monitoring could not detect psyllid in the location. Therefore, the cause for citrus decline in Hemja should be further investigated.

CONCLUSION

Citrus psylla was found in the citrus orchards of Yampaphant, Lohi, Bandipur, ARS, Malepatan and Bhakimli. These sites were located at different altitudes ranging from 475 masl to 1,300 masl. Presence of psyllid at an altitude of 1,300 masl points the adaptability of the insect also at higher altitude. So, precautions should be taken not to contaminate the citrus orchard with greening disease due to psyllid present at high altitude areas (>1,000 masl). Quarantine is important in preventing the disease introduction in disease free and new areas. The peak period of insect population varied due to different altitudinal ranges. At low altitude (<1,000 masl) a high number of insects were found in spring before rainy season while at high altitude (>1,000 masl) the highest number of insect was found after high rainfall period. The temperature was found a key factor for the survival of insect in the high altitude area when a higher temperature was found during the rainy season months.

It has been reported that *D. citri* is the main agent for spreading the greening disease in the country. The greening disease had been reported from Kaski, Parbat, Syangja, Gorkha and Kavre districts of the country (Regmi et. al. 2000). In the view of citrus greening disease spreading in the country, recommendation was made to establish nursery above 1,000 masl. The presence of *D. citri* in Kathmandu (1,250 masl) and recent finding that *D. citri* is present in Bandipur (1,050 masl) and Bhakimli (1,300 masl) puts doubt on the earlier recommendation made on the nursery establishment above 1,000 masl. On this new context recommendation should be made to establish the nursery only in those areas above 1,000 masl where *D. citri* and other devastating diseases have not been detected. Therefore, it is imperative to monitor the psyllid before establishment of citrus nursery.

Earlier report of psyllid presence only below 1,000 masl might be due to survey carried out only during the spring season. At high altitude above 1,000 masl, this monitoring result demonstrated that psyllid were active during the rainy season when temperature was high. So, monitoring of psyllid at high altitude (>1,000 masl) should also be done during the high temperature period of rainy season.

ACKNOWLEDGEMENT

Funding provided by the HARP for implementation of HARP PP 103/98 is highly acknowledged. We are sincerely thankful to Dr. R.P. Sah, Station Chief, for providing necessary facility for conducting the research. We are also thankful to Messrs P. Sharma, D. Pokharel and S.R.Devkota for their active participation during the research. Thanks also goes to AER and OR site coordinators for their valuable works. Mr. R. R. Adhikari and administration staffs are also highly appreciated for their work in producing this paper.

REFERENCES

- APP. 1995. *Agriculture perspective plan*. National Planning Commission, His Majesty Government of Nepal and Asian Development Bank.
- ASD. 2000. *Statistical information on Nepalese agriculture, 1999-2000*. Agriculture Statistic Division Ministry of Agriculture, Kathmandu, Nepal.
- Aubert B. 1986. Towards an integrated management of the citrus greening disease. **In: Proc. 10th iocv conference** in Valencia, Spain.
- Aubert B. 1988. Management of the citrus greening disease in Asian orchards. **In: Proc. 2nd FAO-UNDP Regional Workshop** Lipa Philippines Asian/Pacific Citrus Greening. p. 51-52.

- Aubert B and S Quilici. 1986. Monitoring adult psylla on yellow traps in Reunion Island. **In:** *Proc. 10th Iocv Conference* In Valencia, Spain.
- Bove JM and M Garner. 1984. Citrus greening and psylla vectors of the disease in the Arabian Peninsula. **In:** *Proc. 9th Conf. Iocv*, Riverside. Pp.109-114.
- Catling HD. 1970. Report on a visit to Nepal. *FAO report pl: t/672* Mimeograph.
- Gavarra MR And BG Mercado. 1988. Progress report on studies dealing with the psyllid vector (*diaphorina citri* kuwayama) of greening disease in the Philippines. **In:** *Proc. 2nd FAO-UNDP Regional Workshop* Lipa Philippines Asian/Pacific Citrus Greening. P. 23-29.
- Knorr LC and M Shah. 1971. World citrus problems – V. Nepal. *FAO Plant Prot. Bull.* 19:73-79.
- Lama TK, C Regmi and B Aubert. 1986. Distribution of the citrus greening disease vector (*Diaphorina citri* Kum) in Nepal and attempt of establishing Biological Control Against it. **In:** *Proc. 10th IOCV Conference* in Valencia, Spain.
- Ninth Five Year Plan. 1998-99. *National Planning Commission*, Kathmandu.
- Piehua X, S Chaoan and L Zigu. 1988. A Study on the cold endurance of the Asian citrus Psyllid in Zhejiang. **In:** *Proc. 2nd FAO-UNDP Regional Workshop* Lipa Philippines Asian/Pacific Citrus Greening. Pp.18-22.
- Quilici S. 1988. Biological control of citrus Psyllid in reunion island. **In:** *Proc. 2nd FAO-UNDP Regional Workshop* Lipa Philippines Asian/Pacific Citrus Greening. Pp.39-42.
- Randhawa GS and K Ramakrishna. 1972. *Report of the study team on citrus decline in Nepal*.
- Regmi C and TK Lama. 1986. Greening incidence and greening vector population dynamics in Pokhara. **In:** *Proc. 10th IOCV Conference in Valencia*, Spain.
- Regmi C, S Shrestha and VP Yadav. 2000. Distribution of virus and virus like diseases of citrus in Nepal. *International Conference on Biotechnology and Biodiversity*, Kathmandu, Nepal.
- Roistacher CN. 1991. Graft-transmissible diseases of citrus. *Handbook for detection and diagnosis*. Publication Division Food and Agriculture Organization of the United Nations. Viale delle Terme di Caracalla, 00100, Rome, Italy.
- Roistacher CN. 1996. Assessment of the greening problem, the severity and prevalence of virus and virus-like diseases and development of an appropriate set of procedures for a citrus certification program for Nepal. *A consultancy report, ATSP*, Kathmandu, Nepal.
- Shah RB. 1992. Citrus fruit. *Trainer's manual No. 16*. Department of Agriculture. 18p.
- Shrestha YH. 1999. Key Achievement in citrus section. **In:** *Annual report –1998-99*. Horticulture Development Project, Kirtipur, Nepal.
- Thrower LB. 1968. Report on visit to Nepal. *FAO report Pl.T/51* Mimeograph.
- Verma RN and YP Sharma. 1993. *Citrus diseases—a primer*. Associated Publishing Company, New Delhi, India.
- Yuhua X and X Changfan. 1998. First results of monitoring (*diaphorina citri*, homoptera: chermidae) the vector of huanglungbin with yellow traps. **In:** *Proc. 2nd FAO-UNDP Regional Workshop* Lipa Philippines Asian/pacific Citrus Greening. Pp.32-34.

Agro-morphological Characterization of Common Bean (*Phaseolus vulgaris* L.) at Jumla

Ram K Neupane¹, Renuka Shrestha², Mahesh L Vaidya³ and Ek M Bhattarai⁴

¹ National Grain Legume Research Program, Rampur, Chitwan

² Agronomy Division, Khumaltar, Lalitpur

³ Agricultural Research Station Jumla

⁴ National Rice Research Program, Hardinath, Dhanusha

ABSTRACT

Common bean (*Phaseolus vulgaris* L.) is an important grain legume grown in the hills of mid-western Nepal and other areas with similar agro-climatic conditions. In Jumla and adjoining areas, farmers usually grow beans during summer season in bari-land as a rain fed crop. The predominant cropping patterns are bean-wheat, bean-barley, bean + maize - wheat and bean-other vegetables. A total of 114 accessions of local and exotic bean germplasm collected from various locations were studied for agro-morphological characteristics at Agriculture Research Station Jumla (2300 masl) for two consecutive years 2000-2001. The accessions were grown un-replicated in 2-meter row plots. Data on 13 qualitative and 12 quantitative traits were recorded to assess the variability. A wide range of variation was recorded in seed coat color, seed size, seed shape, plant type, plant height, leaf size and shape, pod color, pod shape, nodulation, root length, root weight, days to flower and maturity, number of pods per plant, number of seeds per pod, 100-seed weight and seed yield. Among 16 selected germplasms evaluated in farmer participatory varietal trials, farmers have preferred PB0001, PB0002 and PB0048 on the basis of suitability to growing both as a sole and/or inter/mixed crop with maize, medium growth habit, attractive seed color and seed size, tolerance to diseases, earliness in maturity, high seed yield, higher dal-recovery percentage and better cooking quality. As the germplasm constitute valuable generic resources of the country, samples of it are stored at gene bank of Plant Genetic Resources Unit (PGRU), Agricultural Botany Division, Khumaltar. These can be utilized for future research work, whereas the farmer-preferred genotypes PB0001, PB0002 and PB0048, which are already in farmer's fields, could be profitably used for mass dissemination in the target area.

Key words: Agro-morphology, diversity, germplasm, *Phaseolus* beans

INTRODUCTION

Phaseolus bean (*Phaseolus vulgaris* L.) also called common bean is an important grain legume grown through the mid hills for green pods and dry seeds. It is an important cash crop in the hills of mid- western region and other areas with similar agro-climatic condition. In Jumla and adjoining areas, farmers usually grow beans during summer season in upland area (bari) land as a rain fed crop. The predominant cropping patterns involving beans are bean-wheat, bean-barley, bean-other vegetables, maize + bean - wheat or barley. It is also grown as an intercrop in the interspaces of apple orchards.

Common bean is used in various ways as split and whole dal, as a dry bean, as green pod vegetable, as bean flour and as a medicinal crop. It is used as a folk medicine for diarrhea, dropsy, dysentery, diabetics and kidney problems (Duke 1991). In Jumla area, it has got religious importance. Besides, it is used as a fodder and green manure and bean flour is used for making *roti* and *dhindo* (Neupane and Vaidya 2002). Farmers regard beans as a cash-generating crop and grow a number of landraces with varying morphology (Neupane and Vaidya 2002). The diversity of beans in the command districts of Agriculture Research Station Jumla is well known. There is no recognized variety of beans for dal purpose. Available local landraces consist of a mixture of beans having different seed coat color, shapes, and sizes, plant morphology and yield potential. There is a huge export potential from this area, as beans produced in the hills have better test and fetch higher market price than those

from the Tarai area. However, genetic deterioration of beans has been reported in recent years due to the intervention of improved agricultural practices. The conservation of local germplasm and their utilization is important for the sustainable development of the agriculture in the area. Therefore, this research was initiated with the objectives of collection, evaluation and characterization of available local and exotic beans so that the local landraces could be conserved and at the same time suitable lines/varieties could be identified and recommended to the farmers.

MATERIALS AND METHODS

Bean germplasm were collected during June 2000 from various sources eg farmer's household, market place, government offices and farmers' field. Few accessions were received from India. After collection/acquisition the germplasm were given a four digit numbers starting from PB0001. This represents the unique name of the particular accession. 100 samples were acquired in the first year and 14 were subsequently added in the second year making the collection 114. These collections represent the samples from Jumla and its adjoining districts, Surkhet, Chitwan and other countries. Most of the bean samples from the local collection were a mixture of several land races. These were separated and assigned a different accession number based on the color and shape of the seeds. The local name of the samples were noted wherever applicable based on the local knowledge, shape, size and color of the seeds.

Phaseolus bean germplasms were field-evaluated at ARS Jumla for agro- morphological characteristics. ARS Jumla is situated at 20° 17' N, 82° 1' E and at an elevation of 2300 masl. Jumla represents high mountain region of the country and is characterized by cool temperate to alpine climate with low rainfall. Monsoon rains are received late. Winter is initiated earlier and crop growth period for summer crops is very short. Average annual rainfall of the area is 866 mm, of which 65% is received during June to September. The occurrence of frost is common after October. Usually snowfall occurs during December-March. The mean monthly rainfall and maximum and minimum temperature for the station is presented in Figure 1.

Soil pH of experimental site ranged from 6.1 to 6.5. Soil reaction was slightly acidic. It is suitable for Phaseolus bean cultivation. Organic matter content ranged from 2.71 to 3.98%. Total nitrogen content was medium. Available phosphorus was medium and ranged from 75.68 to 72.1 kg/ha. Available potassium was high and ranged between 236.5 and 290.3 kg/ha. The soil of experimental site was sandy loam.

Bean germplasms were planted at a spacing of 50- × 20-cm in 2 row plots of size 2- × 0.5-m in an augmented design. Local check was repeated after every 10 test entries. A basal dose of 20 kg N/ha was applied at planting. Remaining 20 kg N/ha was top-dressed before flowering. Agro-morphological data, disease and insect pest and nodulation scoring was done as per the procedures given in IBPGR descriptors and UPOV guidelines for legumes (IBPGR 1982, UPOV 1994). Data on plant growth and yield components were taken from 10 randomly selected plants from each plot. Yield data was recorded from the net plot area and subjected to statistical analysis.

RESULTS AND DISCUSSION

Local name

Rajma, Rajmash, Simi, Kharani, Khairo, Mriggaula, Phokserang, Setosimi, Bhotesimi, Bokasimi, Ratodolpaya, Piyalasimi, Motosimi, Gheusimi, Kalosimi, Malesimi, Akashesimi, Hariyosimi, Lekalisimi are some of the names by which beans are known to the area. Most of the local landraces were a mixture of different types of beans, varying in seed size, shape, and colour and were indeterminate in growth. Bean is planted in May/June at Jumla and surrounding areas and harvested during October to November. It was reported that late-planted crops are adversely affected by cold wave in November. Hence, early maturing variety was of considerable importance to this area. The importance of early maturity of beans in the hills of Nepal is well recognized (Shrestha and Poudel 2000). Mixed cropping bean with maize was a common practice. Farmers sow maize in March and relay-sow beans in May or early June at the time of weeding maize crop.

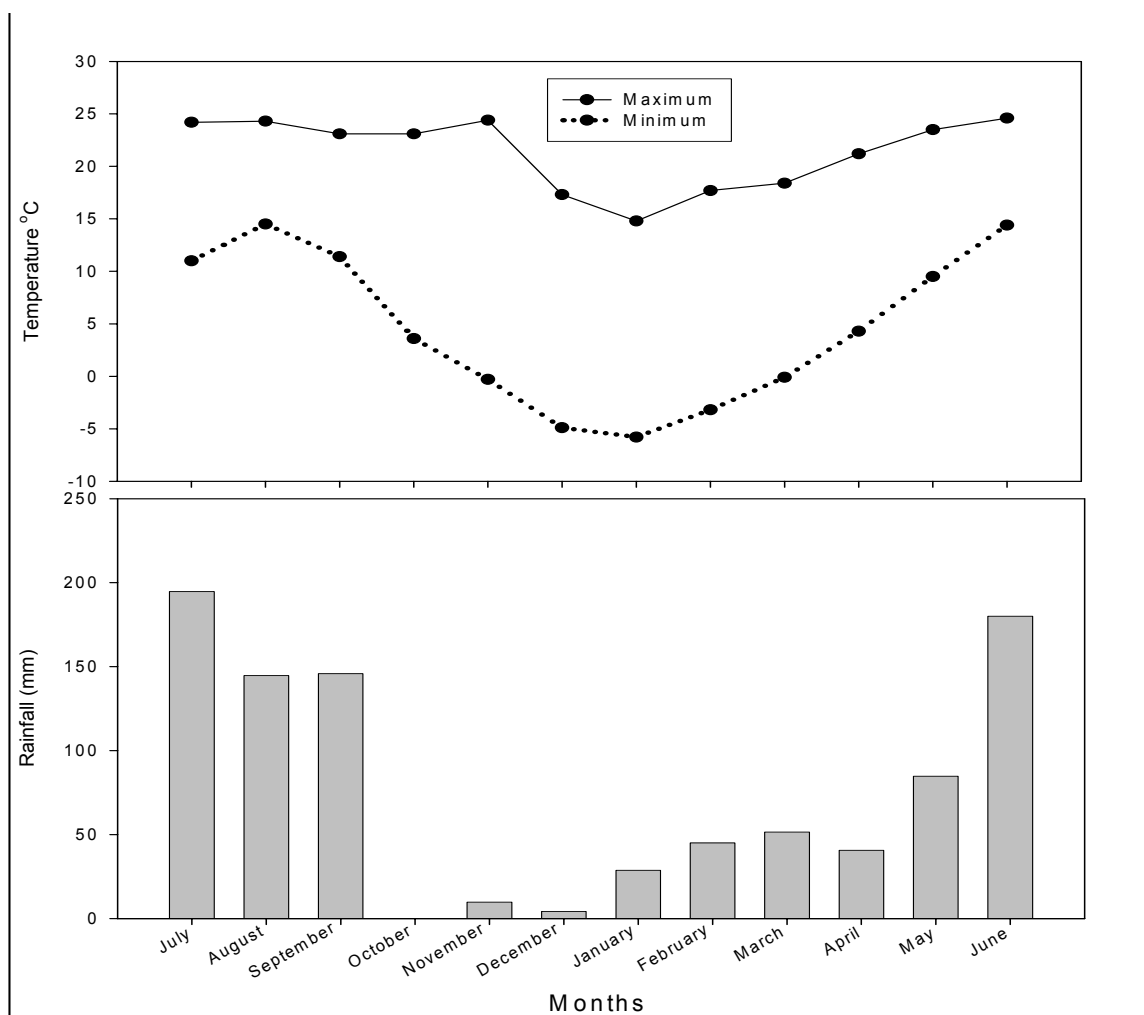


Figure 1. Mean monthly temperature and rainfall at ARS, Jumla (2000/01)

Seed color

The color of the seed are pink, purple, ash, cream, yellow, maroon, black, violet, shining purple, red and different shades of the main color.

Seed shape

Seed shape was predominantly elliptical. Others were ovoid, round, kidney shaped, flat or square and cuboids. Color of hilum varied among accessions.

Plant growth type

Based on the morphology of plants germplasm accessions were classified into dwarf and climbing types. Seven genotypes PB0001, PB0003, PB0004, PB0029, PB0039, PB0040 and PB0067 were dwarf and the rest were climbing. Most of the dwarf accessions were non-vining and bushy.

Climbing type plant only (start of climbing: 80% of plants)

Among climbing types nine genotypes PB0046, PB0047, PB0049, PB0055, PB0073, PB0085, PB0086, PB0092 and PB0093 were early climbers, suggesting that they need staking or support at early plant growth stages. Seven genotypes PB0022, PB0024, PB0027, PB0028, PB0053, PB0066 and PB0091 were late climbers, which need staking at later growth stages and the rest were medium. These genotypes would be ideal for intercropping with maize.

Climbing type plant (speed of climbing)

The speed of climbing was slow for 19, rapid for 1 and medium for the rest of accessions.

Hypocotyl pigmentation

Hypocotyl pigmentation are purple, green and others colors. 28 accessions had purple hypocotyls, 6 had other colors and the rest had green pigments.

Accessions with purple hypocotyle: PB0008, PB0011, PB0022, PB0028, PB0033, PB0034, PB0037, PB0045, PB0047, PB0067, PB0069, PB0070, PB0071, PB0073, PB0075, PB0076, PB0078, PB0079, PB0080, PB0082, PB0084, PB0085, PB0088, PB0097, PB0098, PB0099 and PB0100.

Accessions with green hypocotyle: PB0001, PB0002, PB0003, PB0004, PB0005, PB0006, PB0007, PB0009, PB0012, PB0013, PB0014, PB0015, PB0016, PB0019, PB0024, PB0025, PB0027, PB0029, PB0031, PB0032, PB0035, PB0036, PB0038, PB0040, PB0041, PB0042, PB0043, PB0044, PB0046, PB0048, PB0049, PB0050, PB0051, PB0052, PB0055, PB0056, PB0057, PB0058, PB0059, PB0060, PB0061, PB0062, PB0063, PB0064, PB0065, PB0066, PB0068, PB0072, PB0074, PB0077, PB0081, PB0083, PB0086, PB0087, PB0089, PB0090, PB0091, PB0092, PB0093, PB0094 and PB0095.

Emerging cotyledon color

Two accessions (PB0002 and PB0008) had purple cotyledon, 15 accessions had very pale green, 54 had green and the rest had red cotyledon.

Purple cotyledon: PB0002 and PB0008.

Green cotyledon: PB0001, PB0003, PB0004, PB0006, PB0007, PB0009, PB0011, PB0013, PB0014, PB0015, PB0016, PB0019, PB0023, PB0024, PB0025, PB0027, PB0029, PB0031, PB0032, PB0035, PB0036, PB0038, PB0040, PB0041, PB0042, PB0043, PB0044, PB0046, PB0048, PB0049, PB0050, PB0051, PB0052, PB0053, PB0055, PB0056, PB0057, PB0061, PB0063, PB0064, PB0065, PB0066, PB0067, PB0068, PB0074, PB0077, PB0083, PB0081, PB0089, PB0090, PB0091, PB0092, PB0094 and PB0095.

Pale green cotyledon: PB0030, PB0039, PB0054, PB0058, PB0059, PB0072, PB0073, PB0079, PB0080, PB0084, PB0085, PB0086, PB0087, PB0093, PB0097.

Red cotyledon: PB0022, PB0026, PB0033, PB0037, PB0045, PB0047, PB0060, PB0062, PB0069, PB0070, PB0071, PB0075, PB0076, PB0078, PB0082, PB0088, PB0099, PB0100.

Leaf color of chlorophyll

16 genotypes showed pale green leaf chlorophyll, 23 mediums green and the rest had dark green.

Pale green leaf chlorophyll: PB0001, PB0003, PB0004, PB0011, PB0012, PB0013, PB0014, PB0015, PB0016, PB0019, PB0049, PB0050, PB0065, PB0092, PB0094, PB0095.

Medium green: PB0002, PB0006, PB0007, PB0008, PB0027, PB0036, PB0039, PB0040, PB0041, PB0045, PB0046, PB0053, PB0068, PB0063, PB0066, PB0074, PB0077, PB0079, PB0087, PB0089, PB0091, Check, PB0055.

Dark green: PB0009, PB0022, PB0023, PB0024, PB0025, PB0026, PB0028, PB0029, PB0030, PB0031, PB0032, PB0033, PB0034, PB0035, PB0037, PB0038, PB0042, PB0043, PB0044, PB0047, PB0048, PB0051, PB0052, PB0054, PB0055, PB0056, PB0057, PB0058, PB0059, PB0060, PB0061, PB0062, PB0064, PB0067, PB0069, PB0070, PB0071, PB0072, PB0073, PB0075, PB0076, PB0078, PB0080, PB0081, PB0082, PB0083, PB0084, PB0085, PB0086, PB0088, PB0090, PB0093, PB0097, PB0098, PB0099 and PB0100.

Leaf shape of terminal leaflet of third trifoliate leaf

Leaf shape of terminal leaflet of the third trifoliate leaf was triangular for 36 accessions and quadrangular for the rest.

Triangular: PB0002, PB0003, PB0006, PB0025, PB0026, PB0030, PB0031, PB0043, PB0044, PB0045, PB0046, PB0047, PB0048, PB0049, PB0051, PB0053, PB0055, PB0057, PB0059, PB0060, PB0063, PB0065,

PB0066, PB0070, PB0071, PB0084, PB0085, PB0086, PB0089, PB0090, PB0093, PB0094, PB0095, PB0098, PB0099 and PB0100.

Quadrangular: PB0001, PB0004, PB0007, PB0008, PB0009, PB0010, PB0011, PB0012, PB0013, PB0014, PB0015, PB0016, PB0017, PB0018, PB0019, PB0020, PB0021, PB0022, PB0023, PB0024, PB0027, PB0028, PB0029, PB0032, PB0033, PB0034, PB0035, PB0036, PB0037, PB0038, PB0039, PB0040, PB0041, PB0042, PB0050, PB0052, PB0054, PB0056, PB0058, PB0061, PB0062, PB0064, PB0067, PB0068, PB0069, PB0072, PB0073, PB0074, PB0075, PB0076, PB0077, PB0078, PB0079, PB0080, PB0081, PB0082, PB0083, PB0087, PB0088, PB0091, PB0092, PB0097 and Check.

Color of standard

The colour of the standard was recorded as mentioned below:

White color: PB0024, PB0025, PB0029, PB0035, PB0050, PB0051, PB0068, PB0083 and PB0091.

Green color: PB0002 and PB0003.

Lilac color: PB0004, PB0006, PB0007, PB0009, PB0011, PB0012, PB0013, PB0014, PB0015, PB0016, PB0019, PB0034, PB0037, PB0038, PB0042, PB0043, PB0044, PB0046, PB0048, PB0055, PB0064, PB0065, PB0069, PB0071, PB0072, PB0078, PB0079, PB0080, PB0081, PB0084, PB0088, PB0092, PB0098, PB0099 and PB0100.

White with lilac edge: PB0001, PB0022, PB0040, PB0041, PB0053, PB0056, PB0066, PB0074, PB0094 and PB0095.

White with red stripes: PB0039.

Dark lilac with purple outer edge: PB0006, PB0026, PB0028, PB0030, PB0036, PB0045, PB0047, PB0052, PB0058, PB0059, PB0060, PB0061, PB0062, PB0063, PB0070, PB0073, PB0075, PB0076, PB0077, PB0082, PB0086, PB0087, PB0085, PB0089, PB0090, PB0093 and PB0097.

Carmine red: PB0049.

Pod beak orientation

Upward (curving to dorsal side): PB0012, PB0014, PB0023, PB0031, PB0033 and PB0066.

Straight: PB0001, PB0002, PB0003, PB0006, PB0009, PB0011, PB0013, PB0015, PB0016, PB0024, PB0025, PB0026, PB0027, PB0028, PB0029, PB0030, PB0032, PB0034, PB0037, PB0038, PB0039, PB0041, PB0042, PB0045, PB0046, PB0047, PB0048, PB0049, PB0050, PB0051, PB0052, PB0053, PB0054, PB0055, PB0056, PB0057, PB0058, PB0059, PB0060, PB0061, PB0062, PB0063, PB0064, PB0065, PB0068, PB0069, PB0070, PB0071 and PB0072.

Downward (curving to ventral side): PB0002, PB0004, PB0007, PB0008, PB0022, PB0036, PB0040, PB0043 and PB0044.

Pod beak position

Marginal: PB0002, PB0003, PB0004, PB0006, PB0007, PB0008, PB0009, PB0010, PB0011, PB0012, PB0013, PB0014, PB0015, PB0016, PB0017, PB0018, PB0019, PB0020, PB0021, PB0024, PB0035, PB0036, PB0048, PB0049, PB0051, PB0052, PB0075, PB0080, PB0085, PB0087, PB0089, PB0090, PB0091, PB0092, PB0093, PB0094, PB0096, PB0097, PB0098, PB0099 and PB0100.

Non-marginal: PB0001, PB0004, PB0022, PB0023, PB0025, PB0026, PB0027, PB0028, PB0029, PB0030, PB0031, PB0032, PB0033, PB0034, PB0037, PB0038, PB0039, PB0040, PB0041, PB0042, PB0043, PB0044, PB0045, PB0046, PB0047, PB0050, PB0053, PB0054, PB0055, PB0056, PB0057, PB0058, PB0059, PB0060, PB0061, PB0062, PB0063, PB0064, PB0065, PB0066, PB0068, PB0069, PB0070, PB0071, PB0072, PB0073, PB0074, PB0076, PB0077, PB0078, PB0079, PB0081, PB0082, PB0083, PB0084, PB0086, PB0088, PB0095 and Check.

Dry pod color

Dark purple: PB0002, PB0026, PB0054, PB0058, PB0059, PB0062, PB0071, PB0077, PB0085,

Carmine red: PB0022, PB0025, PB0041, PB0043, PB0050, PB0094,

Purple stripe on green: PB0006, PB0030, PB0038, PB0045, PB0055, PB0060, PB0065 and check.

Pale red stripe on green: PB0027, PB0046, PB0072 and PB0080.

Dark pink (rose): PB0024.

Dull green to silver grey: PB0040, PB0049 and PB0087.

Golden or deep yellow: PB0001, PB0004, PB0039 and PB0086.

Pale yellow to white: PB0003, PB0007, PB0023, PB0028, PB0029, PB0031, PB0033, PB0034, PB0035, PB0044, PB0048, PB0051, PB0053, PB0056, PB0066, PB0068, PB0069, PB0070, PB0073, PB0074, PB0075, PB0076, PB0078, PB0079, PB0081, PB0082, PB0084, PB0088, PB0092, PB0095, PB0097, PB0098, PB0099 and PB0100.

Purple stripe on yellow: PB0032, PB0037, PB0042, PB0061, PB0063, PB0083, PB0090 and PB0093.

Purple stripe on white: PB0008, PB0036, PB0052, PB0064, PB0089, PB0091.

Pod color of fully expanded immature pod

Dark purple: PB0002, PB0022, PB0026, PB0030, PB0032, PB0033, PB0036, PB0044, PB0045, PB0047, PB0051, PB0053, PB0054, PB0055, PB0058, PB0059, PB0060, PB0062, PB0075, PB0077, PB0085, PB0092, PB0093, PB0099, and PB0100.

Carmine red: PB0029, PB0041, PB0080 and PB0086.

Purple stripe on green: PB0046

Carmine stripe on green: PB0001, PB0003, PB0004, PB0008, PB0023, PB0027, PB0031, PB0034, PB0035, PB0037, PB0040, PB0048, PB0052, PB0056, PB0061, PB0063, PB0098, PB0064, PB0068, PB0074, PB0076, PB0078, PB0079, PB0081, PB0082, PB0084, PB0087, PB0088, PB0095 and PB0097.

Pale red stripe on green: PB0006, PB0024, PB0025, PB0028, PB0038, PB0039, PB0042, PB0043, PB0049, PB0050, PB0065, PB0069, PB0070, PB0071, PB0072, PB0073, PB0083, PB0089, PB0090 and PB0094.

Pod color at physiological maturity

Dark purple: PB0002, PB0069, PB0072, PB0075, PB0079, PB0080, PB0088, PB0089, PB0090, PB0092, PB0094, PB0098 and PB0099.

Red: PB0001.

Pink: PB0022, PB0028, PB0030, PB0032, PB0033, PB0037, PB0038, PB0042, PB0044, PB0045, PB0047, PB0052, PB0063, PB0064, PB0070, PB0071, PB0073, PB0076, PB0078, PB0081, PB0082, PB0084, PB0083 and PB0086.

Yellow: PB0003 and PB0004.

Pale yellow with colored mottling or stripes: PB0006, PB0041, PB0046, PB0087, PB0091, PB0093, PB0097, and PB0100.

Persistent green: PB0023, PB0024, PB0025, PB0029, PB0031, PB0034, PB0035, PB0036, PB0039, PB0040, PB0043, PB0048, PB0049, PB0050, PB0051, PB0053, PB0054, PB0056, PB0057, PB0058, PB0059, PB0060, PB0061, PB0062, PB0068, PB0074, PB0077, PB0085 and PB0095.

Pod curvature of fully expanded immature pod

Straight: PB0001, PB0003, PB0004, PB0006, PB0011, PB0012, PB0015, PB0016, PB0023, PB0025, PB0029, PB0035, PB0041, PB0042, PB0044, PB0046, PB0052, PB0053, PB0054, PB0056, PB0058, PB0065, PB0068, PB0075, PB0078, PB0079, PB0083, PB0089 and PB0092.

Slightly curved: PB0007, PB0013, PB0014, PB0022, PB0024, PB0026, PB0027, PB0028, PB0030, PB0031, PB0033, PB0034, PB0036, PB0037, PB0038, PB0039, PB0040, PB0043, PB0045, PB0047, PB0048, PB0050, PB0051, PB0055, PB0059, PB0060, PB0062, PB0063, PB0064, PB0070, PB0071, PB0072, PB0073, PB0076, PB0077, PB0080, PB0081, PB0082, PB0084, PB0085, PB0093, PB0094 and PB0095.

Curved: PB0049, PB0061, PB0069, PB0074, PB0086, PB0091 and PB0099.

Pod length

Average length in centimeters of the largest fully expanded immature pods was measured from 10 random normal plants. The length of immature pods ranged from 6.7 to 17.4 cm with a mean of 10.45 cm. This character is related to the usefulness of green pod vegetable (Table 1).

Table 1. Summary of agro morphological characteristics of common bean germplasm

Parameters	Mean	Minimum	Maximum	CV, %
Agro-morphological parameters				
Hypocotyl length, cm	2.95	1.6	5.1	17
Leaflet length, cm	10.35	6.0	18.0	20
Node number on main stem from base to first inflorescence	9.63	4.4	14.8	18
Inflorescence length, cm	2.60	2.0	3.3	13
Flower buds per inflorescence	4.65	1.8	18.0	39
Pod width, cm	1.67	1.0	3.0	33
Pod beak length, cm	0.96	0.4	2.0	33
Pod length, cm	10.45	6.7	17.4	16
Days to first flowering	46.70	35.0	75.0	16
Days to 50% flowering	53.59	40.0	84.0	17
Days to maturity	97.71	80.0	149.0	7
Plant height, cm	89.25	28.0	144.0	24
Pods per plant	12.60	5.0	32.0	34
Seeds per plant	4.31	3.0	6.0	12
Seed yield, g/m ²	115.80	5.9	306.5	58
100-seed weight, g	30.60	14.5	76.6	32
Root and nodulation parameters				
Root length, cm	20.90	8.30	37.20	32
Root weight, g	8.02	2.80	17.70	30
Nodule weight, g	1.06	0.02	5.50	98
Nodule number	1.59	1.00	5.00	58
Diseases				
Anthraco nose (1-9 scale)	5.09	3	9	36
Rust (1-9 scale)	4.38	1	9	77
Bean yellow mosaic (1-5 Scale)	1.99	1	2	4
Insect-pests				
Pod borer	2.88	1	7	53
Aphid	1.29	1	2	34
Jassid	1.45	1	3	36
Leaf feeding insects	2.40	1	5	47
Thrips	1.74	1	3	39
White fly	1.96	1	3	39

Root length

PB0025 had the shortest root length of 8.3 cm and PB0015 had the longest root Length of 37.2 cm at mid flowering stage. Accessions with more than 20 cm root length were PB0001, PB0002, PB0004, PB0006, PB0007, PB0008, PB0009, PB0011, PB0012, PB0013, PB0015, PB0016, PB0019, PB0022, PB0024, PB0028, PB0030, PB0032, PB0034, PB0041, PB0045, PB0049, PB0055, PB0056, PB0059, PB0070, PB0072, PB0075, PB0076, PB0077, PB0078, PB0079, PB0080, PB0086, PB0087, PB0092, PB0094, PB0097, PB0098, PB0099 and check.

Root weight

The mean fresh root weight of plants at flowering stage ranged from 2.8 to 17.7 g. The genotype PB0075 had the lowest root weight of 2.8 g, whereas, PB0094 had the highest root weight of 17.7 g.

Nodule number per plant

Beans are poor nodulators (HPKV 2000). The average nodule number of 3 plants counted at the flowering stage was very low for all entries. It ranged from 1 to 5. The accession PB0009 had the maximum nodule number of 5 per plant. Majority of accessions had 2 nodules per plant. Genotypes PB0089, PB0091, PB0092 PB0093, PB0094 and check were good nodulators. Selection of effective rhizobium strains (Yami and Khanal 2000) and high nodulating bean genotypes are important for getting high yields from the beans.

Nodule weight

Fresh weight of nodules taken at flowering stage of the plants ranged from 0.02 to 5.5 g/plant with a mean of 1.06 g/plant.

Days to flowering

The number of days from emergence to the first flowering was the minimum (35 days) for PB0040 and the maximum (75 days) for PB0014. The number of days to 50% flowering ranged between 40 and 84. Accession PB0040 was the earliest to flower. Seventy percent of accessions flowered between 49 and 60 days. For high altitude regions like Jumla, early flowering genotypes have special significance, as late flowering don't complete the life cycle due to early onset of winter.

Days to maturity

The number of days from emergence until 90% of pods are matured ranged between 80 for PB0040 to 149 days for PB0080. A wide range of variation was recorded in maturity days. Eighty four percentages of accessions matured within 103 days.

Plant height

Average height in centimeters, at maturity was measured from cotyledon scar to the tip of plant. It ranged from 28 to 144 cm. Accession PB0040 which was determinate, was the shortest while PB0087 was the tallest.

Pods per plant

The number of mature pods per plant ranged from 5 to 32. PB0011 had the lowest number while the check had the highest number. PB0095 and PB0091 had 29 and 28 number of pods per plant respectively.

Seeds per pod

PB0001 had the lowest and PB0032 (6 seed) had the highest number of seeds per pod. PB0002 and PB0048 had 4 seeds per pod. Majority of accessions had 4 seeds/pod.

Seed weight

Wide variations were recorded in seed size. PB0010 had the largest seed size and PB0072 had the smallest seed. One hundred seed weight of PB0001 was 50, that of PB0002 and PB0048 were 38 and 49 g respectively. The check had only 32 g. Accessions with 100-seed weight of 50 g and above were PB0001, PB0010, PB0048 and PB0077.

Seed yield

Wide variation was recorded in seed yield. The accession PB0030 produced the highest yield of 3043 kg/ha and the lowest yield was produced by PB0072. Fifty one percent of accessions produced more than 1000 kg/ha seed yield. Accessions yielding more than 2000 kg/ha were PB0001, PB0002, PB0030, PB0031, PB0045, PB0055, PB0099 and check. PB0001 produced the yield of 2800 kg/ha, whereas PB0002 and PB0048 produced 2570 and 1300 kg/ha respectively. The wide variation of seed yield among local accessions suggests that there is a possibility of selection of superior lines /genotypes from the local landraces which is also reported by Singh and Mishra (1988).

On the basis of desirable characteristics and yield performance, 16 genotypes were selected and evaluated in replicated yield trials. The selected accessions are PB0001, PB0002, PB0004, PB0013, PB0023, PB0030, PB0037, PB0040, PB0042, PB0045, PB0054, PB0058, PB0060, PB0062, PB0095 and PB0048. After evaluation in farmer participatory variety selection (PVS) and farmers' acceptance test (FAT), three accessions PB0001,

PB0002 and PB0048 were preferred by farmers on the basis of suitability to growing both as a sole and/or inter/mixed crop with maize, medium growth habit, attractive seed colour and seed size, tolerance to diseases, earliness in maturity, high seed yield, higher dal- recovery percentage and better cooking quality.

CONCLUSION

As the germplasm constitute valuable generic resources of the country, samples of it are stored at gene bank of Plant Genetic Resources Unit (PGRU), Agricultural Botany Division, Khumaltar. These can be utilized for future research work, whereas the farmer-preferred accessions PB0001, PB0002 and PB0048, which are already in farmer's fields, could be profitably used for mass dissemination in the target area. Future research work should focus on the agronomic management of identified genotypes and evaluation of germplasm across a range of environments to identify and select location specific genotypes.

ACKNOWLEDGEMENTS

We express our gratitude to HARP for funding this research activity through HARP PP: 156/00. The help and cooperation provided by participant farmers, support staff of ARS Jumla, NGLRP Rampur and District Agriculture Development Office Jumla are duly acknowledged.

REFERENCES

- Duke JA. 1991. *Handbook of legumes of world economic importance*. USDA, Beltsville, Maryland, New York and London.
- HPKV. 2000. *Annual report 1998-99*. Himanchal Pradesh Krishi Vishwavidyalaya, Palampur, HP India.
- IBPGR. 1982. *Descriptors for Phaseolus vulgaris 1982*. International Board for Plant Genetic Resources, IBPGR Rome.
- Neupane RK and ML Vaidya. 2002. *Proceedings of the first stakeholders meeting on development of improved production technology of Phaseolus beans to the hills of mid western Nepal*, 22 June 2002 ARS, Jumla. NGLRP Rampur.
- Shrestha RL and KB Poudel. 2000. Early maturing bean S-9 for fresh vegetable. *Pravidhi Sangalo* 1:2 (in Nepali). ARS Lumle, Kaski.
- Singh L and SP Mishra. 1988. Minor pulse crops. **In:** *Grain legumes* (B Baldev, S Ramanujam and HK Jain, eds). Oxford and IBH Pub. New Delhi, Pp.215-225.
- UPOV. 1994. *UPOV Guidelines of legumes 1994*. International Union for the Protection of New Varieties of Plants Revision of /du/von TG/12/14.
- Yami KD and IP Khanal. 2000. Prospects for using microbial inoculants in Nepal. **In:** *Proc. Third National Conference on Science and Technology*, 8-11 March 1999. RONAST, Kathmandu.

Characterization and Evaluation of Indigenous Garlic (*Allium sativum* L.) Germplasms of Nepal

Ram B KC¹, Moha D Sharma², Durga M Gautam², Dilip R Panthee²

¹ RARS, NARC, Nepalgunj

² IAAS, Rampur, Chitwan

ABSTRACT

Germplasm characterization is the fundamental basis for crop improvement. To study the physio-morphological variation, crop duration and yield potentiality in Nepalese indigenous garlic germplasm for both qualitative and quantitative characters, an experiment was carried out at horticultural farm (225 masl), Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal in 2000-2001. One hundred seventy nine garlic germplasms were collected from 51 districts including major agro-ecological zones. After characterization of the collected bulbs, each germplasm was planted for the evaluation in a single plot of 2.25 m² on 2 November 2000. Phenological and physio-morphological characters were recorded and multivariate analysis was performed only on 158 bulb-producing germplasms. Four principal components were identified which altogether explained 58.8% of the variation in qualitative traits. Similarly three principal components accounted for 78.9% of the variability in quantitative characters. Eight different natural groups of more similar characteristics were identified on the basis of cluster analysis. Among 179 germplasms, 21 including six Bhote Lasun adapted to summer cultivation in high hills of Nepal were unable to form bulbs under Chitwan (inner Tarai) condition. The yields of the ten most promising germplasms ranged from 14.5 to 20.1 t/ha, which are substantially higher yields than the national average (4.0 t/ha).

Key words: *Allium sativum*, germplasm, indigenous, variation

INTRODUCTION

Garlic (*Allium sativum* L.) is the most important spice crop in the *Allium* group. It ranks sixth in area under cultivation among the major vegetables in the world (Pathak 1994). As far as the general importance of *Allium* crops is concerned, garlic stands second after onion. It is an important vegetable crop widely grown in all agro-ecological zones of Nepal for spices and medicinal purposes as well. Niroula (1998) reported that the area and production of garlic is estimated to be 2260 ha producing 9036 t and the average productivity is 4 t/ha. Both total area and production of garlic in Nepal are very low.

A number of factors are responsible for low yield of garlic. There is a lack of short duration and high yielding variety of garlic. New varieties are usually developed by means of sexual hybridization and subsequent selection in following generations. However flowering of garlic is not common, hence there is no seed set. Therefore, vegetative propagation is the ultimate mean of garlic production.

In Nepal, farmers have identified very few location specific genotypes. Wider adoption of high yielding and short duration variety is necessary to accelerate the garlic production in the country. In addition to this, research to develop high yielding varieties should be given priority. Varieties suitable to different agro-ecological zones should be developed through the exploitation of genetic diversity of garlic within country. There is a lack of systematic collection, characterization and evaluation of garlic varieties or landraces. Thus, this study was carried out with the objectives to assess physio-morphological characters of garlic germplasms and to evaluate the yield potentiality and crop duration of the garlic germplasms collected from different locations of Nepal.

MATERIALS AND METHODS

A total of 179 garlic germplasms were collected during August to September 2000 from 51 districts covering different agro-ecological zones ranging an altitude from 125 to 2650 masl.

Location and time of study

Germplasms were characterized and evaluated at Institute of Agriculture and Animal Science (IAAS), Rampur (225 masl), Chitwan from November 2000 to May 2001. IAAS is located in the sub humid inner Tarai region of Nepal at 27° 37' N and 84° 29' E. The soil was sandy loam with 5.5 pH value. Monthly average weather of crop growing period was maximum 29.7°C, minimum 13.5°C, rainfall 48.0 mm and relative humidity 83%. The collected germplasms were characterized according to garlic descriptors developed by ECP/GR/IBPGR (1992) before planting.

Land preparation, planting and management practices

Each germplasm was planted on 2 November 2000 in single plot of 1.5- × 1.5-m at 15 cm of row-to-row and plant-to-plant distance. Plots were fertilized @ 40:80:80 kg NPK with 20 farm yard manure/ha as basal application. 80 kg N/ha were applied as two splits of 40 kg each at 30 and 60 days after planting. Other general practices were done as recommended.

Measurement of physio-morphological characters

Pre-harvest traits: days to 75 percent emergence, plant height, longest leaf length, leaf width, total number of leaves, presence of leaf wax, foliage color, leaf erectness, cross-section of leaf, plant vigor, plant uniformity, disease scoring for purple blotch, bulb initiation and bulking duration, were observed in five randomly selected plants. Maturity days and bulb yield were recorded.

Post-harvest: bulb uniformity, size of the bulb/clove, shape of the bulb (BS), bulb skin color, clove number, bulb skin thickness were taken. All these characters are based on the descriptor developed by ECP/GR/IBPGR (1992).

Data analysis

Data of 179 clones were analyzed for qualitative and quantitative characters. Multivariate analysis (Principal component and Cluster analyses) was performed for 158 clones except 21 non-bulb forming germplasms by using software Minitab version 12.23.

RESULTS AND DISCUSSION

Principal component analysis

Comparison between initially collected bulbs before planting and after evaluation is presented in Table 1. Four principal components altogether explained 58.8% of the accumulated variation in qualitative characters, which are presented in Table 2.

Table 1. Mean, standard deviation (SD) and range of various characters measured in 179 garlic germplasms in in-situ (initially collected bulbs) and on farm evaluation

Variable	Mean ± SD		Range†			
	In-situ	On-farm	Min	Max	Min	Max
Days to 75% emergence	-	15.0 ± 3.2	-	-	10.0	25.0
Plant height, cm	-	59.0 ± 10.4	-	-	29.8	84.8
Green leaves at 135 days/ plant	-	6 ± 1	-	-	2.0	10.0
Bulking period (days)	-	60 ± 7	-	-	32.0	70.0
Days to maturity	-	160 ± 6	-	-	148.0	178.0
Bulb weight, g	23.5 ± 25.5	19.6 ± 7.5	1.6	225	4.6	47.8
Bulb diameter, cm	4.0 ± 1.3	3.8 ± 0.5	1.9	15.8	2.3	5.2
Cloves numbers/bulb	15 ± 6	29 ± 8	1	39	11	55
Clove diameter, cm	1.2 ± 0.5	0.9 ± 0.1	0.5	4.4	0.4	1.4
Yield, t/ha	-	8.91 ± 3.9	-	-	1.8	20.1

† Min, Minimum. Max, Maximum.

Table 2. Eigenvalue, percent of the variability of qualitative characters explained by each component

Principle component	Eigenvalue	% variability	Cumulative variability	Responsible characters
1	2.50	20.8	20.8	Bulb shape, plant uniformity and vigor
2	2.04	17.1	37.9	Leaf erectness, wax, cross-section
3	1.30	10.9	48.8	Bulb outer scale number
4	1.20	10.0	58.8	Bulb color

Bulb shape plays major role in characterization of garlic. Consumer prefers uniform bulbs. Alteration in the color of economically important plant parts is of direct importance to the characterization, selection, identification and recommendation. Growing conditions have a large effect on plant vigor and uniformity. Clove size and number plays a positive role to increase size and weight of the bulbs.

The first three principal components provided eigenvalues greater than 1.0 and altogether explained 78.9% of the accumulated variation (Table 3). Although we expect to find very low intraspecific variation because of vegetative propagated crop sufficient physio-morphological variation in both qualitative and quantitative characters has been observed in Nepalese germplasms. This variation was less in qualitative characters than quantitative.

Table 3. Eigenvalue, % of the variability of quantitative characters explained by each component

Principal component	Eigen values	% variability	Cumulative variability	Responsible traits
1	4.43	44.3	44.3	Yield, bulb weight, diameter
2	2.33	23.4	67.7	Clove numbers, days to 75% emergence
3	1.12	11.2	78.9	Days to maturity and clove diameter

Cluster analysis

The cluster analysis identified eight clusters in both qualitative (dendrogram not shown) and quantitative traits, cluster description is given in Tables 4 and 5.

Table 4. Number of germplasms in a cluster with relevant qualitative characters

Cluster	Germplasms in cluster	Predominant characters
I	102	V-shaped erect leaves, thin bulb outer skins
II	1	Irregular bulb shape, medium type of leaf erectness
III	15	Pink bulb color
IV	3	Pink color bulbs with irregular shapes
V	6	Medium green foliage
VI	3	Light green foliage
VII	22	Dark green foliage
VIII	6	Irregular bulb shaped

Table 5. Mean of relevant quantitative characteristics for each of the eight clusters formed from 158 garlic germplasms

Characteristic	Cluster†							
	1 (5)	2 (46)	3 (27)	4 (3)	5 (59)	6 (14)	7 (2)	8 (2)
Days to 75% emergence	17	16	13	12	16	12	16	13
Bulking period (days)	58	62	52	37	65	64	70	36
Days to maturity	157	162	152	157	165	153	170	167
Plant height, cm	35.2	48.9	59.9	58.6	64.9	67.7	79.9	83.6
Green leaves at 135 days/plant	4	6	6	4	7	6	9	6
Bulb weight, g	8.8	16.1	18.9	6.3	23.2	21.9	47.7	9.5
Bulb diameter, cm	2.9	3.6	3.7	2.7	4.11	3.8	5.1	2.9
Clove number/bulb	17	24	29	34	29	46	33	41
Clove diameter, cm	.9	.9	.9	.7	.9	.8	1.3	.6
Yield, t/ha	3.50	6.81	7.8	2.47	11.40	9.25	20.06	5.4

† Figure in parenthesis indicates a number of germplasms in the cluster.

Only quantitative characters characterize the bulb distinctly (Warde and Shinde, 1998). Variation was observed in maturity days mainly due to type of germplasms and might be related to climatic factors, since they were collected from different parts of the country. Yield was highly influenced by maturity period and could be the selection criteria for high yielding cultivars. Bulb yield was clearly affected by bulb size. The highest bulb weight in cluster seven (47.7 g) also gave the highest bulb yield. Mehata and Patel (1985) reported that bulb

weight was positively associated with bulb yield. Influence of bulking period in bulb yield was observed. This was because the longer period allowed large accumulation of photosynthate in the source and its movement towards the sink.

Table 6. Top ten promising cultivars on the basis of yield potentiality

SN	Acc No	Collected site	Bulking period	Days to maturity	Yield, t/ha
1	GIN-147	Palpa- Aryabhanjang (1100 masl)	69	173	20.1
2	GIN-154	Dadeldhura-Dudhkanda (1600 masl)	70	166	20.0
3	GIN-30	Dolkha (2000 masl)	67	167	18.4
4	GIN-57	Panchthar (Fidim-3)	68	164	18.1
5	GIN-83	Lamjung-Tarkughat (1000 masl)	69	166	17.3
6	GIN-151	Doti-Kalena (1500 masl)	64	166	16.7
7	GIN-100	Sunsari (Babiya-6)	54	152	16.2
8	GIN-112	Makawanpur (1600 masl)	64	164	15.6
9	GIN-27	Dolkha-Jiri (1900 masl)	55	153	14.5
10	GIN-135	Mahottari-Jaleshwor (200 masl)	65	164	14.5

Bulb yield

Indigenous Nepalese garlic germplasms have good yielding capability. The bulb yield varied from 1.8 to 20.1 t/ha in this evaluation. In Nepal Niroula (1998) reported that the productivity of garlic was 4.0 t/ha. Pathak (1994) reported that in Asia productivity of garlic was 7.3 t/ha. Pandita (1994) mentioned that productivity of garlic in India was 4.5 t/ha.

Among the 179 garlic germplasms, 21 germplasms did not able to produce bulb yield at Rampur condition. Six genotypes collected from hills of Nepal known as 'Bhote Lasun' produced small-size bulb with no proper growth of clove and flowering. Except the 'Bhote' type, others, which were unable to form bulb properly were prostrate types. The most probable reason for no bulb formation is long day requirement of these germplasms collected from higher altitude where they are grown in the summer season. This finding is in agreement with the Warde and Shinde (1998) indicating that the garlic cultivars adapted to one area are sometimes worthless as a crop in other regions.

CONCLUSIONS

Among 179 germplasms, only 158 were able to produce well-developed bulb at Rampur condition while 21 did not produce bulb, which could be due to their long day requirement for bulb formation. Among these 21, six were large size plants, commonly known as Bhote Lasun. Similarly a greater amount of variation was observed in yield, which ranged between 1.8 to 20.1 t/ha.

There was great amount of diversity among the germplasms for various phenotypic and economic characteristics indicating a good potential for garlic improvement through selection in future breeding. Ten germplasms were found promising on the basis of their yield.

REFERENCES

- ECP/GR/IBPGR. 1992. Allium. **In:** *Fourth Working Group Meeting on Allium, Gatersleben, Germany 10 and 14 June 1991*. European Cooperative Programme for Crop Genetic Resources Networks, International Board for Plant Genetic Resources, Rome, Italy. Pp. 18-26.
- Mehata KG and PH Patel. 1985. Genetic variability and path analysis in garlic. *Madras Agricultural Journal* 71:691-695
- Niroula GS. 1998. Spices: Potential crops for export market. **In:** *Proceeding of the Second National Horticulture Workshop* organized by the Nepal Horticulture Society held at Kirtipur, Kathmandu, 19-21 January. Pp. 31-40.
- Pandita ML. 1994. Status of *Allium* production and research in India. **In:** *Acta Horticulture* (DJ Midmore, ed). International symposium on *Alliums* for the tropics, Bangkok and Chiangmai, Thailand, 15-19 February 1993. Asian Regional Center-AVRDC. 433p.
- Pathak CP. 1994. *Allium* improvement for the tropics: Problems and AVRDC strategy. **In:** *Acta Horticulture* (DJ Midmore, ed). International symposium on *Alliums* for the tropics, Bangkok and Chiangmai, Thailand, 15-19 February 1993. Asian Regional Center-AVRDC. Pp. 23-29.
- Warde SD and KG Shinde. 1998. Garlic. **In:** *Hand Book of vegetable science and technology, production, composition, storage and processing* (DK Salunkhe and SS Kadam, eds). Marcel Dekker Inc., New York. Pp. 397-413.

Chickpea Improvement in Nepal: Progress and Prospect

Nawal K Yadav¹ and Daya N Pokhrel²

¹ National Grain Legumes Research Program, NARC, Rampur

² Regional Agricultural Research Station, NARC, Khajura, Nepalgunj

ABSTRACT

Chickpea occupies fifth position in area (14590 ha) and production (12148 t) of total grain legumes and it is imported from the foreign countries in Nepal. Low grain yield, susceptibility to wilt, botrytis gray mold (BGM) and pod borer are the serious problems of growing chickpea. There is an urgent need to develop high yielding genotypes that are resistant to wilt and BGM and are well adapted to environments. Seed size of local land races is very small while exotic lines yielded poor. Presently some of the genotypes have been developed from the crosses and evaluated in coordinated varietal trials and coordinated farmers field trials at different locations from 1997/98 to 2001/02. In coordinated varietal trials genotypes ICCX 840508-36 (1673 kg/ha) and ICCX 840508-21 (1487 kg/ha) produced 30.32 and 15.84% higher grain yield respectively than Dhanush (1284 kg/ha) over the locations and years. Genotypes ICCX 840508-36 (1422 kg/ha) and ICCX 840508-21 (1298 kg/ha) produced 18.23 and 7.74% higher grain yield than Dhanush (1203 kg/ha) over the locations and years. Their seed sizes are 72.72 and 81.81% higher than Dhanush (11 g) respectively. Medium bold seeded genotype ICCX 840511-25 produced 69.73 and 51.43% higher seed yield as compare to Dhanush at Nepalgunj and Surkhet respectively and this was selected and promoted for the Mid Western and Far Western Tarai. Farmer participatory research is needed in future for identification and faster dissemination of farmer-preferred varieties.

Key words: Chickpea, crossing program, Nepal

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third important winter legume after lentil and grasspea in terms of both area (14590 ha) and production (12148 t) in Nepal. Its national average yield is 833 kg/ha. It is principally grown in Tarai and Inner Tarai in the rain fed areas after rice and maize. It is also grown in a limited scale in some of the valleys and river basin in the hills. It is generally grown on marginal land with poor management. Chickpea is grown either as a sole or mix crop with mustard and/or linseed. Recently the price of chickpea is very encouraging as compared to cereals.

Research activities on chickpea have been going on since 1973. Six varieties of chickpea have been released for cultivation. Two varieties (Dhanush and Trisul) were identified by selection from local germplasm and four varieties ie Sita (ICCC-4), Radha (JG-74), Kosheli (ICCC-32) and Kalika (ICCL-82108) by introduction. National productivity has been increased, though the area is in decreasing trend. Main problems of chickpea growing are wilt complex, botrytis gray mould (BGM) and pod borer infestation. Variety Dhanush is highly tolerant to BGM but it has smaller seed size (Yadav et al 1994).

None of the varieties except Dhanush are producing the satisfactory yield in Rampur condition. The crosses of Dhanush X K 850 (bold seeded) are performing well at different locations. Some of the cross lines such as ICCX 840508-36, ICCX 840508-21, ICCX-840508-38, ICCX-840508-40 and ICCX 840508-41 are performing well (Yadav et al 2001). Varietal improvement experiments were conducted with the objectives to identify bold seeded Desi and Kabuli genotypes with stable and high yield and to select high yielding and diseases and insect pests resistant/tolerant lines.

MATERIALS AND METHODS

The coordinated varietal trials (CVT) were conducted from 1997/98 to 2000/01 at RARS Tarhara, TRP Belachapi, ORP Nawalpur, RARS Bhairahwa, RARS Nepalgunj and ARS Surkhet with fertilizer rate of 20:40:20 kg/ha N:P:K. This trial was consisted of 20 genotypes in RCB design with 4 replications in 6 rows of four-meter length. Data on days to flowering, days to maturity, plant height, number of pods per plant, number of seeds per pod, 100-seed weight and grain yield were recorded. Coordinated farmers field trials were conducted in Rampur, Belachapi, Nawalpur, Bhairahwa and Surkhet during those periods. These trials were consisted of 7 genotypes in 10 rows of four-meter length. Data were combined analysed using MSTATC program.

RESULTS AND DISCUSSION

Crossing program

Chickpea is a self-pollinated crop. Seed yield is the result of many characters, which are inter- dependent. Breeders always look for genetic variation among traits to select desirable types. Some of these traits are highly associated among themselves and with seed yield. Seed yield and its quality, together with straw are the key economic characters (Erskine 1983). Hamid et al (1991) reported that seed yield was positively associated with straw yield, 1000-seed weight and harvest index, while it was negative correlation with days to flowering, days to maturity, number of seeds per pod and seed protein content.

To create genetic variation, hybridization program utilizing the best local cultivars (Dhanush) along with bold seeded genotypes K850 (Desi) and ICCV-2 (Kabuli super early) variety were carried out. The F₂ populations between small seeded varieties Dhanush/ICCV-2 (Kabuli) showed good plant type, seed size (25 g) and early in maturity (135).

Generation nursery

Generation nurseries are raising since 1999 at Rampur. The materials developed from local crosses as well as received from ICRISAT were planted in generation nursery. The segregating populations in F₂ and F₃ were bulked to upgrade the generation and provide the better environment for segregating, while in F₄ generation lines were developed as progeny rows through individual plant selection having high number of pods per plant. In F₃ cross number ICCX-970044 (L550/Radha), ICCX-970053 (PDG84-16/PDG90-2E) and ICCX-970054 (ICCV96029/WR315) were high yielder (80 g/m²) and moderately resistant to helicoverpa. The year 2002/03 was disastrous for chickpea in Rampur and loss estimates was observed up to 90%. Seed yield per plant is not a reliable criteria for selection because it has low heritability (Erskine 1983). Singh and Sharma (1994) reported high heritability estimates and genetic advance for number of pods, seed size and grain yield and they also observed that number of pod per plant had high association with grain yield.

Coordinated varietal trials

Twenty genotypes including Dhanush as a check was planted at Tarhara, Belachapi, Nawalpur, Bhairahwa, Nepalgunj and Surkhet from 1997/98 to 2001/02. Statistical analysis of grain yield of all the stations over years showed significant differences among the tested genotypes. At Tarhara genotypes ICCV-90143 (1419 kg/ha), ICCX 840508-36 (1241 kg/ha) and ICCV-92101 (1214 kg/ha) produced significantly higher yield than Dhanush (957 kg/ha). At Belachapi, genotypes ICCX 840508-36 (1453 kg/ha) and Avrodhi (1370 kg/ha) were found significantly superior than Dhanush (897 kg/ha). At Nawalpur, all the genotypes produced higher yield as compare to other locations but ICCX 840508-21 (2278 kg/ha) and ICCX 840508-36 (2210 kg/ha) produced significantly higher yield than Dhanush (1767 kg/ha). At Bhairahwa, genotypes ICCX 840508-36 (1531 kg/ha) and ICCX 840508-44 (1458 kg/ha) produced slightly higher yield than Dhanush (1426 kg/ha) but were at par. At Nepalgunj, genotypes ICCX 840511-26 (1770 kg/ha), ICCX 840511-25 (1641 kg/ha), ICCV-92101 (1784 kg/ha), ICCV-90143 (1745 kg/ha) and ICCX 840508-36 (1590 kg/ha) produced significantly higher yield than Dhanush (1081 kg/ha). At Surkhet, all most all the genotypes produced higher yield as compare to other locations, however, ICCX 840511-25 (2677 kg/ha), ICCV-92101 (2674 kg/ha) ICCX 840511-26 (2336 kg/ha), ICCV-90143 (2300 kg/ha), ICCL 87312 (2183 kg/ha), ICCX 840508-40 (2101 kg/ha) and ICCX 840508-36 (2016 kg/ha) produced significantly higher yield than Dhanush (1576 kg/ha).

Statistical analysis of locations revealed that at Surkhet and Nawalpur mean yield of genotypes were higher than Tarhara, Belachapi, Bhairahwa and Nepalgunj. Pooled analysis of locations and years also showed significant differences among the genotypes. Genotypes ICCX 840508-36 (1673 kg/ha) produced significantly higher grain

yield than Dhanush (1284 kg/ha). Percentage increase over the check was given in Table 1. Genotypes ICCX 840508-36 and ICCX 840508-21 produced highest mean yield over years at Nawalpur while ICCX 840511-25 at Surkhet. Seed sizes of ICCX 840508-36 and ICCX 840508-21 were 81.81 and 72.72% higher than Dhanush (Figure 1).

Table 1. Grain yield of chickpea genotypes in coordinated varietal trials at different locations, 1997/98-2001/02

SN	Entry	Grain yield, kg/ha						% change	
		RARST	ARSB	NORP	RARSB	RARSN	ARSS	Mean	
1	Avrodhi	800	1370	1695	967	773	984	1098	-14.50
2	BG-1206	949	1099	1587	420	760	969	964	-25.92
3	ICCL – 87312	971	1204	2050	1374	1230	2183	1502	16.97
4	ICCL – 87332	1043	1073	1738	1065	1315	1950	1364	6.22
5	ICCV - 90143	1419	609	1753	586	1745	2300	1402	1.97
6	ICCV - 92101	1214	741	1473	536	1784	2674	1403	9.30
7	ICCV-10	778	1283	1364	435	848	951	943	26.56
8	ICCX - 840508-21	1103	1139	2278	1094	1422	1889	1487	15.84
9	ICCX - 840508-31	1168	1115	1909	969	1275	1663	1350	5.12
10	ICCX - 840508-32	899	1116	1876	887	1320	1819	1319	2.76
11	ICCX - 840508-33	861	945	1923	1127	1404	1924	1364	6.22
12	ICCX -840508-36	1241	1453	2210	1531	1590	2016	1673	30.32
13	ICCX - 840508-38	1101	1064	1762	1280	1264	1874	1391	8.32
14	ICCX - 840508-40	952	1109	1798	1138	1368	2101	1411	9.88
15	ICCX - 840508-41	1065	1173	1931	1390	1261	1566	1398	8.84
16	ICCX - 840508-44	1030	1193	1891	1458	1435	1881	1481	15.36
17	ICCX- 840511-25	1109	842	1735	525	1641	2677	1421	10.69
18	ICCX - 840511-26	1009	626	1849	943	1770	2336	1422	10.74
19	KWR-108	896	1285	1580	749	830	995	1056	-17.78
20	Dhanush (check)	957	897	1767	1426	1081	1576	1284	0
Mean		1155	1091	1832	1086	1350	1833	1391	
CV, %		22.0	19.7	16.5	24.2	28.4	18.6	22.2	
F test									
Genotype (G)		**	*	*	*	*	*	*	
Location (L)								**	
G × L								**	
LSD (0.05)		320	410	380	390	503	424	380 (G) 460 (L) 520 (G × L)	

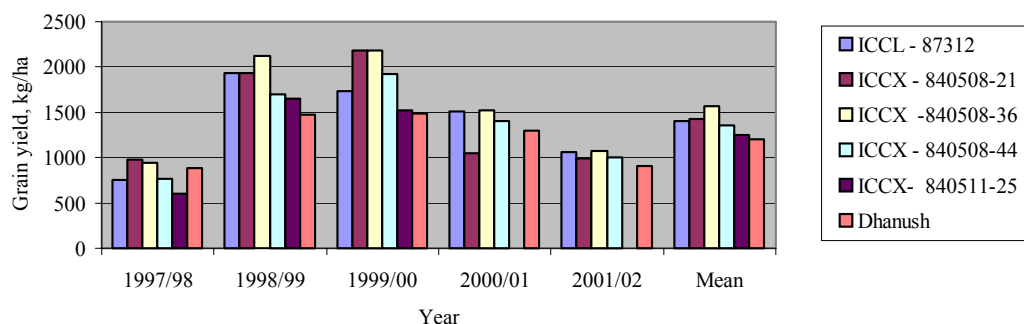


Figure 1. Grain yield of chickpea coordinated varietal trials over years.

Coordinated farmers field trials

At Tarhara, genotypes ICCX 840508-36 and ICCX 840508-21 produced 23.44 and 17.52% higher grain yield than Dhanush. At Rampur, genotypes ICCX 840508-36 and ICCX 840508-21 produced 42.81 and 23.65% higher grain yield than Dhanush. At Nawalpur, genotypes ICCX 840508-36, ICCX 840508-41 and ICCX 840508-21 produced 35.22, 20.0 and 14.48% higher grain yield than Dhanush. At Belachapi, only Avrodhi produced 3.45% higher grain yield than Dhanush.

At Bhirahwa, ICCX 840508-36 produced 26.05% higher grain yield than Dhanush. At Nepalgunj, ICCX 840511-25 produced 47.6% percent higher grain yield than Dhanush while at Surkhet it produced 31.58% higher yield than Dhanush. Pooled mean of grain yield over years and locations also indicated that genotypes ICCX 840508-36 produced 18.23% higher grain yield than Dhanush and ICCX 840508-21 produced 7.74% higher grain yield than Dhanush (Table 2).

Table 2. Performance of chickpea in coordinated farmers field trial at different location during, 1997/98-2001/02

Entry	Grain yield, kg/ha							% change over check	
	RARST	NGLRP	ORPN	ARSB	RARSB	RARSN	ARSS	Mean	
Avrodhi	1400	657	2075	1231	964	937	1360	1232	240
ICCX840508-21	1469	1171	2262	1162	691	980	1339	1296	7.74
ICCX840508-36	1543	1352	2672	1033	1200	875	1281	1422	18.23
ICCX840508-41	1187	995	2371	685	943	813	1233	1175	-2.31
ICCX840511-25	613	1006	1999	781	940	1200	1700	1177	-2.15
ICCX840511-26	962	986	1994	763	850	980	1365	1128	-6.19
Dhanush (check)	1250	947	1976	1190	952	813	1292	1203	-

CONCLUSION

In F₃ ICCX-970044 (L550/Radha) ICCX-970053 (PDG84-16/PDG90-2E), ICCX-970054 (ICCV96029/WR315) //ICCV506EB were high yielder (> 80 g/m²) and moderately resistant to helicoverpa in field levels. In coordinated varietal trials, ICCX 840508-36 and ICCX 840508-21 produced highest mean yield over years at Nawalpur while ICCX 840511-25 at Surkhet.

Genotypes ICCX 840508-36, ICCL 87312, ICCX 840508-21 and ICCX 840511-25 produced 30.32, 16.97, 15.84 and 10.69% higher yield than Dhanush. In coordinated farmers field trials, ICCX 840508-36 and ICCX 840508-21 produced 18.23 and 7.74% higher yield than Dhanush. Seed size of ICCX 840508-36 and ICCX 840508-21 are 81.81 and 72.72% higher than Dhanush. They were tolerant to wilt and BGM.

Genotypes ICCX 840508-36 and ICCX 840508-21 should be recommended for Tarai while ICCX 840511-25 for Mid Western and Far Western. Evaluation and selection of genotypes should be location specific. Breeding for resistant to wilt, BGM, pod borer and seed size should be emphasized. Focus should be given on participatory selection of varieties to suit the need of farmers.

ACKNOWLEDGEMENTS

We are especially thankful to Mr RK Neupane, NGLRP Rampur for his support and valuable suggestions. Authors are grateful to Mr VK Dutta, RARS Nepalgunj, Mr N Chaudhary, ORP Nawalpur, Mr R Mishra, RARS, Parwanipur, Mr DN Chaudhary, ARS Belachapi and Mr BB Rokaya, ARS Surkhet for providing the facilities to conduct the experiment. We are indebted to Dr Jagdish Kumar and Dr PM Gaur, ICRISAT for providing technical support and breeding materials for successful implementation of the program.

REFERENCES

- Erskine W. 1983. Relationship between the yield of seed and straw in lentil. *Field Crops Res.* 7:115-121.
- Hamid A, W Erskine and P Gates. 1991. Relationship among economic character in lentil. *Euphytica* 57:109-116.
- Singh BB and B Sharma. 1994. *Revised and updated paper presented at the International Symposium on Pulses Research*, 2-6 April 1994. Indian Society of Pulses Research Development, Kanpur.
- Yadav NK, BB Rokaya, B Chaudhary and G Chaudhary. 1994. Varietal research works on chickpea in Nepal. **In:** *Proceedings of GLRP-NARC/CLAN-ICRISAT Review and Planning Meeting* held on 13-14 June at Rampur, Nepal.
- Yadav NK, CR Yadav, RR Sah, BN Jha, P Jha, RB Chaudhary and DL Yadav. 2001. Varietal investigation on chickpea in Nepal. **In:** *Proceedings of National Winter Crops Workshop, 2001*. National Grain Legumes Research Program, Rampur, Chitwan, Nepal. Pp.63-79.

Correlation and Path Analyses in F₁ and F₂ Generations of Garden Pea^{*}

Dev K Choudhary¹ and RR Sharma²

¹ Regional Agricultural Research Station, Tarahara, Sunsari

² Division of Vegetable Crops, IARI, New Delhi

ABSTRACT

Correlation and path analyses in F₁ and F₂ generations among 28 crosses obtained through partial diallel crosses of 8 diverse genotypes of garden pea were studied and evaluated under randomized block design with 3 replications at Vegetable Research Farm of IARI, New Delhi during *rabi* season of 2000/01. Eleven different economic parameters viz days to first flowering, first flowering node, days to 50% flowering, days to first green pod harvest, pod length, number of grains per pod, number of pods per plant, pod yield per plant, plant height, shelling percentage and 1000-seed weight were selected for evaluation across the generations. Correlation studies revealed that yield per plant was significantly and positively associated with number of pods per plant, number of grains per pod and pod length in both the generations whereas, path analysis studies concluded that the number of pods per plant, pod length, number of grains per pod, shelling percentage and plant height were the major yield determinant for green pod yield and therefore, could be taken as an index to improve the pod yield per plant through selection.

Key words: Correlation, garden pea, path analysis

INTRODUCTION

Yield, being the most important and complex character, is governed by many physiological processes within the plant and influenced by many environmental factors in which the plant is grown. Direct selection for complex traits like pod yield is often not very effective and indirect selection for some of the component traits associated with pod yield may be rewarding. Therefore, knowledge of correlation and path analyses studies help plant breeder to ascertain the real components of yield and provide an effective basis of phenotypic selection.

MATERIALS AND METHODS

The experimental material were 28 F₁s and 28 F₂s genotypes produced by partial diallele crosses of 8 purelines/varieties viz. Arkel, GP 17, GP 207, GP 4, GP 128, GP 447, GP 468 and GP 471. Experiment was carried out at the Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi during 1999-2001. Seeds were sown on 13 November 2000, in a Randomized Block Design with 3 replications. Seeds of both generations were sown in a spacing of 45-50 cm between rows and 10-15 cm between plants and providing row length of 3.6 m. All recommended agronomic and cultural practices were adopted.

The observations were recorded in 10 randomly selected plants of each row and average of 3 replications were computed. Eleven economic characters to evaluate the experiment were days to first flowering, days to first flowering node, days to 50% flowering, days to first green pod harvest, pod length, number of grains per pod, number of pods per plant, pod yield per plant, shelling percentage, plant height and 1000 seed weight. The correlation and path coefficients were estimated according to Dewey and Lu (1959).

^{*} Part of MSc thesis of the first author.

RESULTS AND DISCUSSION

In F_1 generation significant and positive correlations were observed in days to first flowering, first flowering node, days to 50% flowering, pod length, number of grains per pod vs pod yield per plant (Table 1). In F_2 generation significant and positive correlations were noticed in plant height with shelling percentage, shelling percentage vs 1000 seed weight, number of pods per plant vs pod yield per plant, number of grains per plant vs pod yield per plant (Table 2). The results suggested that these characters could be considered as major pod yield per plant contributing traits in garden pea. The earlier results reported by Natrajan and Armugam (1980), Gupta et al (1998) and Singh and Singh (1999) lend credence to the present findings.

Table 1. Genotypic (below) and phenotypic (above diagonal) correlation coefficients of F_1 generation of garden pea

Character	1	2	3	4	5	6	7	8	9	10	11
1		0.377**	0.950**	0.695**	0.007	0.020	-0.167	-0.244*	0.317**	0.216*	-0.057
2	0.430		0.439**	0.620**	-0.173	-0.116	-0.339**	-0.282**	0.277**	0.089	-0.217*
3	0.974	0.519		0.783**	-0.048	-0.051	-0.275**	-0.361**	0.361**	0.155	-0.133
4	0.705	0.687	0.800		-0.282**	-0.234*	-0.425**	-0.539**	0.254**	0.050	0.397**
5	0.011	-0.381	-0.132	-0.532		0.483**	0.487**	0.563**	-0.080	0.311**	0.436**
6	0.037	-0.258	-0.097	-0.325	0.204		0.592**	0.605**	-0.164	0.330**	0.333**
7	-0.172	-0.393	-0.281	-0.436	0.853	0.891		0.876**	0.099	0.413**	0.557**
8	-0.250	-0.328	-0.368	-0.547	0.970	0.897	0.886		-0.054	0.352**	0.647**
9	0.320	0.314	0.364	0.256	-0.122	-0.242	0.099	-0.055		0.014	0.060
10	0.210	0.093	0.161	0.043	0.538	0.515	0.420	0.355	0.013		0.369**
11	-0.063	-0.254	-0.136	-0.408	0.727	0.491	0.563	0.652	0.059	0.374	

* Significant at 5 % level, ** Significant at 1 % level. 1, Days to 1st flowering. 2, First flowering node. 3, Days to 50 % flowering. 4, Days to first green pod harvest. 5, Pod length, cm. 6, No. of grains/pod. 7, No. of pods/plant. 8, Pod yield/plant, g. 9, Plant height, cm. 10, Shelling percentage. 11, 1000-seed weight, g.

Table 2. Genotypic (below) and phenotypic (above diagonal) correlation coefficients of F_2 generation of garden pea

Character†	1	2	3	4	5	6	7	8	9	10	11
1		0.500**	0.983**	0.872**	-0.025	-0.134	-0.324	-0.370**	0.704**	-0.202	-0.192
2	0.534		0.499**	0.532**	0.069	-0.003	-0.205	-0.155	0.322**	-0.271*	-0.069
3	0.997	0.551		0.884**	0.014	-0.134	-0.348**	-0.360**	0.699**	-0.151	-0.168
4	0.880	0.567	0.895		0.030	-0.119	-0.303**	-0.259**	0.742**	0.017	0.030
5	-0.024	0.113	-0.008	0.036		0.562**	0.342**	0.374**	0.051	0.240*	0.350**
6	-0.183	-0.042	-0.178	-0.181	0.969		0.481**	0.378**	-0.071	0.264*	0.392**
7	-0.326	-0.226	-0.352	-0.305	0.491	0.711		0.811**	-0.210*	0.166	0.605**
8	-0.372	-0.169	-0.365	-0.262	0.501	0.554	0.820		-0.327**	0.141	0.694**
9	0.710	0.357	0.707	0.747	0.062	-0.103	-0.212	-0.329		0.023	0.133
10	-0.209	-0.290	-0.169	0.014	0.266	0.356	0.177	0.145	0.025		0.355**
11	-0.193	-0.073	-0.171	0.030	0.477	0.558	0.612	0.696	0.134	0.373	

* Significant at 5 % level, ** Significant at 1 % level. † Refer to Table 1 for character details.

High direct positive effect was revealed on pod yield per plant by pod length and number of pods per plant in F_1 generation whereas, high positive direct effect of days to first flowering, first flowering node and pod length were observed in F_2 generation. The results were in accordance with Wakanker et al (1974), Chandel (1983), Joshi and Narsinghani (1992), Dev and Rastogi (1999) (Tables 3 and 4).

Table 3. Direct and indirect path coefficients (genotypic) of F_1 generation between different characters in garden pea

Character†	1	2	3	4	5	6	7	9	10	11	γ with yield
1	0.106	0.305	-0.751	0.127	0.003	0.017	-0.012	0.061	-0.024	-0.013	-0.244*
2	0.132	-0.082	-0.400	0.124	-0.113	-0.122	-0.028	0.059	-0.010	-0.051	-0.282**
3	0.298	0.043	-0.771	0.144	-0.039	-0.046	-0.020	0.069	-0.018	-0.028	-0.361**
4	0.216	0.056	-0.616	0.180	-0.158	-0.154	-0.032	0.048	-0.005	-0.093	-0.539**
5	0.003	-0.031	0.102	-0.096	0.297	0.570	0.062	-0.023	-0.060	0.147	0.563**
6	0.011	-0.021	0.075	-0.059	0.357	0.473	0.065	-0.046	-0.058	0.099	0.605**
7	-0.053	-0.032	0.216	-0.078	0.253	0.422	0.272	0.019	-0.047	0.114	0.876**
9	0.098	0.026	-0.281	0.046	-0.036	-0.115	0.007	0.189	-0.002	0.012	-0.054
10	0.064	0.008	-0.124	0.008	0.160	0.244	0.030	0.003	-0.112	0.076	0.352**
11	-0.019	-0.021	0.105	-0.073	0.216	0.232	0.041	0.011	-0.042	0.203	0.647**

Residual effect = 0.0602. † Refer to Table 1 for character details.

Table 4. Direct and indirect path coefficient (genotypic) of F₂ generation between different characters in garden pea

Character†	1	2	3	4	5	6	7	9	10	11	γ with yield
1	-0.195	-0.471	0.453	-0.356	-0.015	0.261	0.212	0.862	0.289	0.31	-0.370**
2	-0.540	-0.183	0.244	-0.23	0.069	0.06	-0.840	0.433	0.401	0.117	-0.155
3	-0.386	-0.487	0.164	-0.362	-0.005	0.255	-0.308	0.859	0.233	0.275	-0.360**
4	-0.863	-0.501	0.522	-0.185	0.022	0.260	-0.136	0.907	-0.019	-0.048	0.259*
5	0.936	-0.099	-0.312	-0.014	0.609	-0.387	0.828	0.075	-0.368	-0.765	0.374**
6	0.026	0.037	-0.872	0.073	0.589	0.432	0.645	-0.125	-0.492	-0.895	0.378**
7	0.534	0.199	-0.554	0.124	0.299	-0.018	0.721	-0.257	-0.245	-0.982	0.811**
9	-0.350	-0.315	0.278	-0.302	0.037	0.147	-0.789	0.214	-0.034	-0.215	-0.327**
10	0.043	0.256	-0.510	-0.006	0.162	-0.510	0.660	0.030	-0.385	-0.598	0.141
11	0.440	0.064	-0.609	-0.012	0.290	-0.799	0.278	-0.515	-0.515	-0.205	0.694**

Residual effect = 0.0130, † Refer to Table 1 for character details.

The high negative direct effects were for days to 50% flowering followed by shelling percentage in F₁ generation whereas, high negative direct effects were for shelling percentage followed by 1000-seed weight. The results were similar to the findings of Tikka and Asawa (1977), Natarajan and Armugam (1980). It could be concluded that the number of pods per plant, pod length, number of grains per pod, shelling percentage and plant height were the major contributing traits for enhancing green pod yield per plant.

REFERENCES

- Chandel KPS. 1983. Path coefficient analysis of yield components in green seeded peas. *SABRAD J.* 15(1):55-64.
- Dev H and KB Rastogi. 1999. Association and path analysis in pod yield and morphological traits of powdery mildew resistant advanced breeding lines of pea. *Adv. Hort. Forestry* 6:93-97.
- Dewey DR and KH Lu. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* 51:515-518.
- Gupta MK, J.P. Singh and VK Mishra. 1998. Heritability, genetic advance and correlation analysis in pea. *Crop Res. Hisar* 16(2):202-204.
- Joshi PK and VG Narsinghani. 1992. Path analysis in powdery mildew resistant recombinants of pea. *Adv. Plant Sci.* 5:246-248.
- Natarajan S and R Armugam. 1980. Correlation and path coefficient analysis in pea. *Madras Agric. J.* 67(2):287-290.
- Tikka SBS and BM Asawa. 1977. Genetic Parameters Interrelationship and Path Coefficient analysis of yield and its components in pea. *GAU Res. J.* 3(1):5-10.
- Singh V and SP Singh. 1999. Variability and correlation studies in pea. *Annals Agri. Biol. Res.* 4(1):87-91.
- Wakanker SM, LN Yadav and GM Kelker. 1974. Path analysis of yield components in garden pea. *JNKU Res. J.* 8(3-4):192-195.

Evaluation of Cauliflower Varieties and their Planting Dates for Commercial Production under Jumla Agro-Ecological Condition

Yam R Pandey

Agricultural Research Station, Lumle, Kaski

ABSTRACT

Field experiments were conducted at Agriculture Research Station, Rajikot, Jumla (2330 masl) in two consecutive years 1999/2000 and 2000/2001 to identify cauliflower varieties suitable under Jumla agro-ecological condition and their appropriate planting dates for extended production period. Five varieties of cauliflower, namely Jyapu Local, Snow Crown, Snowball-16, Kibo Giant and Kathmandu Local were included in the experiment. These varieties were seeded in the nursery in three different dates at one-month interval on 23rd of March, April, and May. First seeding was done in plastic tunnel against frost and cold weather and other two seedings were done in open raised beds. The results of the experiment showed that all the varieties took almost the same period from seeding to curd initiation. Snowball-16 took the shortest period in all the seeding dates March, April and May with an average of 111 days whereas, Kibo Giant took the longest period with an average of 113 days. However, the period from seeding to curd harvest was highly affected by the varieties and different planting dates. Snowball-16 was found to be the earliest variety for days to curd harvest from seeding with an average of 125 days whereas, Kibo Giant took the longest period of 136 days from seeding to curd harvest. Similarly, March seeding took the longest period from seeding to curd harvest with an average of 131 days and other two April and May seedings took the shortest period with an average of 128 days. The variety and different planting dates did not affect the survivability of plants. The average range of plant survivability of different varieties over the season was 98.3% to 99.7%. Similarly, the plant survivability in different planting dates ranged from 98.6% to 99.6%. All varieties were tolerant to riceyness. Kathmandu Local seeded on 23 March produced the highest fresh curd yield (25.6 t/ha) and the yield was substantially reduced in the delayed seedings. The average mean yield of this variety over the season was 18.5 t/ha. The lowest fresh curd yield was produced by Snowball-16 in all three seeding dates with an average of 6.8 t/ha. The results revealed that Kathmandu Local was the best variety for highest marketable curd yield and it could be recommended for the whole cultivation season. The results also revealed that higher yield was obtained from the early planting and the yield was reduced in the subsequent plantings. The results of the experiment showed that cauliflower could be made available from July to October as off-season production under Jumla agro-ecological condition.

Key words: Cauliflower, Jumla agro-ecology, planting dates

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most popular and highly preferred vegetable crops among the farmers, vegetable traders and consumers in Nepal. It is also considered as the prestigious and high quality vegetable in urban as well as in rural areas. The crop can successfully be grown from Tarai to the high hills in normal and off-season (Pandey and Pokharel 2000). Because of its food value and income generating capability, the crop has been regarded as very important crop in the hills of Nepal. Cauliflower varieties Kathmandu Local and Snowball-16 have been identified as mid season varieties for low, mid and high hill areas (Budathoki et al 1991). Previously Kathmandu Local was a dominant variety and its cultivation was limited only in the normal season. However, with the introduction of exotic varieties such as Snowball-16 and Kibo Giant, its cultivation has been made successful in the late mid season and late season plantings (Jaiswal and Subedi 1996).

There are two main approaches for producing off-season cauliflower in the hills. The first option is the utilization of comparative advantage approach in which a particular area is identified for producing the product

where during that time climate is favorable for the crop. This approach is favorable and applicable for early season cauliflower production. Similarly, the off-season cauliflower could be produced with the introduction of heat and rain tolerant F_1 hybrids especially for late season production.

Cauliflower is an introduced vegetable crop in Jumla and it is one of the important and popular among the farmers and consumers. Kathmandu Local and Snowball-16 were the dominant varieties and their cultivation was limited in the vicinity of the district headquarter of Jumla Bazzar. With the introduction of many exotic varieties both open pollinated and hybrids, the production, productivity and local consumption has increased many folds. However, due to the market problem commercial production of cauliflower has not been practiced yet. Jumla is one of the major pockets for off-season cauliflower production. In general, cauliflower cultivation period in Jumla is May to September. This period is the seasonal production in Jumla while it becomes off-season to the consumers in terai including Nepalgunj and also India. Though the cauliflower is available in the local market during July - August, the potentiality of production is from June to October. Generally farmers plant cauliflower only once during the whole cultivation period, but the plantings could be increased and growing period could be extended up to October. Farmers grow Snowball-16 utilizing locally produced seeds. Because of the seed availability, Snowball-16 is a popular and widely grown variety in Jumla. The productivity of Kathmandu Local was 34.3 t/ha at Dillichaur, Jumla (ARS 2000).

It is obvious that Jumla is a very small market for vegetable. However, Jumla is a high potential area for off-season fresh vegetable production if the product gets market. The government has given top priority to Surkhet-Jumla road and it is expected to complete in near future. When the road is completed, fresh vegetables produced in Jumla could be sent to Nepalgunj and other parts of the country and also abroad. During the production period, cauliflower is a scarce vegetable in terai and is very expensive. Therefore, the technologies should be identified and generated before road completion so that the Jumli farmers could be able to get technologies immediately and increase their production and productivity. The objective of the experiment was to identify the best varieties and their appropriate planting time for increased production and continuous supply.

MATERIALS AND METHODS

The experiment was conducted at Agriculture Research Station (Horticulture), Rajikot, Jumla (2250 masl) during 1999/2000 and 2000/2001. The experiment was arranged in a randomized complete block design (RCBD) with 4 replications. Five promising cauliflower varieties namely Jyapu Local, Snow Crown, Snowball-16, Kibo Giant and Kathmandu Local were included in the experiment. The individual plot size for the experiment was 9.61 m² (3.1- x 3.1-m) with one bed per plot, 6 rows in 60 cm apart in a bed and 6 plants per row, counting a total of 36 plants per plot. Among these varieties, Snow Crown was a hybrid and all other were open pollinated. All these varieties were seeded in the nursery in three different dates at one month interval on 23 March, 23 April and 23 May (10 Chaitra, 10 Baishakh and 10 Jestha). First seeding was done in plastic tunnel against frost and cold weather and other two seedings were done in open raised beds. One-month-old seedlings raised in the nursery were transplanted in the field. Compost 20 and NPK 50:60:50 kg/ha was applied as basal dose during field preparation and additional dose of nitrogen 50 kg/ha was applied as top dressing in three equal split doses at 15, 30 and 45 days after transplanting. Irrigation was applied as and when necessary. The observations on number of days to curd initiation, days to curd harvest, marketable curd yield, plant stand at harvest and quality (riceyness) were collected and statistically analyzed.

RESULTS AND DISCUSSION

Days to curd initiation from seeding

The differences among the varieties on days to curd initiation from seeding was statistically non-significant (Table 1). All the varieties took almost the same period for curd initiation in all the seeding dates. In the first seeding date (March), Jyapu Local and Snowball-16 produced the curds earliest (113 days after seeding) whereas Kibo Giant took the longest period (117 days) for curd initiation. Jyapu Local and Snowball-16 produced the curds earliest (110 days) in the second seeding date (April) whereas Kibo Giant took the longest period of 113 days for curd initiation. All varieties Kibo Giant produced the curds in 109 days after seeding in the third seeding (May). However, the period for curd initiation from seeding was longer in the first seeding than other seedings. Curd initiation was observed in 114 days in March seeding whereas it was observed in 111 and 109 days in the subsequent April and May seedings respectively.

Table 1. Effect of varieties (V) and their planting dates (D) on days to curd initiation of cauliflower under Jumla agro-ecological domain during 1999-2001

Variety	1 st seeding (March)	2 nd seeding (April)	3 rd seeding (May)	Mean
Jyapu Local	113	110	109	111
Snow Crown	115	111	109	112
Snowball-16	113	110	109	111
Kibo Giant	117	113	110	113
Kathmandu Local	114	111	109	111
Mean	114	111	109	112
F test	ns	ns	ns	
	D	V	D × V	
P value	<.001	0.002	0.684	
SED	0.48	0.62	1.08	

Days to curd harvest from seeding

The differences among the varieties on days to curd harvest from seeding was highly significant in all the seeding dates (Table 2). The curd harvesting period from seeding was different among the varieties and planting dates. In the first seeding date (March), Jyapu Local and Snowball-16 produced the curds earliest (128 days after seeding) whereas Kibo Giant took the longest period (139 days) for curd harvest. Snowball-16 produced the curds earliest (123 days) in the second seeding date (April) whereas Kibo Giant took the longest period of 135 days for curd harvest. Similarly, Snowball-16 produced the curds in 123 days after seeding in the third seeding (May) whereas Kibo Giant took the longest period of 135 days for curd harvest. However, the period for curd initiation from seeding was longer in the first seeding than other subsequent seeding. The average period from seeding to curd harvest was found longest (131 days) in March seeding whereas the period was shortened to 128 days in the subsequent April and May seeding.

Table 2. Effect of varieties (V) and their planting dates (D) on days to curd harvest of cauliflower under Jumla agro-ecological domain during 1999-2001

Variety	1 st seeding (March)	2 nd seeding (April)	3 rd seeding (May)	Mean
Jyapu Local	128	130	130	129.
Snow Crown	130	125	125	127
Snowball-16	128	123	123	125
Kibo Giant	139	135	135	136
Kathmandu Local	130	129	129	129
Mean	131	128	128	129
F test	**	**	**	
	D	V	D × V	
P value	<.001	<.001	<.001	
SED	0.26	0.34	0.58	

Riceyness

Riceyness is one of the major problems for reducing marketability of cauliflower grown especially in summer season. The main objective to study this character was to evaluate the variety resistant or tolerant to this problem. Riceyness is the effect of temperature and this character reflects whether the variety is heat tolerant or not. All varieties were found resistant to riceyness. No symptom of riceyness was observed during the whole growing period. This might be due to the congenial temperature and suitable environment available during the whole cauliflower cultivation period in Jumla.

Marketable curd yield

Fresh curd yield is the major variable for selecting a suitable variety and determining appropriate planting time. The differences among the varieties on marketable fresh curd yield was highly significant in all the planting dates (Table 3). The highest fresh curd yield was produced by Kathmandu Local (25.6, 16.8 and 13.1 t/ha seeded in March, April and May respectively). The lowest curd yield was obtained from Snowball-16 in all the seeding dates (9.1, 5.4 and 6.0 t/ha respectively). All the varieties produced highest fresh curd yield in the first seeding (March) with an average of 19.2 t/ha. Similarly the mean curd yield of all varieties was 11.3 and 9.4 t/ha in second (April) and third (May) seedings respectively. Fresh marketable curd yield was reduced with the delayed seeding and planting dates. The highest average fresh curd yield over the season was produced by Kathmandu Local (18.5 t/ha) and the lowest yield was produced by Snoeball-16 with an average of 6.8 t/ha.

Table 3. Effect of varieties (V) and their planting dates (D) on fresh marketable curd yield (t/ha) of cauliflower under Jumla agro-ecological domain during 1999-2001

Variety	1 st seeding (March)	2 nd seeding (April)	3 rd seeding (May)	Mean
Jyapu Local	18.2	14.2	10.8	14.4
Snow Crown	23.7	14.0	11.2	16.3
Snowball-16	9.1	5.4	6.0	6.8
Kibo Giant	19.5	6.1	6.0	10.5
Kathmandu Local	25.6	16.8	13.1	18.5
Mean	19.2	11.3	9.4	13.3
F test	**	**	**	
	D	V	D x V	
P value	< .001	< .001	< .001	
SED	0.17	0.22	0.38	

Plant stand at harvest (Survivability)

Plant stand at harvest of the crop varieties is one of the important parameter for summer and off-season production of vegetables, which determines the resistance and tolerance of a variety to a particular environment. The survivability percent among the varieties and planting dates were not statistically different (Table 4). It might due to the suitable period for cauliflower cultivation in Jumla. The survivability is also affected by the adverse climatic condition and it is obvious that the genetic characters of a variety show resistance and susceptibility. The average mean survivability over the growing season was the highest in Snowball-16 (99.7%) and the lowest in Snow Crown (98.3%).

Table 4. Effect of varieties (V) and their planting dates (D) on plant survivability of cauliflower under Jumla agro-ecological domain during 1999-2001

Variety	1 st seeding (March)	2 nd seeding (April)	3 rd seeding (May)	Mean
Jyapu Local	99.0	100.0	99.0	99.3
Snow Crown	96.0	99.0	100.0	98.3
Snowball-16	99.0	100.0	100.0	99.7
Kibo Giant	100.0	99.0	99.0	99.3
Kathmandu Local	99.0	99.0	100.0	99.3
Mean	98.6	99.4	99.6	99.2
F test	ns	ns	ns	
	D	V	D x V	
P value	0.147	0.370	0.177	
SED	0.529	0.682	1.182	

CONCLUSION

Among the evaluated five varieties, no one variety showed the earliness character for curd initiation. But the period from seeding to curd harvest was highly affected by the varieties and seeding dates. Snowball-16 took the shortest period from seeding to curd harvest whereas Kibo Giant took the longest period. Since the environment did not affect the survivability of plants, the result showed that the climate is suitable for cultivation of all cauliflower varieties during the whole growing period for their curd quality and productivity. Kathmandu Local was found to be the most suitable variety for whole season production under Jumla agro-ecological condition for curd quality, production and productivity. However, cauliflower planted in early season produces higher curd yield than delayed plantings. For commercial growers, Kathmandu Local variety could be recommended for the whole season (March to October) cultivation under Jumla agro-ecological condition.

REFERENCES

- ARS. 2000. *Annual report (1999-2000)*. Agricultural Research Station, Rajikot, Jumla, Nepal.
- Budathoki K, PP Subedi and GB Gurung. 1991. Vegetable crop technology recommended for the Western hills of Nepal. *LARC Technical Paper No 6/9*, Kaski, Nepal
- Jaiswal JP and PP Subedi. 1996. Varietal cum boron trial on late season cauliflower conducted at outreach research sites during 1994/95. *LARC Working Paper No 96/33*, Kaski, Nepal.
- Pandey YR and TR Pokharel. 2000. Varietal evaluation of late season cauliflower. **In:** *Proceedings of the Third Horticulture Crops Workshop*. Horticulture Research Division, Khumaltar, Nepal (in press).

Identification of Suitable Wheat Genotypes for Far Western High Hills of Nepal

Mahesh L Vaidya

Agricultural Research Station, Jumla

ABSTRACT

Twenty wheat genotypes were evaluated at Agricultural Research Station, Jumla and Sheep and Goat Research Farm, Guthichour. These two locations represent the high altitude and low altitude of the Far Western high hills of Nepal. The experiment was laid out in randomized complete block design with three replications. The analysis showed highly significant grain yield difference at both the locations. These genotypes have also been evaluated against incidence of major diseases and insect pests. In terms of grain yield four varieties such as WK 904 (3810 kg/ha), WK 935 (3563 kg/ha), WK 914 (3505 kg/ha) and WK 930 (3556 kg/ha) and in terms of bio-mass two varieties WK 921 (4091 kg/ha) and WK 919 (3901 kg/ha) have been identified to be suitable for the study areas. Based on the three years research, these identified varieties can be recommended to similar ecosystem within the Far Western high hill regions of Nepal.

Key words: Far Western, Nepal, wheat

INTRODUCTION

Wheat is cultivated in a wide range of environments ranging from the Tarai to the high mountain region of the country, as a winter crop. It occupies the total area of 660040 ha and the total production is 1183530 t with the average productivity of 1790 kg/ha. In the hilly region, wheat occupies 0.24 million hectares and produce 0.36 million tones of grain. However, wheat productivity in the high altitude is below than the national average. Susceptible to cold are the major factor at high altitude region like Jumla for the low productivity. It also depends on the general practice of late sowing causes late maturity because of the excessive soil moisture of previous crop. Therefore, this experiment was implemented to improve the productivity and the production of wheat, through selecting a superior genotype resistant to diseases, pests and wide adaptability. The existing local cultivars are mostly susceptible to rusts, loose smut, bunt and other stresses. To improve the productivity and production, we need to develop the superior genotypes suitable for high hill conditions ie resistant to poor nutrient management, resistant to insect pests and diseases, wide adoptive to the micro-climatic conditions and resistant to environmental fluctuation (frost and drought).

MATERIALS AND METHODS

Twenty high altitude genotypes including local check were evaluated in RCB design with four replications in 3 years. Plot size of 4 m² was allocated for each treatment. Spacing was continuous, row at a distance of 25 cm. Chemical fertilizer was applied at the rate of 80:40:20 kg N:P:K/ha. Half dose of N with full dose of P and K were applied before sowing as basal dose. Remaining half dose of N was applied during tillering stage of wheat after a month of planting. Seed rate was 150 kg/ha. This trial was conducted at two locations, one at ARS, Jumla and second at Sheep and Goat Research Programme, Guthichour. Irrigation was applied as needed. Seed were sown on 1st week of November in every year. The cropping patterns followed by the farmers at Jumla were wheat-fallow and wheat-beans. Other practices were as farmer's. Germination percent, phenological parameters, lodging score, plant height and yield components were studied.

RESULTS AND DISCUSSION

Among the 20 tested genotypes of wheat, data indicated grain yield was highly significant difference among the genotypes under study, however, the highest yield of 3810 kg/ha was produced by genotype WK-904, which was at par with WK-935 (3563 kg/ha), WK-930 (3556 kg/ha) and WK-914 (3505 kg/ha) (Table 1a, 1b).

Table 1a. Traits responses of wheat genotypes tested for high altitude regions

SN	Genotype	Days to heading			Mean	Days to maturity			Mean	Plant height, cm			Mean
		2000	2001	2002		2000	2001	2002		2000	2001	2002	
1	WK904	219	219	211	216	254	252	245	250	88	101	89.8	92.9
2	WK912	209	207	204	207	249	240	242	244	66	75	65.8	68.9
3	WK914	226	221	217	221	262	257	250	256	78	89	86	84.3
4	WK916	228	220	219	222	262	252	251	255	79	93	79	83.7
5	WK919	229	223	218	223	262	254	253	256	98	100	101	99.7
6	WK921	228	221	217	222	261	250	251	254	79	96	82.8	85.9
7	WK901	215	217	212	215	252	250	249	250	91	104	91	95.3
8	WK960	223	221	214	219	261	251	252	255	83	109	89.5	93.8
9	WK961	210	212	210	211	251	247	249	249	72	87	80	79.7
10	BEZOS'	227	221	214	221	262	251	250	254	97	115	109	107
11	WK962	229	222	213	221	264	258	253	258	95	113	104	104
12	WK963	235	225	222	227	263	249	253	255	75	88	74.3	79.1
13	WK964	228	221	217	222	261	253	251	255	75	91	76.5	80.8
14	WK930	222	215	207	215	261	249	245	252	93	119	105	105.7
15	WK931	225	220	215	220	262	251	249	254	99	122	107	109.3
16	WK933	209	209	205	208	250	240	249	246	71	85	87.5	81.2
17	WK934	209	212	204	208	250	243	244	246	64	80	72.8	72.3
18	WK935	208	208	205	207	251	241	244	245	69	77	68.5	71.5
19	WK936	211	215	208	211	255	246	249	250	78	92	109	93
20	JUMLA	222	220	214	219	261	255	252	256	113	146	120	126.3
Mean					219.8				252.1				90.7
F test					**				**				**
CV, %					1.22				1.02				6.14
LSD (0.05)					4.36				4.24				9.2

Table 1b. Yield and yield related traits of wheat tested for high altitude regions

SN	Genotype	Spikes/m ² , n			Av	1000-grain weight, g			Av	Grain yield, kg/ha			Av	Biomass, kg/ha			Av
		00	01	02		00	01	02		00	01	02		00	01	02	
1	WK904	260	312	216	263	44	32	37	37.7	2771	4962	3698	3810	1302	6417	3860	3860
2	WK912	189	309	238	245	44.1	30	36	36.7	2254	3894	3323	3157	1219	4083	2651	2651
3	WK914	258	243	245	249	44.8	36	38	39.6	3005	4118	3391	3505	1179	6500	3839	3839
4	WK916	254	288	227	256	44.7	33	38	38.6	2918	3984	3463	3455	985	5833	3409	3409
5	WK919	281	242	233	252	40.3	33	37	36.8	2682	4040	2801	3174	1152	6667	3910	3910
6	WK921	329	285	258	291	38	30	36	34.7	3018	4390	2782	3397	1431	6750	4091	4091
7	WK901	216	246	200	221	42.7	34	38	38.2	2541	4375	2757	3224	984	6333	3659	3659
8	WK960	202	262	193	219	45.6	34	36	38.5	2761	4659	2412	3277	829	5500	3165	3165
9	WK961	195	283	235	238	46.3	42	40	42.8	2322	3658	2705	2895	1077	5083	3080	3080
10	BEZOS'	258	258	228	248	43.1	33	39	38.4	2440	4291	2798	3176	1245	6167	3706	3706
11	WK962	249	279	249	259	33.3	28	38	33.1	2504	3639	2850	2998	1097	5417	3257	3257
12	WK963	211	312	260	261	48.6	33	32	37.9	2237	3579	2298	2705	1204	5750	3477	3477
13	WK964	237	269	232	246	36.5	36	36	36.2	2383	3992	3240	3205	849	6083	3466	3466
14	WK930	193	279	219	230	53.8	40	45	46.3	2574	4324	3770	3556	1219	5333	3276	3276
15	WK931	182	282	208	224	44	33	36	37.7	2124	3597	2516	2746	942	4750	2846	2846
16	WK933	173	219	262	218	43	36	36	38.3	2269	3408	2993	2890	1100	4583	2841	2841
17	WK934	226	259	245	243	46.2	33	38	39.1	2499	3717	3801	3339	1311	5750	3531	3531
18	WK935	246	246	247	246	47.4	37	37	40.5	3278	3888	3523	3563	1065	6000	3532	3532
19	WK936	242	213	273	243	37.5	36	39	37.5	1968	4423	3844	3412	1052	4750	2901	2901
20	JUMLA	300	261	243	268	36.5	33	31	33.5	2296	3813	2265	2791	1089	5750	3420	3420
Mean					246				38.1				3214				3396
F test					**				**				**				**
CV, %					12.6				7.5				11.4				10.55
LSD (0.05)					51.0				4.7				603				592

Av, Average. 00, 2000. 01, 2001. 02, 2002.

Genotypes were varied from 107 (WK-935) to 227 (WK-963) days for heading. For maturity, 244 (WK-912) to 258 (WK-962) days were recorded. The very important trait for high yielding, number of spike/unit area was highly difference among the genotypes, which ranges from 243 to 291 per m². This is also low for high altitude regions. The 1000-kernel weight ranges from 46.3 (WK-930) and lowest was 33.5 g (Jumla local). This trait highly significantly influenced grain yield but it was low in terms of normal condition. Highest biomass was recorded in genotype WK-921 (4091) and followed by WK-919 (3910).

CONCLUSION

WK 904, WK 935, WK 930 and WK 914 have been identified to be suitable for high altitude regions of Nepal. These genotypes have higher yield potential and also are resistant to major diseases and insect pests.

Identification of Suitable Rice Genotypes for High Altitude Region of Nepal

Mahesh L Vaidya

Agricultural Research Station, Jumla

ABSTRACT

Sixteen rice genotypes were evaluated at Agricultural Research Station, Jumla. These genotypes were selected from coordinated varietal trials based on their suitability for the high hill eco-system of the Far Western Region. The experiment was laid out at randomized complete block design with three replications. The statistical analysis showed highly significant difference in grain yield. These genotypes have also been evaluated against incidence of major diseases and insect pests. The highest grain yield was produced by Jinling-78 (5651 kg/ha) followed by NR 10288-10J-2J (5271 kg/ha) and Yunlen-1 (5156 kg/ha) respectively. These varieties are resistance to blast, which is a very severe rice disease in this area.

Key words: Cold tolerance, high altitude, rice genotypes

INTRODUCTION

Rice (*Oryza sativa*) is the first important cereal crop consumed as staple food by the people in Nepal. It occupies a total area of 1560044 ha and its total production is 4216465 t with the average productivity of 2600 kg/ha. Out of the total cultivated area of the country 372809 ha (24.7%) is prevalent in the hills and 43460 ha (2.9%) in the high hills. The average productivity of rice in hills and high hills is 2314 and 1905 kg/ha respectively. In Jumla district it is cultivated in an area of 2810 ha and the total production is 4162.5 t with the average productivity of 1730 kg/ha. Low levels of chemical fertilizers are used for rice cultivation and its production is maintained by the application of compost in the range of 10-15 t/ha. Low temperature prevailing during the rice-growing season is the key factors, for lowering its production. This experiment was conducted to identify suitable variety, high yielding, resistant to disease, early maturing and cold tolerant genotypes under Jumla condition.

MATERIALS AND METHODS

Sixteen genotypes including Jumli Marshi were evaluated in this experiment, which was conducted in RCBD with three replications. The plot size was 3- × 2-m. The chemical fertilizers were applied @ 60:30:30 kg N:P:K/ha. Seeded was done in 25 March (traditional date for seed sowing in Jumla). The seedlings were transplanted on 7 June (traditional date for transplanting rice seedling on main field in Jumla). The chemical fertilizers were applied at the time of transplanting on the same day as a basal dose @ 30:30:30 kg N:P:K/ha. The crop was top-dressed with 30 N kg/ha at the time of tillering stage of the crop. Weeding and other agronomic practices were adopted as per requirements of the crop. Observation was recorded on major agronomic parameters like days to heading, maturity, plant height, panicle length, effective tiller, grain yield and straw yield. Harvesting was started from 3rd week of October.

RESULTS AND DISCUSSION

Grain and straw yield data indicated highly significant difference among the genotypes (Table 1). The highest grain yield was produced by the genotype Jinling-78 (5651 kg/ha), NR 10288-10J-2J (5271 kg/ha) ie at par with Yunlen-1 and NR 10288-015J-015J-7 (5135 kg/ha) and is significantly higher than the rest of other genotypes. Lowest grain yield was produced by Chhommrong (3650 kg/ha). The difference in the grain yield in the number

of effective tillers was highly significant. The maximum effective tillers was found in genotype NR10288-10J-2J (252.3). The minimum effective tillers were found in the genotype Jumli Kalo, Jumli Marshi and the Chhomrong. The difference in panicle length was significant and NR 10288-015J-015J-7 ranked second (23.0 cm) after NR10288-10J-2J (22.70 cm). The difference in the plant height was highly significant. NR 10288-10J-2J was the tallest (85.0 cm) which at par with NR 10288-015J-015J-7 (83.3 cm). The shortest plant height was observed in Chhomrong (63.3 cm). The difference in the maturity days was highly significant. NR 10288-10J-2J (200 days) was late maturity type and Chhomrong (184 days) the earliest maturity type. The difference in filled grains per panicle was also highly significant. Filled grain per panicle in NR 10288-10J-2J was 48.3, which is at par with NR 10288-015J-015J-7 (35.66). However, the former has significantly higher unfilled grains than Chhomrong.

Table 1. Comparative performance of rice genotypes in JSVT at ARS Jumla, 1999/2002†

SN	Entry	Days to heading	Maturity days	Plant height, cm	Panicle length, cm	Effective tillers/m ²	# of Panicle/m ²	Unfilled grain/panicle	Filled grains/panicle	1000-grain wt, gm	yield, Grain kg/ha	Straw yield kg/ha
1	NR10288-10J-2J	153.0	200.0	85.0	23.0A	12.30	252.3A	48.3A	120.7A	36.0A	5271AB	9840A
2	NR10288-015J-015J-7	151.0	198.7	83.3	22.7A	10.3	237.0A	35.7B	117.0AB	34.7A	5135AB	8400AB
3	Yunlen-1	146.0	196.0	81.0	22.0A	10.0	236.7A	27.3B	94.3	34.3A	5156AB	8160AB
4	Jinling-78	145.3	196.0	78.0	21.7A	10.0	230.0A	26.3B	88.0	37.5A	5651A	8040ABC
5	NR10262-9-2-3	144.7	193.0	77.66	21.7A	10.0	229.7A	23.3B	79.3	31.7A	4952ABC	7920ABC
6	NR10293-05J-015J-8	139.7	193.0	76.33	21.0A	9.7A	228.3A	22.3C	79.3	31.3A	4880ABC	7680ABC
7	NR10288-15J-1J	139.3	191.7	76.0	20.3A	9.7A	227.7A	20.0C	76.7	31.0A	4801ABC	7200BC
8	NR10288-15J-1J-1	139.0	190.3	72.3	20.3A	9.7A	227.0A	19.0C	71.3	30.7A	4658ABC	6840BC
9	NR10260-10J-4J	137.7	190.0	71.3	19.7A	9B	227.0A	18.7C	66.3	30.3BC	4562ABC	6600BC
10	NR10288-015J-015J-6	137.0	189.7	70.7	19.3A	9.0B	215.0A	18.7C	60.0	30.3BC	4496BCD	6600BC
11	NR10346-4-1-3	132.7	189.0	69.3F	19.3A	9.0B	209.3B	18.0C	65.0	30.0BC	4419BCD	6360BC
12	Jumli Seto	131.0	189.0	69.3F	19.3A	9.0B	206.0B	17.0C	57.7	30.0BC	4192CDE	5760BC
13	Yunlen-3	130.0	189.0	68.0F	18.7B	8.7B	193.3C	16.7C	57.0	29.3BC	4097DEF	5760BC
14	Jumli Kalo	130.0	187.0	67.7F	18.7B	8.3B	191.3C	15.0C	55.3	28.3BC	4078DEF	5400C
15	Jumli Marshi	129.0	187.0	64.0	17.7C	8.3B	179.0D	13.0D	52.0	27.0BC	3821EF	5400C
16	Chhomrong	128.7	184.0	63.3	17.0D	8.0B	178.3D	11.3E	49.7	26.2C	3650F	5360C
	F test	**	**	**	*	ns	**	**	**	ns	**	**
	LSD (0.05)	2.640	5.433	5.194	3.214	2.688	35.69	11.61	29.1	6.671	836.9	22.7
	CV, %	1.14	1.70	4.25	9.56	17.08	9.89	31.76	23.4	12.93	10.93	19.56

† JSVT, Jumla Selection Varietal Trial. ARS, Agriculture Research Station. Value followed by the same letters within the column are not significantly different at 0.05 level. *, **, Significant at 5 and 1% level respectively. ns, non-significant.

The difference in 1000-grain weight was not significant within the genotypes but NR 10288-10J-2J has the highest grain weight (38.3 g) and Chhomrong (26.21 g). The straw yield was highly significant. The highest straw yield of 9840 kg/ha was produced by the genotype NR 10288-10J-2J ie at par with NR 10288-015J-015J-7 (8400 kg/ha) and Yunlen-1 (8160 kg/ha) but the lowest straw yield was produced by Jumli Kalo (5400 kg/ha), Jumli Marshi (5400 kg/ha) and Chhomrong (5360 kg/ha). Among these genotypes considering the phenological, agronomic and yield potential NR 10288-10J-2J and NR 10288-015J-015J-7 were good however these genotypes were highly susceptible to stalk rot and moderately susceptible to neck blast. So, further research is necessary.

Improvement of Banana Productivity through Varietal and Husbandry Practices in the Western Hills of Nepal

Yam R Pandey, Deep N Sah and Amar B Pun

Agricultural Research Station, Lumle

ABSTRACT

Banana genotypes and crop management (optimum fertilizer dose, clump management and date of planting) experiments were conducted in participation with the farmers at Chambas and Rising Patan, Tanahu; Taranagar, Gorkha and Pakuwa, Parbat in three consecutive years 1999 to 2002 to evaluate and identify the best genotype(s) and to develop crop management practices for increased production and productivity of banana in the western hills of Nepal. Ten genotypes namely, Jhapali Malbhog, Rajhar Malbhog, Chiniya Champa (Rampur), William Hybrid (Rampur), Harichhal (Chambas), Malbhog (Rising Patan), Kanthali (Rising Patan), Lahan Basarai Dwarf, Malbhog (Pokhara) and Chiniya Champa (Trishuli) were evaluated in the farmer's fields. Among these, Jhapali Malbhog and William Hybrid were identified as the best genotypes due to high yield (24.3-26.37 kg bunch weight ie >50 t/ha), less winter injury, better fruit size, taste, aroma, storability and marketability in the low hills and river basin areas of western Nepal. Among the different doses and combination of fertilizer application, 300:110:300 gram NPK/plant/year in three split doses in February, May and August has been identified as the optimum dose for earliness (465 days to flowering), highest number of fingers (210) per bunch and bunch weight (52.65 kg) and the biggest bunch size (152.62 cm²). Planting single sucker in a hill spaced 2 m between hills and leaving a new sword sucker along with the mother plant before flowering has been found to be the best clump management practice for earliness, bigger fruit size and higher fruit yield. The appropriate time of banana planting in the low hills is February to April that can escape cold injury and increase the banana productivity. The results also revealed that the delayed plantings reduced the fruit yield, number of palms and fingers and also delayed the harvesting time.

Key words: Banana, husbandry practices, Western hills

INTRODUCTION

Banana (*Musa* spp) is the second most important fruit for production purposes and is popular under subsistence farming in the hills (LARC 1993). Banana is available throughout the year and it is highly preferred by consumers. Since banana is considered as a holistic plant it is widely used in religious occasions and festivals. Banana has the highest food value among the fruit crops and it surpasses most vegetables including potato in energy value and tissue building elements (Karki 2002). The average national productivity of banana is 12 t/ha but under better management condition, the yield potential is up to 50 t/ha. Total area under banana cultivation in Nepal is 4216.4 ha and the annual production from the fruiting area of 3467 ha is 49204 t (ASD 2002).

The remoteness, marginality and fragility features of hills and variation in altitude, steepness, slope facing, temperature, rainfall etc limit the developmental option in the hills and offers a comparative advantage for cultivation of fruit crops. The fruit crops give higher productivity than any other crops (Shrestha and Sharma 1995) which can help to reduce the poverty in the hills, provide farmers a high income opportunity, reduce migration of hill people to cities and Tarai and minimize environmental degradation. Land holdings of hill farmers are small as compared to Tarai farmers. Therefore, growing high value fruit crop like banana on sloppy and marginal land reduces soil erosion and can benefit resource poor farmers.

Most of the hill farmers grow banana in kitchen garden but not on commercial scale. They do not take care technically about proper management like manuring, irrigation and optimum plant population. In the hills, the performance of banana is poor due to lack of cold tolerant high yielding banana varieties. Malbhog, Dhusre, Mugre and Chiniya Champa are the predominant local cold tolerant genotypes in the hills. Dhusre and Mugre are considered as the low quality bananas and their productivity is also low. Despite very low productivity of local Malbhog banana, taste, storability and marketability is very high. Many commercial and semi-commercial banana orchards exist at low altitudes (250-1000 masl), but the production and productivity of banana in these areas are not satisfactory.

It is a well known fact that the banana plant is an extremely nutrient demanding and therefore, addition of mineral fertilizers is of prime importance for its cultivation on many soils. In general, hill farmers plant banana in marginal land or low fertile homestead and no fertilizer is applied during the whole crop period. The total uptake of elements shows that the primary elements are utilized more during the vegetative and reproductive phases.

In the western hills, farmers do not maintain the clumps and suckers for high production and quality. Farmers are unaware of sword and water suckers and number of suckers in a hill to be maintained. The suckers produced by different varieties vary in number and the time of sucker production by parent plant has shown that more than half the number of total suckers produced by a plant are produced since flowering of the mother plant (Shanmugavelu et al 1992). In a pure crop of banana, where single crop is only taken, usually all the suckers which arise before flowering are removed as it will compete with mother plant for nutrients resulting in reduction of bunch size. Removal of all suckers up to flowering of the plant and maintaining only one sucker afterwards is the best desuckering practice (Rao and Shanmugavelu 1973).

Banana is a tropical plant and it does not resist cold. The vegetative and reproductive phases of banana should be escaped from winter cold. Planting season should be adjusted to escape high winds and severe cold at the time of flower or near flowering stage. The planting period should be adjusted so that active growth phase of the plants can continue smoothly during flower bud initiation stage.

The poor production and productivity of banana is mainly due to the lack of appropriate variety and poor management practices like clump management, soil fertility maintenance, timely irrigation and plant protection measures (LARC 1993). In addition to this, the poor quality of fruits of existing varieties fetch low price in the market. The objectives of this study were to identify high yielding varieties of banana for a wide range of agro-climatic conditions and to develop management practices to increase the productivity of banana in the Research Command Area (RCA) of ARS, Lumle.

MATERIALS AND METHODS

Local and exotic genotypes were collected from the major banana growing pockets of the country. Based on their yield performance and farmer's preferences ten promising genotypes were selected for evaluation.

Evaluation of genotypes

The collected 10 genotypes were evaluated from 1999 to 2002 at Chambas, Rising Patan and Taranagar. Four landraces of Malbhog from different sources, two of Chiniya Champa, one each of William Hybrid, Kanthali, Harichhal and Basarai Dwarf were evaluated in a Randomized Complete Block Design with 3 replications (farmer as a replication). Four plants of each genotype were planted in bari land at a spacing of 2- × 2-m between the hills. Compost 20 kg and DAP 120 g, urea 100 g and MoP 139 g per plant were applied as a basal dose at the time of pit preparation (in February). In May, 81 g of urea and 139 g of MoP/pit were top dressed. From the next season onward fertilizer was applied in three split doses (in February, May and August @ 225:110:250 g NPK/hill/year). Timely desuckering, removal of old leaves and other cultural operations were done. A questionnaire was developed and information were collected from the farmers on pre and post harvest quality and fruit preferences. The collected data was analyzed by using MSTAT computer software.

Fertilizer management

A fertilizer management experiment was conducted at Rising Patan and Pakuwa. A total of 6 different treatments were evaluated in William hybrid variety. The specified treatments were splitted into 3 times (February, May

and August) and were applied in a ring. Different doses of fertilizer were 150:110:150; 300:110:300; 150:110:300; 300:110:150; 225:110:250 g NPK/plant/year and as a check 0:0:0 g NPK/plant. Planting was done in a spacing of 2- × 2-m between plants and rows. A new sucker was left before flowering along with the mother plant and desuckering of all other new suckers was done. Hoeing, weeding and mulching was done as and when needed. Mulching and irrigation was done during the summer season.

Clump management

The experiment on clump management was conducted at Rising Patan, Taranagar and Pakuwa in William Hybrid variety. A total of 7 treatments with different plant combinations were evaluated in a RCBD with three replications (farmer as a replication). Single plant per hill in all the treatments were planted in February-March. The treatments were single mother plant left in a hill and all other new suckers removed; two mother plants left in a hill and all other new suckers removed; three mother plants left in a hill and all other new suckers removed; one mother plant one new sucker left in a hill before flowering; one mother plant two new suckers left in a hill before flowering; one mother plant two new suckers left in a hill at different age and one mother plant three new suckers left in a hill before flowering. The planting was done in a spacing of 2- × 2-m between plants and rows and each replication have 4 plants. Compost 20 kg and DAP 120 g, urea 100 g and MoP 139 g per plant was applied as a basal dose at the time of pit preparation in February. As a top dressing in May, 81 g of urea and 139 g of MoP/pit was applied. From the next season onward fertilizer was applied in three split doses in February, May and August @ 225:110:250 g NPK/hill/year. Timely desuckering, removal of old leaves and other operations were done.

Time of planting

In order to identify the appropriate time of banana planting, William hybrid was planted in seven different dates at one month interval starting from 1 February to 1 August (17 Magh to 17 Shrawan) at Pakuwa and Chambas. Fairly uniform sized suckers were planted in a RCBD with three replications (farmer as a replication). Planting was done with a spacing of 2- × 2-m between plants and rows. Four plants per replication were maintained. A sucker was left before flowering along with the mother plant. Compost 20 kg and DAP 120 g, urea 100 g and MoP 139 g per plant was applied as a basal dose at the time of pit preparation in February. As a top dressing in May, 81 g of urea and 139 g of MoP/pit was applied. From the next season onward fertilizer was applied in three split doses in February, May and August @ 225:110:250 g NPK/hill/year. Timely desuckering, removal of old leaves and other operations were done.

RESULTS AND DISCUSSION

Genotypic evaluation

Genotypic variation for days to flowering, bunch weight, number of palm/bunch, number of fingers/bunch and plant height were found significantly different (Table 1). The flowering days was highly affected by the genotypes. The longest duration for flowering was found in Basarai Dwarf (517 days) and the shortest duration in Rajhar Malbhog (387 days). The highest bunch weight was recorded in Kanthali (35.62 kg) followed by Basarai Dwarf (27.22 kg) and William Hybrid (26.37 kg). The lowest bunch weight was recorded in Rajhar Malbhog (11.4 kg).

The highest number of palms/bunch (14) was recorded in Kanthali followed by Basarai Dwarf (12), William Hybrid and Rampur Chiniya Champa (11). Since banana fruits are sold by counting the fingers, number of fingers/bunch is the most important traits that contribute the overall banana productivity and economic return. The variation among the genotypes was highly significant. The high number of fingers was recorded in Kanthali (259), Basarai Dwarf (238), William Hybrid (220) and Jhapali malbhog (217). However, considering the pre and post harvest attributes of banana including marketability of the fruit, farmers ranked Jhapali Malbhog first, William Hybrid second and Basarai Dwarf (Robusta) third. Genotypes varied significantly for the plant height. The tallest plant (396.67 cm) was recorded in Kanthali and the shortest (150.20 cm) stature was in Harichhal.

According to the perception of farmers from experimental sites, Robusta and Kanthali were late in maturity, whereas William hybrid and Harichhal were early. Yield potential of William Hybrid, Jhapali Malbhog and Robusta was high. The overall ranking of the tested genotypes showed that Jhapali Malbhog, William Hybrid and Robusta stood first, second and third respectively (Table 2). Despite the high yield of Kanthali and Robusta,

farmers ranked Kanthali as worst for taste and Robusta was very susceptible to cold, the main constraint for banana cultivation in the hills.

Table 1. Crop duration and yield parameters of banana genotypes in RCA of ARS, Lumle during 1999-2002.

SN	Genotype	Days to flowering	Bunch weight, kg	Number of palm/bunch	Number of finger/bunch	Plant height, cm
1	Jhapali Malbhog	418	24.3	10	217	275.66
2	Rajhar Malbhog	387	11.4	8	103	323.66
3	Chiniya Champa (Rampur)	413	17.75	11	165	290.00
4	William Hybrid (Rampur)	425	26.37	11	220	303.00
5	Harichhal (Chambas)	397	26.13	9	148	150.20
6	Rising Patan Malbhog	388	12.00	8	94	320.00
7	Rising Patan Kanthali	474	35.62	14	259	396.67
8	Lahan Basarai Dwarf	517	27.22	12	238	216.00
9	Pokhara Malbhog	426	13.10	8	151	337.50
10	Chiniya Champa (Trisuli)	464	12.82	8	116	278.65
	Mean	431	20.07	10	157.7	289.13
	CV, %	5.51	32.43	14.50	20.69	16.71
	P value	<0.001	<0.01	<0.001	<0.001	<0.01
	SED	9.7	5.32	1.18	26.64	24.64

Table 2. Farmer's perception on the performance of banana genotypes in Lumle's RCA during 1999-2000

SN	Variety	Pre-harvest							Post-harvest		Rank	
		DTM	WintInj	YldPot	WindSus	Taste	Aroma	Color	Fruit	Stor		Mark
1	Jhapali Malbhog	Medium	Less	High	Less	Best	Best	Good	Best	Best	Good	1
2	Rajhar Malbhog	Medium	Less	Low	Less	Better	Best	Better	Good	Good	Good	5
3	Chiniya Champa	Medium	Less	Low	Less	Good	Poor	Best	Good	Good	Fair	4
4	William Hybrid	Early	Less	High	Less	Good	Best	Good	Better	Poor	Good	2
5	Harichhal	Early	Less	Low	Less	Fair	Good	Bad	Worst	Good	Poor	7
6	Rising Patan Malbhog	Medium	Less	Low	Less	Good	Good	Good	Good	Good	Good	6
7	Kanthali	Late	Severe	Low	High	Worst	Poor	Better	Good	Good	Poor	7
8	Robusta	Late	Severe	High	Resist	Good	Good	Fair	Good	Poor	Good	3
9	Pokhara Malbhog	Medium	Less	Low	Less	Good	Good	Good	Good	Good	Good	5
10	Chiniya Champa Trisuli	Medium	Less	Low	Less	Good	Fair	Better	Good	Good	Fair	4

DTM, Maturity days. WintInj, Winter injury. YldPot, Yield potential. WndSus, Wind susceptibility. Fruit, Fruit size. Stor, Storability. Mark, Marketability. Rank, Overall ranking.

Fertilizer management

Among the six different fertilizer doses and combinations, none of the treatments varied significantly for days to flowering (Table 3). However, application of 300:110:150 g NPK/plant/year prolonged flowering to longest duration (561 days). Plants fertilized with 300:110:300 g NPK/plant/year took the shortest crop duration of 465 days. Treatment variation on number of palms/bunch was highly significant. The highest number of palms/bunch (15) was recorded in 300:110:300 and 150:110:300 g NPK/plant/year and the lowest number of palms/bunch was recorded in control plot (without fertilizer application).

The effect of N, P and K on number of fingers per bunch was highly significant. The highest number of fingers/bunch (210) was recorded in 300:110:300 g NPK/plant/year followed by 150:110:300 (205) and 225:110:250 g NPK/plant (202). The lowest number of fingers/bunch (143) was recorded in control (without fertilizer application). The effect of N, P and K on the weight of bunch was highly significant. The highest bunch weight was recorded in 300:110:300 g NPK/plant (52.65 kg) followed by 150:110:300 g NPK/plant (51.1 kg). The lowest was recorded from control plot 31.44 kg. The difference among the treatments on finger size was found significantly different. The biggest finger size (152.62 cm²) was obtained from 300:110:300 g NPK/plant/year and the smallest fingers from the control (100.65 cm²).

Clump management

Among the seven treatments evaluated, treatment variation was observed highly significant (Table 4). The longest crop duration ie days to flowering (458 days) was taken by the plants where three suckers were left before flowering along with the mother plant. The earliest flowering (406 days) was recorded in the treatment where the single sucker was left before flowering along with the mother plant. The treatment variation on

producing the number of palms per bunch was also highly significant. The highest numbers of palms were recorded (30) in the treatment where triple plants were left in a hill and all other new suckers were removed. The lowest number of palms (12) was in the treatment where single plant was left for flowering and all other new suckers were removed (Desuckering).

Table 3. Effect of different combinations of N, P and K on the crop duration and yield contributing factors of banana in RCA of ARS, Lumle during 1999-2002

Treatment (g NPK/plant)	Days to flowering	Number of palm/bunch	Number of fingers/bunch	Bunch weight, kg	Finger size, cm ²
1. 150:110:150	559	12	194	38.73	121.75
2. 300:110:300	465	15	210	52.65	152.62
3. 150:110:300	508	15	205	51.10	123.00
4. 300:110:150	561	14	192	44.20	120.35
5. 225:110:250	500	14	202	47.30	117.60
6. 0:0:0	536	10	143	31.44	100.65
Mean	522	13	161	44.30	122.67
CV, %	11.04	3.83	3.18	3.57	12.73
P value	ns	<0.001	<0.001	<0.001	<0.01
SED	-	0.36	4.2	1.2	11.04

Table 4. Performance of different clump management practices on yield parameters of William hybrid banana in RCA of ARS, Lumle during 1999-2002

Treatment	Days to flowering	Total number of palm/hill	Total number of fingers/hill	Girth of finger, cm
1. Single plant + desuckering	411	12	196	3.6
2. Double plant + desuckering	441	22	353	3.6
3. Triple plant + desuckering	442	30	465	2.0
4. Single plant + 1 sucker before flowering	406	23	354	3.4
5. Single plant + 2 suckers before flowering	436	21	339	3.2
6. Single plant + 2 suckers of different age	438	20	286	3.2
7. Single plant + 3 suckers before flowering	458	20	254	3.1
Mean	433	21	321	3.3
CV, %	2.86	3.44	4.05	4.35
P value	<0.001	<0.001	<0.001	<0.001
SED	8.75	0.5	9.19	0.1

The difference among the treatments on number of fingers/hill was highly significant (Table 4). The highest number of fingers (465) was recorded in the treatment where triple plants were allowed to grow as mother plant and all other new suckers were removed followed by single mother plant and single sucker left before flowering (354 fingers/hill).

Girth of finger is considered as one of the important character of banana that influences the quality and marketability of the fruit. Bigger the girth of the fruit higher is the consumer's preference. The difference among the treatments on girth of finger was found to be highly significant. The highest fruit girth (3.6 cm) was recorded in single and double plant per hill as mother plant and all other new suckers removed followed by treatment single sucker left before flowering along with the mother plant (3.4 cm). The lowest fruit girth (2.0 cm) was recorded, where triple plants were planted in a hill. Farmers of western low hills preferred planting one single sucker as mother plant and a sucker left before flowering. The reasons for the preferences were easy to cultivate the field, good crop growth, attractive bunches and fingers, higher marketable finger yield, less diseases and pest attack, proper utilization of the space and resources and continuous fruiting.

Time of planting

Seven different dates (first February to first August) were designed and evaluated. The performance of banana plants planted after April was poor. The effect of time of planting on flowering days was highly significant (Table 5). The earliest flowering was observed in February planting (268 days) and August planting took the longest period to flowering (509 days). The flowering days increased with the subsequent time of planting since February. Banana planting up to April could be harvested within 12-13 months. A highly significant variation among the treatments was observed on number of palms/bunch. The highest number of palms per bunch (10) was recorded in February and March plantings and the lowest (8) in July and August plantings.

Table 5. Effect of planting dates on crop duration and yield parameters of banana in RCA of ARS Lumle during 1999-2002

Planting date	Days to flowering	Number of palm/bunch	Number of fingers/bunch	Bunch weight, kg	Plant height, cm
1. February	268	10	129	37.76	165.00
2. March 1	400	10	157	32.20	195.50
3. April 1	402	9	170	31.74	205.00
4. May 1	465	9	120	24.10	202.50
5. June 1	476	9	101	17.72	176.25
6. July 1	479	8	96	15.52	223.50
7. Aug 1	509	8	94	11.25	174.00
Mean	427	9	124	24.33	191.68
CV, %	7.54	4.86	8.28	16.63	17.01
P value	< 0.001	<0.001	<0.001	<0.001	ns
SED	23.0	0.324	7.26	2.86	-

Number of fingers/bunch is considered to be the most important trait of banana. The variation for this trait among the different time of planting was evident. The highest number of fingers/bunch was recorded in April planting (170 fingers) followed by 157 fingers in March planting and 129 in February planting. With the subsequent time of plantings from May, the number of fingers per bunch was decreasing. Variation among the treatments was also highly significant in producing the bunch. The highest bunch weight was recorded in February planting (37.76 kg) and it was at par with March and April plantings. The bunch weight decreased with the subsequent planting time since February. The plant height was not affected by the planting dates on banana variety William Hybrid.

CONCLUSION

The performance of Jhapali Malbhog and William Hybrid was promising for their yield, earliness, finger quality, storability and marketability. Application of 300:110:300 g NPK/plant/year splitted into three doses (February, May and August) significantly increased the number of palms and fingers as well as better color of the skin. Planting one plant in a hill and spaced 2 m plant to plant and row to row and a sword sucker left before flowering produced significantly higher number of fingers/bunch and matured earlier than other combinations. February – April was the best time of planting in the river basin/low hills of Lumle's RCA, since it can escape the winter injury, a major constraint of banana cultivation in the hills of Nepal.

ACKNOWLEDGEMENTS

We would like to express our sincere appreciation to Dr RP Sah, Director of Crops and Horticulture, NARC for his encouragement to accomplish this work. We would like to thank Hill Agriculture Research Project (HARP) for providing fund to implement this project at Lumle. The authors are thankful to Mr RB Prasad and Mr TB Karki for initiation and implementation of the project. Hard work of field based AER and OR site staff of ARS, Lumle are highly appreciated. We also wish to record our appreciation for word processing of this paper by Mr RR Adhikari.

REFERENCES

- ASD. 2002. *Statistical information in Nepalese agriculture*. HMG/MOAC. Agricultural Statistics Division, Singh Durbar, Kathmandu.
- Karki TB. 2002. Improvement of banana productivity through varietal and crop management research in the western hills of Nepal. *Lumle Technical Paper No. 2002/4*. Agriculture Research Station, Lumle, Kaski, Nepal.
- LARC. 1993. *Program Paper of Horticulture Section*. Lumle Agricultural Research Centre, Kaski, Nepal.
- Rao VNM and KG Shanmugavelu. 1973. Fruit research in Tamilnadu. Cited by Shanmugavelu KG, K Aravindakshan and S Sathiamoorthy. 1992. *Banana: Taxonomy, breeding and production technology*. Metropolitan Book Co Pvt Ltd, New Delhi.
- Shanmugavelu KG, K Aravindakshan and S Sathiamoorthy. 1992. *Banana: Taxonomy, breeding and production technology*. Metropolitan Book Co Pvt Ltd, New Delhi.
- Shrestha TB and KB Sharma. 1995. Status of fruit development in national economy. Paper presented at the *Seminar on Fruit Development in Nepal* jointly organized by Horticulture Development Project, HMG/JICA and APROSC, Kathmandu, Nepal from 22-24 February 1995.

Participatory Plant Breeding in Rice: Experience of National Rice Research Program, Hardinath

Bedanand Chaudhary¹, Sanjay Gyawali², Krishna D Joshi³, Shambu P Khatiwada¹, Kedar P Shrestha⁴, Ashok Mudwari⁵, Madhusudan P Uphadhyay⁵, Bal K Joshi⁵, Bhuwon R Sthapit⁶ and Hari K Shrestha¹

¹ National Rice Research Program, NARC, Hardinath, Dhanusha

² Local Initiatives for Biodiversity, Research and Development, PO Box 324, Pokhara

³ DFID, PSP, CIMMYT South Asia Office, Singh Durbar Plaza Marg, Kathmandu

⁴ Sat Dobato Khumaltar, Lalitpur

⁵ Agriculture Botany Division, NARC, Nepal

⁶ IPGRI-APO, 10 Dharmasahila Budha Vihar Marg, Nadipur Patan, Pokhara

ABSTRACT

Rice is the most important cereal crop in Nepal. The crop is grown in diverse agro-ecosystems where a large number of landraces are still cultivated to meet the farmers' specific requirements. However, many landraces are endangered and need attention to be conserved for present and future use. Participatory plant breeding (PPB) approach was employed to improve selected rice landraces of Kachorwa, Bara ecosite in order to make them competitive with other options and to conserve them on farm. Six crosses were made utilizing five landraces and six donor parents. A modified bulk population method was adopted for generation advancement. The participating farmers were pleased to find variable plant types in segregating populations and they identified desirable ones among them. F₃ populations derived from Dudhisaro/BG 1442 and Lajhi/Rampur Masuli were found promising in the field condition of Kachorwa and were planted at Taruwa of Nawalparasi to have F₄ population under rapid generation advance. Therefore, these two populations are at F₅ generation, three populations are at F₄ generation and Lajhi/Sabitri cross was missed at F₂ generation due to failure in germination. The participating farmers visited PPB activities at Taruwa of Nawalparasi and monitored seed multiplication of PPB product named Judi141F selected by farmers of Chitwan. They also interacted with the farmers of Chitwan and became highly impressed with their works. They are conscious about the value of landraces and have established gene bank at local level to conserve them *ex-situ* for future use. They are determined to select and improve better lines or populations out of five crosses suited to their specific needs. This will lead to creation and conservation of genetic diversity on farm. Growing suitable rice genotypes within 7-8 years of crossing will also benefit them and thus this approach may be applied to develop varieties and conserve them on farm by improving landraces for some specific niches in Nepal where specific genotypes are required.

Key words: Participatory plant breeding, rice, selection criteria

INTRODUCTION

Rice is the most important cereal crop in Nepal for ensuring food security and enhancing economic growth. The crop is grown in diverse agroecological zones ranging from lowland Terai of 60 masl to 3000 masl of Jumla district (NARC 1997). Based on rainfall pattern and altitudes, Uphadhyay (1996) classified eleven rice production and recommendation domains at macro level. At present, the development of varieties and production technologies is based on major rice production domains as described by Chaudhary (2002). At micro level, there is wide diversity in farmers' resources endowments, production objectives, agroecological conditions and socio-cultural settings for rice production even within the Terai (Gauchan et al 1997, Gauchan 2001). In addition, farmers used to grow more than 2000 rice landraces before introduction of modern varieties (Joshi 2000). This demands a wide range of rice varieties to meet the farmers' requirements and farmers still grow more than 200 landraces of rice to address their specific needs.

In rice crop, a total of 48 varieties have been released so far (Chaudhary 2002). Varietal development requires an investment of cost and time before farmers grow the varieties and realize benefits. The conventional approach of plant breeding takes about 13-15 years for developing variety (Sthapit 1995) and provides farmers less or no choices to select the preferred one(s). However, participatory plant breeding (PPB) approach requires 9-10 years only and involves farmers in either or both consultative and collaborative roles in early generations of the varietal development process (Witcombe et al 1996). This approach increases farmer's participation in developing sustainable technology because the farmers possess the ability and the knowledge for selecting crops and species to suit their environments and resources, and to meet quality and other consumer requirements (Hardon 1995). PPB minimizes resource-use, produces farmer-acceptable products, and increases biodiversity. Increase in biodiversity is useful since pathogens and pests are exposed to a particular genotype for less time and have less chance to overcome host plant resistances (Mackenzie 1979, Wolfe 1985, Mundt 1994).

Farmers grow different landraces of rice suited to their specific environments and to their social and cultural purposes. Many landraces are endangered and attention has to be paid to conserve them either *ex situ* or *in situ* for present and future use. *In situ* conservation is considered to be the method for conserving forest species and wild crop relatives. However, there is increasing interest in the use of *in situ* conservation for crops (Brush 1995). This allows evolution to continue, increases the amount of diversity that can be conserved and strengthens links between conservation workers and the communities who have traditionally maintained and used the resources. PPB approach was employed to improve and conserve the selected landraces of rice at Kachorwa, Bara (Joshi et al 2000), because PPB can be a dynamic form of *in-situ* genetic conservation (Witcombe et al 1996).

METHODOLOGY

A series of discussion and brain storming sessions were held at different levels to understand and internalize PPB approach in national crop breeding strategy. For example, discussions were made in national multidisciplinary group and technical coordination committee meetings. Finally, plant breeders, socioeconomists and national project coordinator of *in situ* conservation project discussed and decided to test PPB on rice at Bara as an approach to conserve genetic diversity on farm. Need assessment along with willingness of farmers to participate in this approach was done through focus group discussion (FGD).

Identification of parents

Rice growing households were categorized into four cells on the basis of area coverage and number of farmers growing them. At least one landrace from each cell was included in the PPB program. Based on FGD, a multi-disciplinary team identified the landrace parents following preference ranking. The team also assessed their positive and negative traits using matrix ranking. The analysis of negative traits helped to understand deficiency in landrace parent to be improved. Exotic donor parents were selected on the basis of negative trait analysis (Table 1).

Table 1. Cross combinations of rice landraces and donor parents

SN	Landrace	Donor parent	Remark
1	Dudhisaro	BG 1442	Bhadaiya rice
2	Dudhisaro	Pant 10	Bhadaiya rice
3	Nakhisaro	IR 36	Bhadaiya rice
4	Nakhisaro	Chaite 2	Bhadaiya rice
5	Rato Basmati	Basmati 385	Aghani rice
6	Rato Basmati	Sabitri	Aghani rice
7	Lajhi	IR 64 × KIII	Aghani rice
8	Lajhi	Semidwarf Basmati	Aghani rice
9	Mansara	IR 64	Aghani rice
10	Mansara	Rampur Masuli	Aghani rice

Management of crosses

Crossing was done at National Rice Research Program (NRRP), Hardinath (Table 2). F₁ generation was grown at NRRP, Hardinath. F₂ generations of six crosses were evaluated in the farmer's fields at Kachorwa, Bara during 2001 (Table 2). Overall methodology was followed as the procedures mentioned by Witcombe et al (1996). F₃ generations of five crosses were grown in the succeeding year (Table 3). Traveling seminar was organized in both the years to evaluate and discuss the further works for improvement. Plant breeders, local multidisciplinary

team and cooperative farmers participated in the seminar and selected the desirable plants. However, 3 panicles from each hill were harvested and one panicle from each hill was bulked, separately.

Table 2. List of cooperative farmers growing F₂ population of successful crosses Kachorwa, Bara during 2001

SN	Parentage	Participant (Farmer)
1	Lajhi/Rampur Masuli	Bhola Thakur Lohar
2	Lajhi/Rampur Masuli	Ram Ayodhya Kalwar*
3	Mansara/IR 62161-134-3-1-2-2	Bhola Thakur Lohar
4	Lalka Basmati/IR 59606-119-3	Saraflal Prasad Yadav
5	Lajhi/62161-22-1-2-1-1	Basdev Ray Yadav
6	Dudhisaro/BG 1442	Kapildev Das Tatma*
7	Dudhisaro/BG 1442	Jaga Dev Ray Yadav*
8	Dudhisaro/BG 1442	Kapil Dev Bhagat Mali
9	Nakhisaro/BG 1442	Magnisa Sonar
10	Lajhi/Sabitri	Sitaram Ray Yadav*

* Farmers failed to produce seedlings

Table 3. Evaluation of F₃ populations and plant selection criteria for generation advancement at Kachorwa, Bara during 2002

SN	Parentage	Selected hills, n	Selection criteria
1	Lajhi × Rampur Masuli	91	High yielding, dwarf, disease free, medium maturity, high tillering, Lajhi type in grain color and size
2	Mansara × IR 62161-134-3-1-2-2	443	High yielding, dwarf, disease free, late maturity, high tillering, Mansara type grain color and size
3	Lalka Basmati × IR 59606-119-3	Harvested bulk from 3 hills	High yielding, dwarf, disease free, late maturity, high tillering, Lalka Basmati type in grain color and size
4	Lajhi × IR 62161-22-1-2-1-1	20 and harvested bulk from the remaining	High yielding, dwarf, disease free, medium maturity, high tillering, Lajhi type in grain color and size
5	Dudhisaro × BG 1442	140	High yielding, dwarf, disease free, medium maturity, high tillering, Dudhisaro type in grain and size

Rapid generation advancement

F₃ populations from crosses of Lajhi × Rampur Masuli and Dhudisaro × BG 1442 were preferred by most of the participating farmers and bulk seeds of these populations were advanced at Taruwa, Nawalparasi during winter season. After harvest, these populations will be grown and evaluated at Kachorwa, Bara.

RESULTS AND DISCUSSION

During traveling seminar, participating farmers were very much encouraged to have variable plant types (including desirable ones) within the F₂ segregating population of the crosses. They were allowed to select the hills with required plant height, desirable grain type and color. They obviously selected the hills with dwarf plant type, higher number of tillers, grain color and type resembling to landrace parent types (Table 3). The selection was towards the priorities set for improvement of the landrace.

After a long discussion, PPB experts and local multi disciplinary group team finalized to follow modified bulk population method for improvement of the materials. Therefore, three panicles from all the hills except lodged, diseased, and dead hills were harvested in order to encompass the total variability within the population. The participating farmers, who were interested to select their own were allowed to do for further improvement. However, no farmers harvested the selected hills in their own and did not, thus, promote separately due to lack of confidence.

The participating farmers along with research team also monitored F₃ segregating populations during traveling seminar in 2002. The similar methods of selection were followed as done in selecting F₂ populations.

Populations derived from Dudhisaro × BG 1442 and Lajhi × Rampur Masuli seemed promise and the team suggested to multiply F₄ generation of population of these two crosses at Taruwa of Nawalparasi for rapid generation advance.

Out of six crosses, Lajhi × Sabitri cross was missed due to failure in germination of the seeds (Table 2). Two populations (Dudhisaro × BG 1442 and Lajhi × Rampur Masuli) were in advanced Boro season to plant their F₅ bulk and F₄ bulk of the rest crosses in 2003. Participating farmers are convinced that PPB can conserve the desirable traits of rice landraces by producing acceptable populations (in terms of plant height and type, grain color and type) for them. They have also become conscious about genetic erosion and endangered rice landraces, and realized the importance and value of rice landraces for future use. This has led them to establish gene bank for conserving landraces *ex situ* at local level in addition to *in situ* conservation through PPB.

The participating farmers of Kachorwa visited Taruwa, Nawalparasi and Gitanagar, Chitwan under PPB exposure visit program. They observed PPB product materials at Taruwa and interacted with the farmers about this approach at Gitanagar. LI-BIRD staff provided few grams of F₅ seeds of segregating materials (Kalinga III/IR 64) to the farmers of Gitanagar few years' back (Gyawali et al 2002). Farmers started selection in their own way targeting to replace CH 45 with superior genotype(s). One of the participating farmers named Dev Raj Sapkota has become successful to select one population that is tolerance to lodging, 5-7 days earlier in maturity than and superior in grain yield and taste to CH 45. This population is under seed multiplication program at the farmers' level to further spread the variety because strengthening local seed supply system is the only reliable way to link PPB (Sthapit et al 1998). The concerned farmers are claiming their patent right as well. At present, LI-BIRD has promoted this product as Judi 141F.

With such interaction and observation of PPB product, participating farmers of Kachorwa are highly impressed especially with efforts and dedication of farmers of Chitwan. They are highly motivated and enthusiastic that they are ones to select better product (genotype) suitable to their specific needs from the segregating populations. This year, the participating farmers have realized their responsibility to improve and promote the products in collaboration with researchers. In this regard, they have acquired the bulk seeds of the population and decided to do all the activities themselves. Choices may differ among the participating farmers and thus they may select different PPB products out of the bulk population, creating genetic diversity among the farming community. Earlier studies (Sthapit et al 1996, Joshi et al 2001, Witcombe et al 2001) have already demonstrated such evidences. Farmers have selected different rice genotypes as per their needs (Joshi et al 2003).

Acceptance of the PPB products and their spread will reflect the success and prospects of this approach for creating genetic diversity and conserving them on farm. If this is case, PPB approach will help conserve the desirable traits of rice landraces with improvement in grain yield and will help reduce expenses of resources providing its products to the farmers 7-8 years earlier than conventional breeding method. Such examples have been already reported from Nepal (Sthapit et al 1996, NARC 1997) and very recently from India (Virk et al 2002). In addition, frequent interactions between researchers and farmers help diagnose the problems associated with varietal development so that further improvement can be made. A case study in Thailand illustrated that economic benefit from completing the current breeding cycle two years earlier was found to be \$10 dollar/ha of rice area planted (Pandey and Rajatasereekul 1999). Case of Chitwan and progress of Kachorwa, Bara shows that this approach may be employed successfully for development of suitable varieties utilizing landraces as parent to some specific niches to conserve them on farm in Nepal.

REFERENCES

- Brush S. 1995. In situ conservation of landraces in centers of crop diversity. *Crop Sci.* 35:346-354.
- Chaudhary B. 2002. Rice research and development in Nepal: Current status, perspective and strategies. *Paper presented at the 20th Session of the International Rice Commission* at Bangkok, Thailand, 23-25 July 2002.
- Gauchan D. 2001. Economics and diversity of rice-based production systems in Nepal's Central Tarai. **In:** *Advances in Agricultural Research in Nepal* (HK Manandhar, CL Shrestha, RK Shrestha and SM Pradhan, eds). Society of Agricultural Scientists, Nepal Agricultural Research Council, Nepal. Pp.49-57.
- Gauchan D, HK Shrestha, N Pandey and R Shrestha. 1997. A socioeconomic study of rice based production systems in Nepal Tarai. *Report No. 26*. Outreach Research Division, Nepal Agricultural Research Council, Nepal.
- Gyawali S, KD Joshi and JR Witcombe. 2002. Participatory plant breeding in rice in low altitude production systems in Nepal. **In:** *Breeding rainfed rice for drought-prone environments integrating conventional and participatory plant*

- breeding in South and Southeast Asia* (JR Witcombe, LB Parr and GN Atlin, eds). Proceedings of a DFID Plant Sciences Research Programme/IRRI Conference 12-15 March 2002, Philippines. Pp.8-10.
- Hardon J. 1995. Participatory plant breeding. The outcome of a workshop on participatory plant breeding. *Issues in genetic resources* No. 3, October 1995. IPGRI, Rome Italy.
- Joshi BK, KP Shrestha, KD Joshi, A Mudwari, SP Khatriwada, P Chaudhary, RB Yadav, D Pandey, PR Tiwari, BK Baniya and BR Sthapit. 2003. Precious documentation on deployment of rice and buckwheat diversity through participatory varietal selection for specific adaptation. **In:** *On farm management of agricultural biodiversity in Nepal* (BR Sthapit, MP Upadhyay, BK Baniya, A Subedi and BK Joshi, eds). Proceedings of a National workshop 24-26 April 2001, Lumle. Pp.229-232.
- Joshi KD. 2000. Strengthening the farmers' seed system in Nepal. *Biotechnology and Development Monitor* No.42. Pp.15-17.
- Joshi KD, BR Sthapit and JR Witcombe. 2001. How narrowly adapted are the products of decentralized breeding? The spread of rice varieties from a participating plant breeding programme in Nepal. *Euphytica* 122:589-597.
- Joshi KD, DK Rijal, RB Rana, SP Khatriwada, P Chaudhary, KP Shrestha, A Mudwari, A Subedi and BR Sthapit. 2000. Adding benefits through PPB, seed networks and grassroots strengthening. **In:** *Conserving agricultural biodiversity in situ: A scientific basis for sustainable agriculture* (D Jarvis, B Sthapit and L Sears, eds). International Plant Genetic Resources Institute, Rome, Italy. Pp.206-209.
- Mackenzie DR. 1979. The multi-line approach to control some cereal diseases. **In:** *Proc. Rice Blast Workshop*. International Rice Research Institute, Los Banos, Philippines. Pp.199-215.
- Mundt CC. 1994. Use of host genetic diversity to control cereal diseases: Implications for rice blast. **In:** *Rice Blast Disease* (RS Zeigler, SA Leong and PS Teng, eds). CAB International, Wallingford, UK. Pp.293-308.
- NARC. 1997. *25 year of rice research in Nepal (1972-1997)*. Nepal Agricultural Research Council, National Rice Research Program, Nepal. 41 p
- Pandey S and S Rajatasereekul. 1999. Economics of plant breeding: The value of shorter breeding cycles for rice in Northeast Thailand. *Field Crops Research* 64:187-197.
- Sthapit BR. 1995. Variety testing, selection and release system for rice and wheat crops in Nepal. *Seed regulatory frame works*. Lumle Agricultural Research Centre, Nepal.
- Sthapit BR, KD Joshi and JR Witcombe. 1996. Farmer participating crop improvement. III. Participatory plant breeding: A case study for rice in Nepal. *Experimental Agriculture* 32:479-496.
- Sthapit BR, KD Joshi, RB Rana and A Subedi. 1998. Spread of varieties from participatory plant breeding in high altitude villages of Nepal. *LI-BIRD Technical Paper No 1*. Local Initiatives for Biodiversity Research and Development, Pokhara, Nepal.
- Upadhyay HK. 1996. Rice recommendation domains and implications for biotechnology initiatives in Nepal. **In:** *Rice Genetics III*. International Rice Research Institute, Manila, Philippines. Pp.971-977.
- Virk DS, DN Singh, R Kumar, SC Prasad, JS Gangwar and JR Witcombe. 2002. Participatory plant breeding in rice in eastern India: The success of an NGO/GO partnership. **In:** *Breeding rainfed rice for drought-prone environments integrating conventional and participatory plant breeding in south and southeast Asia* (J.R. Witcombe, LB Parr and GN Atlin, eds). Proceedings of a DFID Plant Sciences Research Programme/IRRI Conference, 12-15 March 2002. Laguna, Philippines. Pp.5-7.
- Witcombe JR, A Joshi, KD Joshi and BR Sthapit. 1996. Farmer participating crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. *Experimental Agriculture* 32:445-460.
- Witcombe JR, KD Joshi, RB Rana and DS Virk. 2001. Increasing genetic diversity by participatory varietal selection in high potential production systems in Nepal and India. *Euphytica* 122:575-588.
- Wolfe MS. 1985. The current status and prospects of multi-line cultivars and variety mixtures for disease resistance. *Ann. Rev. Phytopathology* 23:251-273.

Performance of Bush Type French Bean in the Hills of Nepal

Khadga B Paudel, Jeet N Chaudhary, Ishwori P Gautam, Kalika P Upadhaya and Bhogendra Khatri

NARC, Nepal

ABSTRACT

Eight genotypes of bush type French bean collected from Mustang, Myagdi and Kaski, Nepal and nine genotypes introduced from the USA were evaluated under observation nursery at Rising Patan (450 masl), Tanahu, Outreach Research (OR) site of Agriculture Research Station (ARS), Lumle, Kaski during post monsoon of 2000. The promising entries from observation nurseries were evaluated under co-ordinated varietal trial at Rising Patan, ARS, Pakhribas and ARS, Lumle during spring season (February 2001), summer seasons (April 2001) and pre and post-monsoon season (April and August 2001) respectively. The performances of these genotypes were almost similar at all locations. The most promising genotypes were LB-25, LB-27, S-9 and Pant Anupama in terms of yield and other horticultural traits. Considering over all performance, pod length, pod diameter, fibre content, marketable fresh pods yield and resistant to bean rust, genotype LB-25 was superior among the tested genotypes.

Key words: Agromorphological traits, french bean, hilly areas

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) (also called kidney bean, haricot bean, snap bean, navy bean and common bean) is one of the most important legume crops, grown for pulses as well as fresh vegetable. It can be grown in wide range of soil and climatic conditions (Schoon et al 1991). French bean contains high amount of protein, vitamins and minerals. The leaves and stems are also good source of livestock fodder. French beans can be determinate (bush type) and indeterminate (pole type). The determinate type does not need staking which is environmentally sound and save other extra inputs and operation. The bush type can be grown as sole crop, mixed crop or under orchard as an inter-crop. It can grow well under poor soil and management conditions, which are common in the hills of Nepal. It also increases soil fertility by fixing atmospheric nitrogen and fit in the rice and maize-cropping pattern in upland area. Due to higher nutritional value and good taste, this crop fetches high market price.

However, there are several limiting factors to cultivate and produce bush type French beans in the hills of Nepal. Bhattarai et al (1997) reported that the main problems/constraints are i. Lack of suitable varieties for the wider adoption and large-scale production of the bush type of French bean, ii) The local varieties are not suitable for commercial production and export due to low yield and low quality and iii) Lack of suitable technologies on cultural practices, disease and pest control. Hence this study has developed the complete package and practices for bush type French bean cultivation for the pre and post monsoon seasons in the country.

MATERIALS AND METHODS

Eight genotypes of bush type French bean were collected from Myagdi, Mustang and Kaski districts in July 2000. Another nine genotypes of bush bean were introduced from the USA in August 2000 and total of seventeen genotypes were evaluated in observation nursery at Agriculture Research Station, Lumle and outreach

Research site, Rising Patan during post monsoon of 2000. Selected promising lines from the observation nurseries were evaluated under Co-ordinated Varietal Trial (CVT) at randomised complete block design with three replications at OR site Rising Patan, Tanahun during spring season (Feb 2001); ARS, Lumle and ARS, Pakhribas during summer season (April 2001). Elite genotypes were again evaluated at ARS, Lumle during post monsoon (Aug 2001) at RCBD with four replications. The crop distance in CVT was 60 cm row-to-row and 30 cm plant-to-plant with 4.32 m² net harvesting area. Fertilizers were applied @ 40:60:30 N:P:K kg/ha along with 15 t compost. All the cultural practices were performed as required. Observations were taken on date of seeding, plant population at establishment, days to 50% flowering, days to first harvest, number of pickings, days to last harvest, fresh pod yield, pod length, pod diameter, pod shape, pod colour, fibre content of the fresh pod at harvest (1-low, 2- medium, 3- high for fibre), response to bean rust and major insect pests, market price and farmers' choice in terms of taste. The data were analysed by MSTAT software.

RESULTS

CVT at Rising Patan (450 masl), Tanahun during spring season, 2001

Significant effect was observed on days to 50% flowering among the tested genotypes. Gaint Stringless, LB-29, IBRN, Pant Anupama, S-9, Pokhara Selection, LB-25, Contender and LB-40 were at par. Genotype LB-40 was earlier (44 days) where as LB-41 was late (56 days) (Table 1).

Table 1. Performance of bush bean genotypes at Rising Patan, Tanahun during February to June 2001

SN	Genotype	Days to 50% flowering	No. of harvested plant (4.32 m ²)	Pod length, cm	Pod diameter, mm	Marketable fresh pod yield, t/ha	Fibre content†
1	Pokhara Selection	49	22.7	9.7	6.3	0.9	1.0
2	S-9	48	23.3	11.7	8.6	1.8	2.0
3	Gaint Stringless	46	22.7	8.8	9.2	0.7	1.3
4	Pant Anupama	48	23.0	10.0	8.0	1.3	1.3
5	PDH -14	52	22.0	7.5	6.7	0.9	1.0
6	IBRN	47	22.0	7.4	8.5	1.7	1.3
7	Contender	50	21.7	9.9	5.0	1.2	1.3
8	LB-25	50	23.3	12.6	9.1	2.9	1.0
9	LB-27	52	22.7	11.6	9.6	2.3	1.0
10	LB-26	53	21.0	9.7	7.80	2.4	1.0
11	LB-29	47	20.7	9.9	9.3	1.5	1.0
12	LB-40	44	22.3	5.8	4.3	1.8	2.3
13	LB-41	56	22.0	9.2	8.7	1.0	1.0
	F test	*	ns	**	**	***	*
	CV, %	7.8	6.9	16.4	18.4	21.9	35.5
	LSD (0.05)	6.5	-	2.6	2.4	0.6	0.8

† Rating scale, 1 = less, 2 = medium and 3 = high fibre in the fresh pod.

Highly significant effect was observed on pod length among the tested genotypes. S-9, LB-27, Pant Anupama and LB-25 genotypes were found significant at par. LB-25 produced the longest pod (12.6 cm) where as the shortest pod was recorded in LB-40 (5.8 cm) (Table 1). Highly significant effect was observed on pod diameter. LB- 29, Gaint Stringless, LB-25, LB-41, S-9, IBRN and LB-27 genotypes were found significant at par. Genotype LB-27 produced the highest diameter (9.6 mm) where as, LB-40 produced the lowest (4.3 mm) (Table 1). Highly significant effect was observed on marketable fresh pod yield. LB- 26 and LB-25 were found significant at par. Genotype LB-25 produced the highest yield (2.9 t/ha) where as, Gaint Stringless produced the lowest (0.7 t/ha).

Minimum fiber content was observed in Pokhara selection, PDH-14, LB-25, LB-27, LB-26 and LB-29 genotypes where as the maximum observed in LB-40, which is desirable character for marketing and consumers.

CVT at ARS, Lumle during spring season, 2001

Highly significant effect was observed on days to 50% flowering among the tested genotypes. Genotype Pokhara Selection, S-9 and IBRN were early flowering (48 days) and PDH-14 was late (55 days) (Table 2). Highly significant effect was observed on days to first picking among the tested genotypes. Genotypes S-9, Gaint Stringless, Pant Anupama, IBRN, Contender, LB -25 and LB-27 were earlier (76 days) where as, PDH-14 was found late (83 days). Significant effect was observed on last picking among the tested genotypes. IBRN, S-9, Pokhara Selection, Pant Anupama, LB-25 and LB-27 genotypes were found significant at par. Genotype IBRN was earlier (81 days) where as, Contender and PDH-14 were late (93 days).

Table 2. Performance of bush type French bean genotypes at ARS Lumle during April - August 2001

SN	Genotype	Days to 50% flowering	Days to 1 st harvest	Days to last harvest	No. of pickings	No. of harvested plants	Pod length, cm	Pod diameter, mm	Marketable fresh pod yield, t/ha	Fibre content†
1	Pokhara Selection	48	78	83	2	21.0	12.9	9.5	3.5	2.0
2	S-9	48	76	83	2	20.3	15.3	8.8	5.1	1.0
3	Gaint Stringless	52	76	87	3	20.3	15.3	9.0	6.1	2.3
4	Pant Anupama	53	76	86	3	22.0	15.4	8.4	4.0	2.0
5	PDH -14	55	83	93	2	19.3	12.8	10.7	4.2	3.0
6	IBRN	48	76	81	2	18.7	15.6	7.9	5.5	2.0
7	Contender	52	76	93	3	20.7	15.4	8.2	9.0	3.0
8	LB-25	53	76	86	3	22.7	15.3	8.8	11.2	1.0
9	LB-27	54	76	86	3	22.0	14.5	8.4	6.0	1.0
	F test	***	***	*	**	ns	**	**	***	***
	CV, %	2.77	1.8	4.7	16.2	8.1	5.9	6.2	13.4	9.9
	LSD (0.05)	2.5	2.3	7.0	0.7		1.5	0.9	1.4	0.3

† Rating scale, 1 = less, 2 = medium and 3 = high fibre in the fresh pod.

Highly significant effect was observed on number of picking among the tested genotypes. LB-25, Gaint Stringless, Pant Anupama and LB -27 genotypes were found significant at par. Genotypes Contender and LB-25 gave maximum picking (3 times) where as, Pokhara Selection and IBRN gave minimum (1.67 time).

Highly significant effect was observed on pod length among the tested genotypes. IBRN, Pant Anupama, Contender, LB-25 S-9, Gaint Stringless and LB-27 genotypes were found significant at par. Genotype IBRN produced the longest pod length (15.6 cm) and the shortest was recorded in PDH-14 (12.8 cm). Highly significant effect was observed on pod diameter. Genotype PDH-14 produced the pod with highest diameter (10.7 mm) and the lowest pod diameter was recorded in IBRN (7.87 mm). Highly significant effect was observed on the marketable fresh pod yield among the tested genotypes. Genotype LB-25 produced the highest yield (11.19 t/ha) where as, Pokhara Selection produced the lowest (3.46 t/ha).

Less fiber content was observed in genotypes S-9, LB-25, LB-27 and LB-29 and these all are significantly at par where as, the maximum fibre content was found in Contender and PDH-14.

CVT at ARS, Pakhribas, Dhankuta during summer season, 2001

Significant effect was observed on pod length among the tested genotypes. LB-27, S-9, Pokhara Selection, LB-25 and Contender genotypes were found significant at par. Genotype LB-27 produced the longest pod (15.3 cm) where as, Pant Anupama produced the shortest (9.2 cm) (Table 3).

Highly significant effect was observed on the marketable fresh pod yield among the tested genotypes. S-9, Pokhara Selection, Gaint Stringless, Contender, LB-25 and LB-27 genotypes were found significant at par. Genotype S-9 produced the highest yield (3.5 t/ha) where as, Pant Anupama produced the lowest (1.7 t/ha). Less fiber content was observed in genotype LB-25 where as, the maximum in Contender and PDH-14.

Highly significant effect was observed on number of harvested plants because of low plant stand observed in LB-25 due to which fresh pod yield was decreased in LB-25 (2.55 t/ha) as compared to S-9 (3.52 t/ha) and others (Table 3).

Table 3. Performances of bush type French bean genotypes at ARS, Pakhribas during April - August 2001

SN	Genotype	Days to 50% flowering	No. of harvested plant	Pod length, cm	Pod diameter, mm	Marketable fresh pod yield, t/ha	Fibre content†
1	Pokhara selection	64.00	28.33	14.23	5.03	3.2	2.66
2	S-9	63.66	24.66	14.63	5.56	3.5	2.33
3	Gaint Stringless	69.66	26.00	12.53	6.53	2.9	2.00
4	Pant Anupama	69.63	24.00	9.20	5.73	1.7	1.00
5	PDH -14	63.00	30.33	10.43	6.66	1.3	2.66
6	IBRN	68.33	25.00	11.23	6.03	1.8	1.33
7	Contender	70.66	27.33	13.03	4.80	2.9	2.66
8	LB-25	68.66	21.66	14.16	4.86	2.6	1.00
9	LB-27	68.33	27.33	15.26	5.16	2.5	1.33
	F test	ns	**	*	ns	**	**
	CV, %	19.37	7.9	13.72	0.075	24.7	25.72
	LSD (0.05)		3.60	3.026		1.06	0.841

† Rating scale, 1 = low, 2 = medium and 3 = high for fibre content.

CVT at ARS, Lumle and ARS, Pakhribas during summer season, 2001

Significant effect was observed on pod length among the tested genotypes. S-9, LB-27 LB-25, Contender, Gaint Stringless, Pokhara selection and IBRN genotypes were found significant at par. Genotype S-9 and LB-27 produced the longest pod length (14.9 cm) where as, PDH-14 produced the shortest (11.6 cm) (Table 4). Significant effect was observed on pod diameter. PDH-14, LB-25, Gaint Stringless, Pokhara Selection, S-9 and Pant Anupama genotypes were found significant at par. Genotype PDH-14 produced the highest pod diameter (7.9 mm) where as, Contender produced the lowest (6.5 mm).

Table 4. Performances of bush type French bean genotypes at ARS, Lumle and ARS, Pakhribas

SN	Genotype	No. of harvested plants	Pod length, cm	Pod diameter, mm	Marketable fresh pod yield, t/ha	Fibre content†
1	Pokhara selection	25	13.6	7.3	3.3	2
2	S-9	23	14.9	7.2	4.3	2
3	Gaint Stringless	23	13.9	7.8	4.5	2
4	Pant Anupama	23	12.3	7.1	2.8	2
5	PDH -14	25	11.6	7.9	2.7	1
6	IBRN	25	13.4	6.9	3.6	2
7	Contender	24	14.2	6.5	5.9	3
8	LB-25	22	14.7	6.8	6.9	1
9	LB-27	25	14.9	6.8	4.2	1
	F test	ns	*	*	***	***
	CV, %	10.6	13.1	10.3	35.2	26.9
	LSD (0.05)		2.1	0.9	1.8	0.6

† Rating scale, 1 = low, 2 = medium and 3 = high for fibre content.

Highly significant effect was observed on the marketable fresh pod yield among the tested genotype. Genotype LB-25 was highest yielder (6.9 t/ha) followed by Contender (5.9 t/ha) where as, the lowest yield was recorded in PDH-14 (2.74 t/ha). The reason of high CV for marketable fresh pod yield was due to differences in yield of the same genotype between ARS, Pakhribas and ARS, Lumle. Less fiber content was observed in genotype Contender where as, the maximum was found in Contender, Pokhara Selection and PDH-14.

Five elite genotypes under CVT at ARS, Lumle during post monsoon season, 2001

Highly significant effect was observed on the marketable fresh pod yield among the tested genotypes. Genotype LB-27 produced the highest yield (8.8 t/ha) where as, the lowest yield recorded in S-9 (3.6 t/ha) (Table 5). Highly significant effect was observed on days to last picking among the tested genotypes but non-significant result was observed within IBRN, Pant Anupama and LB-52 genotypes. Genotype S-9 was earlier (85 days)

where as, LB-27 was found late (92 days).

Table 5. Performances of bush bean genotypes at ARS, Lumle during August - December 2001

SN	Genotypes	Days to 50% flowering	Days to 1 st picking	Days to last picking	No. of harvested plants	Marketable fresh pod yield, t/ha
1	S-9	50	77	85	32	3.4
2	LB-25	52	78	91	32	6.3
3	LB-27	53	78	92	33	8.8
4	LB-52	52	77	86	33	6.3
5	Pant Anupama	53	77	85	32	4.9
	F test	ns	ns	***	ns	***
	CV, %	7.1	1.5	1.79	6.6	10.4
	LSD (0.05)			2.685		1.07

Four elite genotypes in different seasons and locations

The overall performance of genotypes during different seasons of year and locations is presented in Table 6. The days to 50% flowering ranged from 53 (S-9) to 57 days (LB-27).

The marketable fresh pod yield ranged from 3.0 t/ha (Pant Anupama) to 5.7 t/ha (LB-25), with difference of 2.8 t/ha, which is the very important economical factor. The range of fibre content was 1 (LB-25 and LB-27) to 2 (S-9). The low fibre content is one of the important horticultural traits for fresh vegetable. LB- 27 and LB-25 were found superior to all among the tested genotypes.

The range of pod diameter was 6.4 (S-9) to 7.7 mm (LB-27). The pod length ranged from 13.7 (LB-25) to 14.2 cm (LB-27). Thus, LB -27 had the highest pod diameter and length but the superiority of LB -27 over LB-25 was surpassed by LB-25 due to its high and stable marketable fresh pod yield.

Table 6. Overall performance of four elite bush bean genotypes conducted in different seasons during 2001

A.

Genotype	Year														Mean
	Rising Patan, Tanahun (Feb – June 2001)			ARS, Lumle				ARS, Pakhribas (April – Aug 2001)							
	DTF	MPod, t/ha	Fibre†	April – Aug 2001		Aug – Dec 2001		DTF	MPod, t/ha	Fibre	DTF	MPod, Fibre t/ha			
				DTF	MPod, Fibre t/ha	DTF	MPod, Fibre t/ha								
S-9	48	1.8	2	48	5.0	1	50	3.6	2	64	3.5	2	53	3.5	2
LB-25	50	2.9	1	53	11.2	3	52	6.3	1	69	2.6	1	56	5.7	1
LB-27	52	2.3	1	54	6.0	1	53	8.8	1	68	2.5	1	57	4.9	1
Pant Anupama	48	1.3	1	53	4.0	2	53	4.9	2	69	1.7	1	56	3.0	2

B.

Genotype	Rising Patan		ARS Lumle		ARS Lumle		ARS Pakhribas		Mean	
	PodL,	PodD,	PodL,	PodD,	PodL,	PodD,	PodL,	PodD,	PodL,	PodD,
	cm	mm	cm	mm	cm	mm	cm	mm	cm	mm
S-9	11.7	8.6	15.3	5.1	15.0	6.1	14.6	5.6	14.2	6.4
LB-25	9.9	10.0	15.3	8.8	15.4	8.5	14.2	4.9	13.7	6.8
LB-27	12.6	9.1	14.5	8.4	14.5	8.2	15.3	5.2	14.2	7.7
Pant Anupama	10.0	8.0	15.4	8.4	15.3	8.2	9.2	5.7	12.5	7.6

B.

Genotype	Rising Patan		ARS Lumle		ARS Lumle		ARS Pakhribas		Mean	
	PodL, cm	PodD, mm	PodL, cm	PodD, mm	PodL, cm	PodD, mm	PodL, cm	PodD, mm	PodL, cm	PodD, mm
S-9	11.7	8.6	15.3	5.1	15.0	6.1	14.6	5.6	14.2	6.4
LB-25	9.9	10.0	15.3	8.8	15.4	8.5	14.2	4.9	13.7	6.8
LB-27	12.6	9.1	14.5	8.4	14.5	8.2	15.3	5.2	14.2	7.7
Pant Anupama	10.0	8.0	15.4	8.4	15.3	8.2	9.2	5.7	12.5	7.6

† Rating scale, 1 = low, 2 = medium and 3 = high in fibre content. DTF, Days to flowering. MPod, Marketable pod yield. Fibre, Fibre content. PodL, Pod length. PodD, Pod diameter

There was low severity of rust disease in all the tested genotypes of bush bean. However, there was significant difference in the disease severity on the tested genotypes (Table 7). LB-40 and LB-41 were found completely free from disease. Among the genotypes, Pant Anupama had the highest severity (16.7%). Disease progress curves of rust on selected genotypes are shown in Figure 1. S-9 and LB-25 had same disease severity and the

disease infection was started earlier in LB-25, however the disease progress remained constant. Pant Anupama exhibited high disease severity in the earlier period, but the disease progress remained constant.

Table 7. Disease severity of rust in different bush bean genotypes at Rishing Patan, Tanahu, 2001

SN	Genotype	Disease severity, %
1	LB 25	1.7 (1.3) ^b
2	S - 9	1.7 (1.3)
3	LB 29	10.0 (2.8)
4	Contender	6.7 (2.4)
5	IBRN	3.3 (1.6)
6	Pant Anupama	16.7 (4.5)
7	LB 27	5.0 (2.1)
8	PKR Selection	13.3 (4.1)
9	LB 41	0.0 (0.7)
10	LB 26	11.7 (3.4)
11	PDH 14	15.0 (3.8)
12	Gaint Stringless	1.7 (1.3)
13	LB 40	0.0 (0.7)
P value		0.00***
CV, %		37.9
LSD (0.05)		1.5

† Mean of 3 replications. Values in parenthesis is square root transformation.

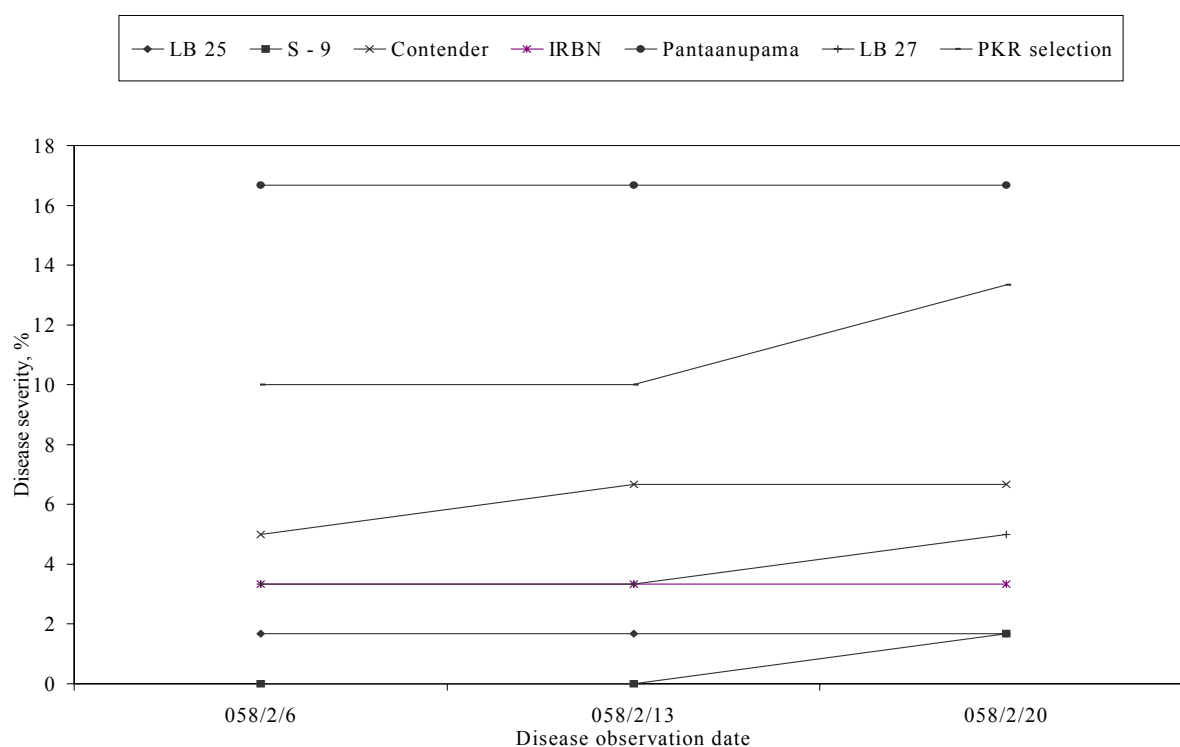


Figure 1. Disease progress curve of rust on selected bush type bean genotypes at Rishing Patan, Tanahu, 2001.

Bean rust disease severity and marketable fresh pod yield under the natural epiphytotic condition for bean rust during August-December, 2001 at ARS, Lumle are given in Figure 2. The range of disease severity was from 15 (LB-25) to 27.5% (Pant Anupama).

DISCUSSION

The result revealed that LB-25 (Blue Lake), LB -27 (Kentucky Wonder 125) and S-9 can be grown at river basin during spring and autumn seasons and can be fitted well into existing cropping system viz bush bean-rice and maize-bush bean. Before July 2000, trials of bush and pole type French bean were done in one experiment. Due to this reason, actual performance of bush and pole bean genotypes could not be observed, because bush bean genotypes produced early fresh marketable pod without providing staking which solve great problem of farmers of fertilizer, spacing and others cultural operation. Therefore, from July 2000, trials were arranged separately to these bush and pole types.

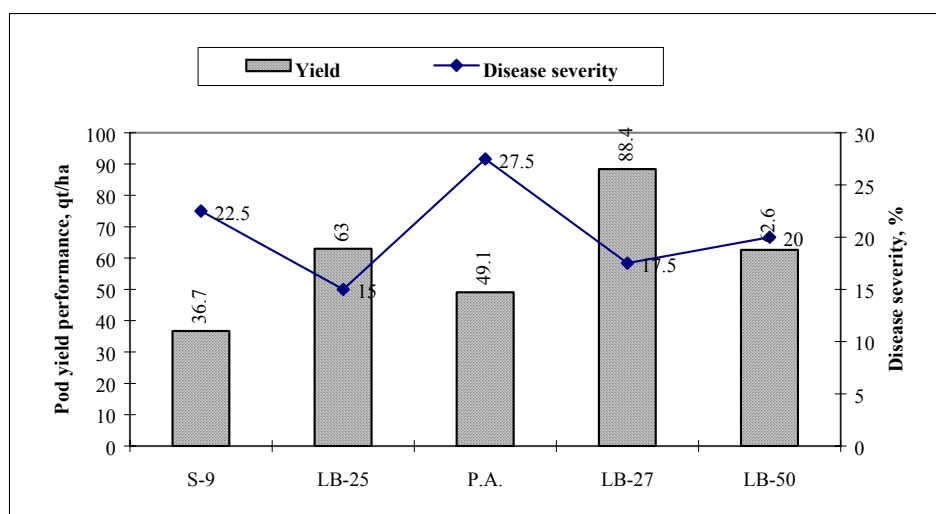


Figure 2. Bean rust disease severity (%) and marketable fresh pod yield (qt/ha) of bush type French bean at pod ripe stage during post monsoon season.

These genotypes can also be grown the in mid-hills during the pre and post monsoon seasons. Thus the availability of fresh bean pod can be extended throughout the year exploring. Average market price of fresh bean pod during spring, summer and post monsoon seasons were Rs40, Rs20 and Rs30 per kg respectively at local markets near the research sites. The highest price of spring season was due to unavailability of fresh bean pods.

New pole bean genotype LB-27 produced the longest pod (14.2 cm) followed by S-9 and LB-25 (14.1 and 13.7 cm respectively) as compared to genotypes, which were promising in previous years as reported by Lohar et al (1995). However, farmers preferred LB-25 genotype due to moderate resistant to bean rust and good taste.

Fibre content is an important criteria, which determines price of a particular genotypes of French bean. Genotypes LB-25 and LB-27 have lower fibre content than S-9 and Pant Anupama which fulfils the problem raised by GC et al (1997).

LB-25 produced the highest marketable fresh pod yield in OR site, Rising Patan, Tanahun (2000) and ARS, Lumle (2001) ie 2.9 and 11.2 t/ha respectively. S-9 produced the highest yield (3.5 t/ha) in the ASR, Pakhribas and LB-27 produced the highest yield in the ARS, Lumle (2001). But, LB-25 produced the highest yield (6.9 t/ha) in the combined analysis of ARS, Lumle and ARS, Pakhribas during Aug - Dec 2001. However, average yield over years and locations showed that LB-25 produced the highest yield (5.7 t/ha) followed by LB-27 (4.9 t/ha). The marketable fresh pod yield was less during spring season but the genotypic trend in terms of yield was similar in subsequent evaluations. Production of spring season fresh pod fetched very high market price (NR 40/kg) and the cultivation was found economical.

Under the natural epiphytotic condition LB-25 was found having less bean rust severity and good in other traits during post monsoon season (August to December) at ARS, Lumle. The plant height covered by disease and rust severity was 60% and 15.7% respectively in LB-25. The plant height covered by disease was 87%, 75%, 87%

and disease severity 27%, 23% and 27% in LB-27, S-9 and Pant Anupama respectively. Thus LB-25 can be regarded as moderately resistant to bean rust.

RECOMMENDATION

LB-25, LB-27 and S-9 can be cultivated in different seasons in river basin to mid hills of Nepal. In addition to this, LB-25 should be tested at high hills during summer season

ACKNOWLEDGEMENTS

We are grateful to NARC and HARP for providing funds. Our gratitude and thanks are due to Dr DN Sah, Mrs N Sharma, Mr S Malla, Mr RP Paudel and Mr KP Devkota for their help to achieve the outputs of the project. Special and sincere thanks are extended to Dr K Budhathoki, HRD, Khumaltar, Mr PP Khatiwada, ARS, Pakharibas, Mr DB Gurung, ARS, Dailekh for their collaboration in this project.

REFERENCES

- Bhattarai SP, PP Subedi, JP Jaiswal, S Sharma, SR Gimire, TB Gurung, NA Khan and RP Bari. 1997. The strategy for commercial vegetable research. *LARC Strategy Paper No. 97/8*. Lumle Agricultural Research Centre, Kaski, Nepal.
- GC YD, SP Bhattarai and DP Lohar. 1997. Leguminous vegetable research during 1997/96. *LARC Working Paper No. 97/15*. Lumle Agricultural Research Centre, Kaski, Nepal.
- Lohar DP, HM Gurung and LK Amatya. 1995. Varietal studies on vegetable type soybean, cowpea, for high hills and common bean at LARC during 1994/95. *LARC Working Paper No. 95/9*. Lumle Agricultural Research Centre, Kaski, Nepal.
- Schoon HA and Voysest O. 1991. Common bean research for crop improvement. *CIAT cali Colombia*. Pp.199-286,835-862.

Performance of Cauliflower Varieties under Different Agro-Ecological Domains of Western Hills of Nepal

Amar B Pun, Yam R Pandey and Yogendra P Yadav

RARS, Lumle, Kaski

ABSTRACT

A total of eight cauliflower varieties, Snow Crown, Snow Dome, Snow King, Snow Ball-16, Kibo Giant (Holland), Kibo Giant (Nepal), Kathmandu Local and Madhuri were evaluated for consecutive three years in different agro ecological domains western hills of Nepal during 1998 to 2001. Snow Crown, Snow Dome, Snow King and Madhuri were F₁ hybrids and the others four varieties were open pollinated. The experiments were conducted in four agro ecological research (AER) sites and eight-outreach research (OR) sites under the research command area (RCA) of RARS, Lumle. Snow Dome, Snow Crown, Snow King and Kibo Giant (Holland) were promising followed by Kathmandu Local and Madhuri. The hybrid variety Snow King was observed as outstanding for early and off-season production, whereas Snow Crown, as a superior variety in term of high curd yield (24.7 t/ha). The lowest mean curd yield (16.86 t/ha) was recorded in Kathmandu Local. Snow Dome, Snow King and Snow Crown showed better performance for early production, whereas Kibo Giant (Holland) and Madhuri were appropriate for late season production in the altitude range of 800 to 1600 m. The good quality curd (marketable size, compactness and color) was found in Snow Dome and Snow King and these varieties were highly preferred by the farmers and consumers.

Key words: Cauliflower, curd yield, field varietal trials, Western hills

INTRODUCTION

Cauliflower is one of the important crops in Nepal. Due to its cash generation nature it was included in the Participatory Technology Development of Horticultural crops in Outreach Research Program at RARS, Lumle. It can be successfully grown from the Tarai to the high hills in normal and off-season, if appropriate varieties are provided. Off-season production can fetch high market price (Jaiswal et al 1996). However, due to the development of different hybrids and OP varieties over time, farmers are lacking knowledge about the appropriate varieties for right season and altitude. Therefore, there is necessary to verify the different varieties across the agro-ecological domains in the different production seasons in western hills of Nepal.

The promising four varieties of cauliflower viz Kibo Gaint (Holland), Snow Ball-16, Kathmandu Local and Kibo Gaint (Nepal) were tested in 1998. The variety Kibo Gaint (Holland), Kibo Gaint (Nepal) and Snow Ball-16 yielded more or less same and have same crop duration. The similar trial Farmers Field Varietal Trial on cauliflower varieties (excluding Snow Ball-16 and Kibo Gaint (Nepal) and including two new hybrid varieties viz Snow Crown and Snow Dome was conducted in 1999. Lastly, the same varietal trial including six varieties viz Kibo Gaint (Holland), Snow Crown, Kathmandu Local, Snow Dome, Snow King and Madhuri was conducted in 2000. These research works were designed to identify appropriate cauliflower cultivar(s) suitable for early, medium and late seasons production at different altitude, so that farmers can fetch high market price from cauliflower production. This report presents the results of the experiments Farmers Field Varietal Trial (FFVT) conducted at agro ecological research/outreach research sites of RARS, Lumle over the altitude range of 500 - 1700 masl from 1998 to 2000.

MATERIALS AND METHODS

The experiments were conducted at the different agro-ecological outreach research sites of RARS Lumle in three consecutive years, 1998, 1999 and 2000.

FFVT 1998

The experiment was conducted at six OR sites (Kauleni, 1200-1500 masl; Taranagar, 300-500 masl; Arghali, 400-660 masl; Bamgha, 1000-1500 masl; Thulopokhara, 1100-1600 masl and Barabise, 620 masl) of research command area of RARS, Lumle from October 1998 to February 1999. A randomized complete block design (RCBD) with four replications (farmer as a replicate) was used at each site. Four varieties, namely Kibo Gaint (Holland), Snow Ball-16, Kathmandu Local and Kibo Gaint (Nepal) were tested.

FFVT 1999

This experiment was conducted at six OR sites (Chambas, 440-500 masl; Taranagar, 300-500 masl; Arghali, 400-660 masl; Madhuwa, 800-1100 masl and Bamgha, 1000-1500 masl) of research command area of RARS, Lumle in 1999. RCBD with five replications (farmer as a replicate) was used at each site. Four varieties namely Kibo Gaint (Holland), Snow Crown, Kathmandu Local and Snow Dome were tested.

FFVT 2000

This experiment was conducted in the farmers' field of seven OR sites (Taranagar, 300-500 masl; Chambas, 440-500 masl; Barabise, 620 masl; Arghali, 400-660 masl; Pakuwa, 800-1200 masl; Deurali, 1100-1500 masl and Baglung, 1200-1500 masl) from September 1999 to January 2000. RCBD with four replications (farmer as a replicate) was used at each site. Six varieties, namely Kibo Gaint (Holland), Kathmandu Local as OP varieties and Snow Crown, Snow Dome, Snow King and Madhuri as hybrids were tested. Kathmandu Local at Pakuwa and Madhuri at Baglung, Pakuwa, Chambas and Taranagar were excluded because poor initial plants stand.

In all these activities the following methods were applied. Experiment plot size was 8.1 m² (30 plants per plot) and spacing was maintained at 60- × 45-cm between and within rows. Seeds were sown in nursery in 2 week of Aswin to 1st week of Kartik. About 30-35 day old seedlings were transplanted and gap filling was carried out within 1st week of transplanting. Manure and fertilizer were applied @ 20 t FYM and 120:45:70 kg NPK/ha at the time of final land preparation. Half dose of nitrogen was top dressed in three split doses; first 20-25, second 40-45 days after transplanting and third at curd initiation stage. Farmers' practices were followed. Plots were kept weed free manually. No insecticides and fungicides were used in the crop. Harvesting of curd was carried out when curds became marketable size. Observations were recorded on days to first harvest, marketable curd yield, unmarketable curd yield, percentage of well developed curd, curd quality (compactness, size, color) and farmers' preferences and were analyzed. The pooled analysis was not possible due to heterogeneity nature of results. Therefore, the results were presented here separately.

RESULTS AND DISCUSSION

FFVT 1998

Marketable curd yield of four varieties of cauliflower tested at different OR sites are presented in Table 1. The tested varieties differed significantly at all locations except at Taranagar. The variety Kibo Gaint (Holland) was the highest curd yielding (21.88 t/ha) variety followed by Snow Ball-16 (21.55 t/ha) whereas Kathmandu Local produced the lowest curd (16.86 t/ha) at Thulopokhara, Bamgha and Barabise. Kibo Gaint (Holland) produced 210%, 78% and 45% more curd yield respectively than the lowest curd producing variety Kathmandu Local at Thulopokhara, Bamgha and Barabise. However, Kathmandu Local produced highest yield of 23.17 and 17.82 t/ha respectively at Kauleni and Arghali Kibo Gaint (Holland) and Snow Ball-16 were found the most promising varieties of cauliflower in term of highest curd production potentiality. These varieties showed a non significant yield differences to each other. Kibo Gaint (Holland) produced about 1.5%, 29% and 21% higher curd yield than Snow Ball-16, Kathmandu Local and Kibo Gaint (Nepal) respectively.

Most of the farmers at different sites preferred the Snow Ball-16, as the best variety followed by Kibo Gaint (Nepal) in spite of lower curd yield. The main reasons for preferring Snow Ball-16 variety were for its good quality curd (ie compact, attractive and marketable curd size) and good taste. Most of the farmers did not preferred Kibo Gaint (Holland) in spite of its highest curd yield. The reasons behind were its long crop duration and big size of curd as compared to other varieties. Kathmandu Local was not in farmers' priority because of its poor performance with respect to yield and percentage of curd formation.

FFVT 1999

The results of cauliflower tested during 1999 are presented in the Table 2. The tested varieties for marketable curd yield differed significantly at Bamgha, Madhuwa, Arghali and Chambas except Taranagar. The variety

Snow Dome produced the highest curd yield (58.9, 41.97 and 30.22 t/ha) respectively at Bamgha, Madhuwa and Arghali. The overall mean curd yield also indicated that Snow Dome produced the highest marketable curd yield (34.02 t/ha). Whereas lowest mean curd yield (19.21 t/ha) was recorded in Kathmandu Local. The variety Snow Dome was preferred by farmers because of its high curd yield and quality.

Table 1. Marketable curd yield (t/ha) of cauliflower varieties under FFVT at different OR sites of RARS, Lumle, 1998

Variety	Kauleni	Taranagar	Arghali	Bamgha	Thulopokhara	Barabise	Mean
Kibo Gaint (Holland)	10.74	22.62	10.93	24.6	42.94	19.49	21.88
Snow Ball-16	22.92	19.10	12.17	18.4	40.74	16.02	21.55
Kathmandu Local	23.17	19.13	17.82	13.8	13.83	13.43	16.86
Kibo Gaint (Nepal)	14.40	18.40	8.84	22.7	36.54	12.60	18.91
Mean	17.89	19.8	12.44	24.6	33.52	15.39	
CV, %	10.40	11.4	17.3	9.88	14.9	14.8	
P value	< 0.01	0.09	< 0.01	< 0.01	< 0.01	0.03	
SED	1.51		1.35	1.6	3.16	1.85	

Table 2. Marketable curd yield (t/ha) of cauliflower varieties tested under FFVT at different AER/OR sites in 1999

Variety	Chambas	Argali	Maduwa	Bamgha	Taranagar	Mean
Kibo Gaint (Holland)	16.73	24.23	24.65	26.77	29.16	24.308
Snow Crown	12.35	22.87	37.82	33.65	30.63	27.464
Kathmandu Local	9.88	16.88	27.12	30.68	23.01	21.514
Snow Dome	12.94	30.22	41.97	58.90	29.49	34.704
Mean	12.97	23.55	32.89	37.5	28.07	
CV, %	11.68	15.61	5.95	1.9	11.09	
F test	**	**	**	**	ns	
SED	1.64	5.18	4.81	0.41		

FFVT 2000

Days to first curd harvesting is one of the important parameter for off-season vegetable production. Even one or two days differ in harvesting time affects greatly on economic return to the farmers in off-season vegetable production

Mean days to first harvesting from transplanting was 100 days. The varietal effect in the experiment for days to first harvest was significant at all locations except Baglung and Pakuwa. The hybrid variety Snow King (69 days) was the earliest variety, which was 18 days earlier than the latest variety Kathmandu Local (87 days) and 5 days earlier than the Snow Crown (74 days) at Barabise. At Baglung, Chambas, Taranagar and Deurali. The variety Snow King was earlier than other varieties. Whereas Kathmandu Local (98 days) and Kibo Gaint (Holland) (78 days) were respectively 4 and 10 days earlier than Snow King at Arghali and Pakuwa respectively.

The overall mean of the individual variety over the locations indicated that Snow King was earlier (91 days) followed by Snow Crown (97 days) across the locations except Arghali and Pakuwa., whereas Kibo Gaint (Holland) (105 days) was observed late variety followed by Kathmandu Local (104 days) (Table 3). The marketable curd yield of six cauliflower varieties tested at different ecological sites are presented in Table 4. The marketable curd yield due to varieties was significantly different only at three sites Kauleni, Arghali and Barabise out of seven tested sites. The variety Snow Crown was the highest curd yielding variety at Taranagar, Deurali and Barabise, whereas Kibogaint (Holland) and Snow Dome were the highest curd yielding varieties at Kauleni, Pakuwa; Chambas and Arghali respectively.

Though the overall treatment mean across the locations indicates that Snow Crown was the most promising variety followed by Kibo Gaint (Holland) and Snow Dome (23.9 t/ha) in term of highest curd production potentiality, the difference among the varieties was not significant. Snow Crown produced about 15%, 30% and 22% more curd yield than Kathmandu Local, Snow King and Madhuri respectively. The average lowest curd yield of 18.94 t/ha and 20.16 t/ha were recorded on Snow King and Madhuri respectively.

Most of the farmers from all sites preferred the variety Snow Dome, as the best variety for year round production. The reasons for preferring were good quality curd (ie compact, marketable size and attractive color) and high percentage of curd formation. Snow King grabbed second position on farmers' preference because of its short crop period that could be harvested prior to winter inception. Snow Crown was equally preferred variety for reasonable curd yield and its suitability for year round production (Bhattarai et al 1996).

Table 3. Days to first harvest of cauliflower varieties tested at different AER/OR sites of RARS, Lumle in 2000

Variety	Baglung	Pakuwa	Chambas	Taranagar	Deurali	Barabise	Arghali	Mean
Kibo Gaint (Holland)	147.4	78.3	128.0	104.4	109.7	98.0	102.5	105
Snow Ball-16	144.0	90.0	121.0	84.6	94.0	74.0	101.8	97
Kathmandu Local	144.2	-	119.7	102.0	106.0	87.8	98.5	104
Snow Dome	146.0	92.3	122.7	107.2	111.7	98.0	103.0	107
Snow King	143.8	88.7	106.0	77.0	79.5	69.5	102.5	91
Madhuri	-	-	-	-	107.7	98.3	107.0	104
Mean	145.2	87.3	119.5	95.04	101.5	87.58	102.54	
CV, %	2.2	11.2	3.7	3.2	5.4	1.0	3.1	
F test	0.275	0.386	0.003	< .001	< .001	< .001	0.053	
SED	1.992	7.98	3.62	1.92	3.85	0.606	2.28	

Table 4. Marketable curd yield (t/ha) of cauliflower varieties tested at different AER/OR sites of RARS, Lumle in 2000

Variety	Baglung	Pakuwa	Chambas	Taranagar	Deurali	Barabise	Arghali	Mean
Kibo Gaint (Holland)	46.3	18.2	16.6	29.2	14.5	20.6	24.2	24.2
Snow Crown	43.1	14.1	11.4	32.3	22.1	27.2	22.9	24.7
Kathmandu Local	45.6	-	14.1	23.0	16.1	13.2	16.9	21.5
Snow Dome	33.0	13.7	18.6	29.5	20.3	22.0	30.2	23.9
Snow King	35.2	11.5	12.2	24.7	16.9	14.3	17.8	18.9
Madhuri	-	-	-	-	12.5	21.1	26.9	20.2
Mean	41.4	14.4	14.6	27.7	17.1	19.74	23.14	
CV, %	11.2	41.7	27.5	20.7	38.3	20.4	15.6	
P value	< 0.001	0.615	0.241	0.119	0.352	0.002	0.001	
SED	2.932	4.90	3.28	3.63	4.62	2.84	2.55	

CONCLUSIONS

The varietal trial for normal season cauliflower conducted in 1998 revealed that Kibo Gaint (Holland) gave the highest yield (21.88 t/ha) followed by Snow Ball-16 (21.55 t/ha). However, most of the farmers preferred Snow Ball-16 and Kibo Gaint (Nepal) for quality curd and taste in spite of low curd yield. On the same varietal trial conducted in 1999, Snow Dome performed better in terms of quality and production. Variety Snow Crown stands in second position for high curd yield and year round production. Some of the farmers ranked the variety Snow Dome on a top for its quality and short crop duration.

The varietal trial conducted in 2000, revealed that Snow Crown produced the highest curd yield followed by Kibo Gaint (Holland). The Snow Crown was also the highest yield in 1998, so this variety is the best variety on account of highest curd yield. The overall mean of crop period indicated that Snow King was earliest, followed by Snow Crown. Farmers also preferred Snow King for its short crop period and quality curd. Therefore, on hybrid varieties, Snow Dome and Snow King should be recommended for early and quality curd production.

ACKNOWLEDGEMENTS

The authors are grateful to Dr RP Sah, RARS, Lumle for approval and support to carry out these activities. The continuous support and encouragement of Dr DN Sah, RARS, Lumle is highly acknowledged. Our sincere thanks are due to all staff members of OR Division and AER/OR sites coordinators, who helped us for conducting trials and data recording. We offer our thanks to Mr IP Gautam for his valuable suggestion and review this paper. The contribution and support of our collaborative farmers are also highly appreciated.

REFERENCES

- Bhattarai SP, PP Subedi and JP Jaiswal. 1996. Off-season cucumber, cauliflower, tomato and normal season onion and shallot variety and management research for the hills during 1992-1995. *LARC Seminar Paper No. 96/8*. Lumle Agricultural Research Centre, Kaski, Nepal.
- Jaiswal JP, PP Subedi and SP Bhattarai. 1996. Summary findings of on-farm verification trials on vegetable crops conducted at outreach research sites, 1992-1995. *LARC Seminar Paper No. 96/20*. Lumle Agricultural Research Centre, Kaski, Nepal.

Performance of True Potato Seed Progenies for Transplanted Crop in Eastern Tarai

Ram C Adhikari¹ and Deo K Chaudhary²

¹ National Agriculture Research Institute, NARC, Khumaltar, Lalitpur

² Regional Agricultural Research Station, Tarahara, Sunsari

ABSTRACT

Six different hybrid true potato seed (TPS) progenies received from International Potato Center, Lima, Peru were raised in nursery beds and 30 days old seedlings were transplanted in the field to see the performance of TPS progenies at Eastern Tarai conditions of Nepal during 2001-2002 and 2002-2003. The survival of the transplanted seedlings in the field ranged from 95.00 to 96.67%. Late blight disease buildup in all the progenies was very low. The tested progenies gave the average tuber production in the ratio of 15:45:40 of over seed size (>50 g), seed size (25-50 g) and under seed size (<25 g) tubers respectively. TPS progenies HPS II/67 and LT 8 x TPS 13 produced highest tuber number per plant (9.69) and highest average per tuber weight (16.25 g), respectively. The result suggests that the genotype Serrana x TPS 67, LT 8 x TPS 67 and HPS II/67 were highest yielder.

Key words: Progeny, seedlings, transplantation, true potato seed, tuber yield

INTRODUCTION

Conventional propagation by seed tubers increases cost of production, disseminates diseases, diverts valuable food for seed and involves handling and storage problems of bulky seed material. By using true potato seed (TPS), seed rate can be reduced from two tons (tuber seed) to 100 g (Accantino and Malagamba 1982). This alternative has also high production potential and there is no loss of potential food as planting material. By using TPS as planting material about 18% of total edible potato production in developing countries can be saved for food (CIP 1982). The cost of producing, storing and distributing TPS are lower than those for seed tubers (Monares et al 1983). Also use of TPS helps to avoid most tuber borne diseases. It requires no fungicides at any stages of crop (Lama and Khatri 1997).

Three main systems can be adapted for the utilization of TPS (Sadik 1983). The first system relies on the direct field sowing of botanical seed, the second is the transplanting of seedlings from seedbeds into the field and the third method is to use TPS to produce seed tubers (seedling tubers). Use of transplant has been suggested as a practical method for growing potatoes from TPS especially, in areas where human labor is not a limiting factor, farmers are skillful in vegetable production, soils are of adequate physical structure and irrigation is available (Monares et al 1983). In the present study an experiment was conducted to see the performance of TPS genotypes to produce tuber yields and resistance to diseases especially late blight.

MATERIALS AND METHODS

Six different hybrid TPS progenies received from CIP, Lima were tested and compared with locally produced hybrid progeny during November to February at Tarahara, Sunsari during 2001-2002 and 2002-2003 in randomized block design with three replications having net plot size of 4- × 2.5-m. Tuber production from transplanting seedlings involves two steps, viz raising of seedlings in nursery bed and transplanting them in the field. Nursery bed was prepared by mixing the surface soil and farmyard manure (FYM) in the ratio of 1:1. The top of the bed was covered with 1 cm thick layer of sieved FYM and moistened by sprinkling water. The

following day, top of the bed was hoed and leveled to break the crust to get proper texture. TPS were evenly placed in 0.5 cm deep furrows at 10 cm apart on bed and trays @ 2 g/m² on October second week in both years. Seeds were covered with thin layer of sieved FYM and dry paddy straw. The bed was sprinkled with water 2-3 times in a day for a week. Mulch was removed when seedlings started to germinate. The seedlings were sprayed with 0.1% urea on alternate days after emergence of first true leaf. The field for transplanting the seedling was prepared and applied basal dose of FYM @ 10 t/ha and half dose of N (50 kg/ha) and full dose of phosphorous (100 kg/ha) and potash (100 kg/ha). Furrows about 20 cm deep and 60 cm apart were made and irrigated a day before transplanting. One healthy seedling per hill was transplanted at 20 cm apart in afternoon, in such a way that roots get placed below the watermark. The furrows were kept moist till seedling establishment. After 45 days of transplanting the remaining half dose of nitrogen (50 kg/ha) was applied at the time of earthing up. Harvesting was done at full maturity on 8 March 2002 and 4 March 2003. The data were recorded on plant height (cm), ground cover by foliage (%), late blight infection (1-9 scale), number of tuber per plant, average tuber weight (g), tuber sizes (<25 g, 25-50 g, and >50 g), yield of tuber (t/ha). The data were analyzed as per procedure of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The performance of TPS family for seedling transplanting was evaluated according to seedling survival, plant height, ground cover by foliage, late blight infection and tuber yields.

Seedling survival

Percentage survival of the transplanted seedlings in the field ranged from 90.28 to 906.66%. The TPS progeny MF I x TPS 67 had the highest survival and the LT 8 x TPS 67 the lowest but statistically the difference among the progenies were not significant in both the years (Table 1). This may be due to the favourable growing conditions for seedlings of all the tested hybrid TPS progenies. Singh and Bahal (1997) also reported similar finding.

Table 1. Seedling survival and ground cover by foliage of TPS genotypes under transplanted condition at Tarahara, Sunsari

TPS genotype	Seedling survival, %			Ground cover, %		
	2001/02	2002/03	Mean	2001/02	2002/03	Mean
MF I x TPS 67	96.67	96.66	96.67	71.67	70.00	70.84
MF II x TPS 67	95.56	90.56	93.06	76.67	70.00	73.34
Atzimba x TPS 67	92.20	91.11	91.66	68.33	71.67	70.00
Serrana x TPS 67	92.78	89.44	91.11	68.33	80.00	74.17
LT 8 x TPS 13	95.00	91.67	93.34	71.67	66.67	69.17
LT 8 x TPS 67	90.00	90.57	90.29	75.00	63.33	69.17
HPS II/67	96.67	95.00	95.84	81.67	85.00	83.34
F test	ns	ns		*	**	
LSD (0.05)				5.44	9.18	
CV, %	4.13	5.27		6.37	7.30	

*, ** Significant at 1 and 5% level, respectively.

Ground cover

The process of photosynthesis is related with the interception of active radiation by green foliage, which depends on the area of the ground cover by it (Beukema and Vander Zaag 1990). In this aspect groundcover by potato can be consider as an important parameter for the light interception. The ground cover differences among the TPS progenies were found statistically significant in both the years.

The check progeny HPS II/67 produced highest ground cover (81.67%) which was at par with MF II x TPS 67 (76.67%) and significantly higher than all other TPS genotypes during 2001-02 (Table 1). In 2002-03, it was also maximum in HPS II/67 (85.00%) followed by Serrana x TPS 67. The two-year mean ground cover ranged from 68.33 to 83.34%. The check progeny HPS II/67 had highest (83.34%) ground cover by foliage followed by Serrana x TPS 67 (80.00%).

Plant height

The plant height differences among the TPS genotypes were statistically significant in both the years. The check progeny HPS II/67 produced tallest plant (38.17 cm), which was significantly tallest than all other TPS progeny

in 2001-02. In 2002-03 TPS genotype LT 8 x TPS 13 was tallest (39.67 cm) followed by LT 8 x TPS 67 (37.03 cm) (Table 2). The two years mean showed that the genotype HPS II/67 followed by LT 8 x TPS 13 produced tallest plant after transplanting. The variation in plant height may be due to recover capacity of transplant shock. Similar results have been reported by Verma and Singh (1995), Batra et al (1992).

Table 2. Plant height and late blight infection of TPS genotypes under transplanted condition at Tarahara, Sunsari

TPS genotype	Plant height, cm			Late blight infection (1-9 scale)†		
	2001/02	2002/03	Mean	2001/02	2002/03	Mean
MF I x TPS 67	23.67	27.67	25.67	1.00	1.00	1.00
MF II x TPS 67	21.67	28.80	25.24	2.00	2.00	2.00
Atzimba x TPS 67	27.33	35.13	31.23	1.67	1.33	1.50
Serrana x TPS 67	30.33	29.77	30.05	2.00	1.00	1.50
LT 8 x TPS 13	24.12	39.67	31.90	1.00	1.33	1.16
LT 8 x TPS 67	25.67	37.03	31.35	2.00	1.00	1.50
HPS II/67	38.17	28.77	33.47	2.00	1.00	1.50
F-test	**	**		**	**	
LSD (0.05)	4.53	3.56		0.39	0.57	
CV%	9.34	6.33		13.09	25.94	

*, ** Significant at 1 and 5% level, respectively. † Late blight incidence rating: 1 = no symptoms, 2 = 0–5%, 3 = 5–15% 4 = 15–35%, 5 = 35–65%, 6 = 65–85%, 7 = 85–95%, 8 = above 95% affected and 9 = dead.

Late blight incidence

Disease buildup in the TPS progenies was far lower (Table 2). TPS progenies represent vast genetic variability within a cross that is genetically not uniform and hence each seedling acted as different genotype, which needed different matching race of *Phytophthora infestans* (Singh and Bahal 1997). Under such circumstances accumulation of higher genes of virulence by a pathogen becomes extremely difficult. This phenomenon not only delayed the infection but also checked the buildup of late blight. This phenomenon supports the results for low level of late blight infection in crop raised through TPS.

Tuber production

The highest tuber number per hill was produced by HPS II/67 (9.77) followed by Serrana x TPS 67 (9.63) during 2001-02. During 2002-03, it was maximum (9.60) in HPS II/67 followed by MF II x TPS 67 (9.35). The average per tuber weight among the TPS genotypes was not significant during 2001-02. During 2002-03, it was significantly highest per tuber weight (19.72 g) in LT 8 x TPS 13 followed by MF I x TPS 67 (17.88 g). The number of tuber per plant differed significantly among the genotypes in both the years (Table 3). The maximum number of tuber was found in check progeny HPS II/67 during both the years, which was in agreement with the findings of Verma and Singh (1995). The data presented in Table 3 indicated that the number of tuber per hill has negative relation in tuber weight. Verma and Singh (1995) have also reported that there is a negative relation between tuber number and average tuber weight.

Table 3. Performance of TPS genotypes for tuber production in seedling transplanted crop at Tarahara, Sunsari

TPS genotypes	Number of tuber/plant			Average weight, g/tuber			Tuber yield, t/ha		
	2001/02	2002/03	Mean	2001/02	2002/03	Mean	2001/02	2002/03	Mean
MF I x TPS 67	5.73	7.27	6.50	13.39	17.88	15.64	6.40	10.82	8.61
MF II x TPS 67	7.02	9.35	8.19	13.37	14.58	13.98	7.88	11.15	9.52
Atzimba x TPS 67	9.10	9.10	9.10	13.05	12.87	12.96	9.88	9.84	9.86
Serrana x TPS 67	9.63	8.21	8.92	12.81	15.95	14.38	10.97	10.58	10.77
LT 8 x TPS 13	7.53	5.00	6.27	12.77	19.72	16.25	8.02	8.23	8.13
LT 8 x TPS 67	9.17	7.98	8.58	14.22	13.94	14.08	10.28	10.99	10.64
HPS II/67	9.77	9.60	9.69	15.16	12.27	13.72	12.37	9.61	10.99
F test	**	**		ns	**		**	**	
LSD (0.05)	1.02	1.85			3.33		0.89	0.93	
CV, %	6.89	12.59			12.68		5.32	5.24	

*, ** Significant at 1 and 5% level, respectively.

The tuber yields among the TPS genotypes were statistically significant during both the years. In 2001-02, the highest tuber yield was recorded in HPS II/67 (12.37 t/ha) followed by Serrana x TPS 67 (10.97 t/ha) and minimum in MF I x TPS 67 (6.40 t/ha). During 2002-03, the highest tuber yield was recorded in MFII x TPS 67 (11.15 t/ha) followed by LT 8 x TPS 67 (10.99 t/ha). The two years mean data showed that the highest tuber yield was recorded in HPS II/67 (10.99 t/ha) followed by Serrana x TPS 67 (10.77 t/ha) and LT 8 x TPS 67

(10.64 t/ha). The data also indicate that the ground cover by foliage and plant height have positive bearing on yield of the crop. Allen and Scott (1980) have shown that there is a close relationship between total intercepted light by green foliage and tuber yield.

Tuber size

The production of over seed size (>50 g) tuber were significantly different during 2001-02. TPS progeny Atzimba x TPS 67 produced significantly highest tuber yield (1.42 t/ha) of over seed size tubers followed by HPS II/67 (1.10 t/ha). TPS progeny HPS II/67 produced significantly highest tuber yield (3.36 t/ha) of seed size (25-50 g) followed by MF I x TPS 67 (2.16 t/ha) during 2002-03 (Table 4). Progeny HPS II/67 produced significantly highest yield (7.29 t/ha) of seed size tubers followed by Serrana x TPS 67 (6.00 t/ha) and minimum by LT 8 x TPS 13 and MF II x TPS 67 (4.15 t/ha) during 2001-02. During 2002-03, it was maximum in Serrana x TPS 67 (4.26 t/ha) followed by MF I x TPS 67 (4.11 t/ha). The mean tuber weight among the TPS genotypes of under seed size (<25 g) was significant in both the years. The highest tuber yield (3.98 t/ha) of under seed size was recorded in the check progeny HPS II/67 while minimum in MF I x TPS 67 (1.32 t/ha) during 2001-02. During 2002-03, the highest tuber yield of under seed size was recorded in Atzimba x TPS 67 (6.00 t/ha) and minimum in LT 8 x TPS 13 (3.01 t/ha). The two years mean data showed that TPS progeny HPS II/67 produced highest weight (5.20 t/ha) of seed size (25-50 g) tubers, which also has good yield potential. The yield of small and medium size tubers was higher with all the TPS progenies. TPS seedlings have tendency to produce more number of medium and small size tubers (Singh and Bahal 1997).

Table 4. Performance of tuber genotypes for tuber size in transplanted crop at Tarahara, Sunsari

TPS progeny	Graded tuber yield, t/ha								
	<25 g			25-50 g			>50 g		
	2000/02	2002/03	Mean	2001/02	2002/03	Mean	2001/02	2002/03	Mean
MF I x TPS 67	1.32	4.56	2.94	4.41	4.11	4.26	0.67	2.16	1.42
MF II x TPS 67	2.83	4.98	3.90	4.15	2.89	3.52	0.87	3.36	2.11
Atzimba x TPS 67	2.94	6.00	4.47	5.53	3.27	4.40	1.42	0.57	1.00
Serrana x TPS 67	3.71	4.72	4.22	6.00	4.26	5.13	1.38	1.46	1.42
LT 8 x TPS 13	3.00	3.01	3.01	4.15	3.15	3.65	0.88	2.07	1.48
LT 8 x TPS 67	3.72	5.43	4.58	5.78	3.77	4.78	0.78	1.79	1.29
HPS II/67	3.98	5.14	4.56	7.28	3.11	5.20	1.10	1.37	1.24
F test	**	**		**	**		**	**	
LSD (0.05)	0.37	0.79		0.66	0.36		0.35	0.58	
CV, %	6.75	9.22		6.93	5.93		19.43	18.03	

*, ** Significant at 1 and 5% level, respectively.

The TPS progenies Serrana x TPS 67, LT 8 x TPS 67 and HPS II/67 were high yielder than that of other tested TPS genotypes for potato production by transplanting the seedlings in Eastern Tarai condition.

ACKNOWLEDGEMENTS

The authors are thankful to Mr KC Upreti and DP Bhattarai for their assistance in conducting the experiment.

REFERENCES

- Accantino P and P Malagamba. 1982. *Potato production from true potato seed*. International Potato Center, Lima, Peru. 20 p.
- Allen EJ and RK Scott. 1980. An analysis of growth of potato crop. *J. Camb.* 94:583-608.
- Batra VK, YS Malik and ML Pandita. 1992. Effect of growth regulators on establishment of potato seedlings in relation to seedling tuber production. *J. Indian Potato Assoc.* 19:17-20.
- Beukema HP and DE Vander Zaag. 1990. *Introduction to potato production*. Pudock Wageningen. 208 p.
- CIP. 1982. *World potato facts*. International Potato Center (CIP), Lima, Peru. 54p.
- Gomez KA and A Gomez. 1984. *Statistical procedure for agricultural research*. 2nd eds. John Willy and Sons, New York. 680 p.
- Lama TL and BB. Khatri. 1997. Utilization of true potato seed (TPS) in Nepal. *Nepalese J. Agric.* 1:149-151.
- Monares A, P malagamba and D Horton. 1983. Prospective systems and users for true potato seed in developing countries. **In: Proceedings International Congress Research for the potato in the year 2000**. International Potato Center, Lima, Peru. Pp.134-136.
- Sadik S. 1983. Potato production from true seed - present and future. **In: Proceedings International Congress Research for the potato in the year 2000**. International Potato Center. Lima, Peru. 19p.

- Singh K and VK Bahal. 1997. Performance of TPS families for ware potato production in Northeast hills. *J. Indian Potato Assoc.* 24(3-4):148-153.
- Verma RB and RD Singh. 1995. Performance of TPS families for potato production as transplanted crop. *J. Indian Potato Assoc.* 22(1-2):66-69.

Performance of Vegetable Soybean in the Hills of Nepal

Khadga B Paudel, Jeet N Chaudhary, Ishwori P Gautam, Kalika P Upadhyay and Bhogendra Khatri

NARC, Nepal

ABSTRACT

Elite genotypes of vegetable soybean were introduced from Asian Vegetable Research and Development Center (AVRDC), Taiwan and were evaluated under Co-ordinated Varietal trials (CVT) at Agriculture Research Station (ARS), Lumle and Horticulture Research Division (HRD), Khumaltar during 2000 and 2001. Enough variability was found in plant height, days to harvest, marketable fresh pod yield, total biomass, 100-green seed weight and resistant to powdery mildew. The performance of genotypes in economic traits, were almost similar in all tested locations. Considering overall performance, marketable fresh pod yield per day per hectare, 100-green seed weight and resistant to powdery mildew, the vegetable soybean genotype AGS-352 was superior to rest of the tested genotypes.

Key words: Economic traits, hilly areas, vegetable soybean

INTRODUCTION

Vegetable soybean (*Glycine max* (L) Merr.) is a new vegetable crop and has huge potentiality to support food security, health improvement, income generation and maintenance/ improvement of soil fertility in the hills of Nepal. It is one of the important vegetable crops in Japan, China and Korea, (Prasan 1994). Japan imports the frozen vegetable soybean pods, which is primary export of Taiwan (Manyvong 1997). It is getting popularity in other foreign countries for its unique taste and high nutritional value. The vegetable soybean is ready for harvesting after the R6 and before R7 growth stage while the pod is still green. The vegetable soybean provides 35% of world vegetable requirement and is a major source of protein of two billion people in Asia (Tindal 1998). Vegetable soybean can help to reduce malnutrition problem of rural people by providing protein, vitamins and minerals and also helps to earn foreign money by export. Its appearance, sweetness, flavour, aroma and texture determine exportable quality of vegetable soybean. The bright green pods are sold quickly where as yellow pods are unacceptable due to decline in taste and vitamins. The standard graded products should have two to three seeds per pod and hundred-grams pod weight should not have more than 175 pods (Wihong 1997). The pods having large seed more than (30 g/100-green seeds) are preferred.

Asian Vegetable Research and Development Center (AVRDC), Taiwan has broadened research on vegetable soybean to cover adoption of the crop in the tropics and subtropics. Well-adopted cultivar of vegetable soybean for a particular agro-system can be grown throughout the year, exploring the potential of off-season vegetable production. The vegetable soybeans are responsive to fertilizer and need additional use of nutrients for yield and quality (Chuansong 1990, Maneechote 1991, Hung et al 1991, Khadka 1993, Xuan Thu 1993). The basal nitrogen application is necessary to increase the photosynthesis at seedling stage whereas 2-3 times top dressing by nitrogen are required for growth, flowering and pod filling.

The study on vegetable soybean was initiated by Lumle Agricultural Research Centre during early 1990s and the genotype OCB# 81 was recorded as a promising genotype (Budhathoki et al 1991a, 1991b). Initial varietal screening trials at LARC revealed that the genotypes of vegetable soybean introduced from AVRDC, Taiwan were promising at off-station research sites (GC et al 1997). However, Bhattarai et al 1997 reported that the

main researchable problems limiting the cultivation of vegetable soybean are i. Lack of suitable vegetable soybean variety to grow in pre and post-monsoon seasons and ii. Lack of nutrient management techniques for producing quality product. To address these problems, a study was done to identify the suitable genotypes of vegetable soybean for different agro-ecological environments in the hills of Nepal.

MATERIALS AND METHODS

Ten genotypes of vegetable soybean from AVRDC, Taiwan were introduced and evaluated during 2000 and 2001 for their economic traits at Horticulture Research Division, Khumaltar and Agriculture Research Station, Lumle. Few genotypes were brought from Agronomy Division, Khumaltar and included in Co-ordinated Varietal Trial (CVT) at Randomized Complete Block Design with three replications. The distance in CVT was 50 cm row to row and 20 cm plant to plant. Fertilisers were applied @ 70:60:40 kg N:P:K along with 10 t compost per ha. All the cultural practices were done as required. Observations were taken on date of seeding, plant establishment at 30 days, days to 1st flower opening, plant height, days to maturity, number of pod/5 plants, number of two seeded pods/5 plants, weight of two seeded pods/5 plants and plant stand at harvest. The data were analysed on MSTAT software.

RESULTS

CVT at Horticulture Research Division, Khumaltar during March, 2000

Highly significant effect was observed on plant height among the tested genotypes. AGS-334, AGS-335 and AGS-351 were found significant at par. Genotype AGS-351 was tallest (109.7 cm) where as, AGS-292 was the smallest (27.5 cm) (Table 1). Highly significant effect was observed on days to harvest among the tested genotypes. Genotype AGS-292 was earlier (94 days) where as, AGS-352 was late (148 days).

Table 1. Performance of vegetable soybean under CVT at HRD, Khumaltar during March 2000

SN	Genotypes	Plant height, cm (N-5)	Days to harvest	Marketable pod yield, t/ha
1	AGS-292	27.5	94	4.5
2	AGS-333	74.1	122	9.2
3	AGS-334	109.7	120	11.3
4	AGS-335	93.1	121	12.0
5	AGS-351	94.7	142	17.4
6	AGS-352	65.1	148	17.5
7	Hauchin	57.7	137	10.5
8	AGS-354	87.9	121	11.7
9	AGS-355	87.4	122	12.4
10	Sujuyutaka	76.5	120	8.8
	F test	***	***	***
	CV, %	16.9	1.5	23.7
	LSD (0.05)	22.4	3.0	4.7

Highly significant effect was observed on marketable fresh pod yield among the tested genotypes. AGS-352 and AGS-351 were found significant at par. Genotype AGS-352 produced the highest yield (17.5 t/ha) where as, AGS-292 produced the lowest (4.53 t/ha).

CVT at Agriculture Research Station, Lumle (1675 masl) during 2000

Highly significant effect was observed on plant height among the tested genotypes. AGS-334, AGS-335 and AGS-351 were found significant at par. Genotype AGS-351 was the tallest (79.1 cm) and Sujuyutaka was the smallest (37.1 cm) (Table 2). Highly significant effect was observed on days to first flowering. Genotype AGS-292 was found earlier (75 days) where as, AGS-352 found late (112 days).

Highly significant effect was observed on days to harvest among the tested genotypes. Genotype AGS-292 was found earlier (108 days) where as, AGS-352 found late (164 days). Highly significant effect was observed on

total bio-mass production. Genotype AGS-352 produced the highest bio-mass yield (37.5 t/ha) where as, AGS-292 produced the lowest (6.9 t/ha).

Highly significant effect was observed on marketable fresh pod yield among the tested genotypes. AGS-334, AGS-335, AGS-351, AGS-352 and AGS-354 were found significant at par. Genotype AGS-351 produced the highest yield (13.7 t/ha) where as, AGS-292 produced the lowest (2.02 t/ha). Highly significant effect was observed in 100-green seed weight among the tested genotypes. AGS-333, AGS-352 and AGS-355 were found significant at par. Genotype AGS-352 produced more bolded seed (111.7 g) as compared to other genotypes.

Table 2. Performance of nine different promising lines of vegetable soybean under CVT at ARS, Lumle (1675 masl), 2000

S N	Genotypes	Plant height, cm (N-5)	Days to 1 st flower opening	Days to harvest	Total biomass yield, t/ha	Marketable fresh pod yield, t/ha	100-green seed weight, gm
1	AGS-292	38.0	75	108	6.9	2.0	73.3
2	AGS-333	60.3	91	136	28.0	8.7	103.3
3	AGS-334	76.9	89	136	25.0	9.6	83.3
4	AGS-335	69.7	91	133	20.7	9.3	86.7
5	AGS-351	79.1	105	157	37.5	13.7	78.3
6	AGS-352	60.1	112	164	27.1	12.2	111.7
7	AGS-354	57.6	98	135	20.0	9.0	85.0
8	AGS-355	59.3	94	129	22.5	8.0	100.0
9	Sujuyutaka	37.1	82	124	15.0	6.7	52.7
	F test	***	***	***	***	***	***
	CV, %	10.6	2.0	1.4	19.2	19.2	11.6
	LSD (0.05)	11.0	3.3	3.4	7.5	4.7	17.3

CVT at ARS, Lumle (1675 masl) during March 2001

Highly significant effect was observed on plant height among the tested genotypes. AGS-334, and AGS-351 were found significant at par. Genotype AGS-351 was tallest (80.5 cm) and Sujuyutaka was the smallest (20.4 cm) (Table 3). Highly significant effect was observed on days to first flowering among the tested genotypes. Genotype AGS-292 was earlier (76 days) where as, AGS-352 was late (109 days).

Table 3. Performance of ten different promising lines of vegetable soybean under CVT at ARS, Lumle

SN	Genotypes	Plant height, cm (N-5)	Days to 1 st flower opening	Days to harvest	Total biomass yield, t/ha	100-green seed weight, g	Marketable fresh pod yield, t/ha
1	AGS-292	20.4	76	102	2.3	90.0	0.7
2	AGS-333	47.9	85	134	38.3	110.0	16.8
3	AGS-334	71.7	86	136	32.7	100.0	12.4
4	AGS-335	39.5	88	134	21.7	113.3	7.8
5	AGS-351	80.5	102	156	41.5	106.7	18.4
6	AGS-352	47.6	109	164	25.0	113.3	12.5
7	Hauchin	45.1	87	152	31.1	73.3	11.8
8	AGS-354	43.0	90	135	21.8	100.0	9.3
9	AGS-355	41.6	91	126	28.18	120.0	12.6
10	Sujuyutaka	30.9	84	117	19.3	63.33	9.0
	F test	***	***	***	***	***	***
	CV, %	13.2	2.7	1.21	17.2	11.7	13.9
	LSD (0.05)	10.5	4.1	2.8	7.7	20.0	2.6

Highly significant effect was observed on days to harvest among the tested genotypes. Genotype AGS-292 was earlier (102 days) and AGS-352 was late (164 days). Highly significant effect was observed on total bio-mass production. AGS-333, and AGS-351 were found significant at par. Genotype AGS-352 produced the highest bio-mass yield (41.5 t/ha) where as, AGS-292 produced the lowest (2.3 t/ha).

Highly significant effect was observed in 100-green seed weight among the tested genotypes. AGS-333, AGS-334, AGS-335, AGS-351, AGS-352, AGS-354 and AGS-355 were found significant at par. Genotype AGS-355 produced more bolded seed (120.0 g) as compared to other genotypes. Highly significant effect was observed on marketable fresh pod yield. AGS-333 and AGS-351 were found significant at par. Genotype AGS-351 produced

the highest yield (18.4 t/ha) where as, AGS-292 produced the lowest (0.73 t/ha).

CVT at ARS, Lumle, 2000 and 2001

Highly significant effect was observed on plant height among the tested genotypes. AGS-334, and AGS-351 were found significant at par. Genotype AGS-351 was the tallest (79.8 cm) where as, Sujyutaka was the smallest (29.3 cm) (Table 4). Highly significant effect was observed on days to harvest. Genotype AGS-292 was earlier (76 days) where as, AGS-352 was late (111 days).

Table 4. Performance of nine different promising lines of vegetable soybean under CVT at ARS, Lumle (Average of 2000 and 2001)

SN	Genotypes	Plant height, cm	Days to 1 st flower opening	Days to harvest	Total biomass yield, t/ha	100-seeds weight, g	Marketable fresh pod yield, t/ha
1	AGS-292	29.3	76	105	4.6	81.7	1.4
2	AGS-333	54.1	88	135	33.1	106.7	12.8
3	AGS-334	74.3	88	136	28.8	91.7	11.0
4	AGS-335	54.4	90	134	21.2	100.0	8.6
5	AGS-351	79.8	104	157	39.5	92.5	16.0
6	AGS-352	53.9	111	164	26.0	112.5	12.3
7	AGS-354	50.3	94	135	20.9	92.5	9.2
8	AGS-355	50.5	93	127	25.3	110.0	10.3
9	Sujyutaka	34.0	83	121	17.2	58.0	7.8
	F test	***	***	***	***	***	***
	CV, %	14.2	2.7	1.7	19.9	11.7	22.9
	LSD (0.05)	12.4	4.1	3.8	7.9	18.1	3.8

Highly significant effect was observed on days to harvest among the tested genotypes. Genotype AGS-292 was earlier (105 days) where as, AGS-352 was late (164 days). Highly significant effect was observed on total biomass yield. AGS-333 and AGS-351 were found significant at par. Genotype AGS-352 produced the highest biomass yield (39.5 t/ha) where as, AGS-292 produced lowest (4.6 t/ha). Highly significant effect was observed on hundred green seed weight among the tested genotypes. AGS-333, AGS-335, AGS-352 and AGS-355 were found significant at par. Genotype AGS-352 produced more bolded seed (112.5 g) as compared to others. Highly significant effect was observed on marketable fresh pod yield among the tested genotypes. AGS-333, AGS-334, AGS-351 and AGS-352 were found significant at par. Genotype AGS-351 produced the highest yield (16.0 t/ha) where as, AGS-292 produced the lowest (1.4 t/ha).

DISCUSSION

There was adequate variability in the tested genotypes on plant height, days to harvest and marketable fresh pod yield. The tested genotypes were photo-insensitive and can be grown in pre and post-monsoon seasons. The post-monsoon season was utilized to multiply the required seed for pre-monsoon trials. The choice of cultivars in terms of early, medium and late depends on the particular cropping system. The vegetable soybean genotype AGS-292 gave the lowest yield, however it can be used as catch crop between wheat and rice cropping system (Shrestha 2000).

The AGS-292 was short duration genotype, which took 94 days to harvest, with fresh pod yield 4.53 t/ha and AGS-352 was the long duration genotype with fresh pod yield 17.5 t/ha. Thus the yield per day per hectore of AGS-292 was 48.2 kg where as, the yield of AGS-352 was 118.5 kg. So AGS-352 and AGS-351 were superior to the rest of the tested genotype in terms of the yield per day per hectore. Similar results were noted in the subsequent studies, indicating AGS-351, AGS-352, AGS-333, AGS-355 and AGS-334 superior to rest of the other genotypes. However, AGS-351 and AGS-334 were susceptible to powdery mildew. AGS-352 was the best in terms of over all performance at the field as compared to AGS-333 and AGS-355, having dark green leaves which indicates the availability of required amount of nitrogen to provide high quality and bold seeds. Besides, AGS-352 can be grown in spring, summer and autumn seasons in the mid-hills of Nepal.

CONCLUSION

AGS-352 was found superior to rest of the genotypes in terms of productivity, disease resistance and other horticultural traits. In addition, AGS-352 is suitable for growing during pre and post-monsoon seasons in the mid hills of Nepal. AGS-292 was early and can be utilized as a catch crop. The vegetable soybean is one of the potential vegetable crops for improvement of public nutrition and income generation. Further testing of elite genotypes throughout mid hills in pre and post-monsoon seasons in different farming systems such as inter-crop, mixed-crop with maize and sole crop have become essential. So the collaborative research with ADO and HMG/N Agricultural Farm will be good way for future studies. Varietal improvement and introduction of Chinese vegetable soybean will be good in such studies.

ACKNOWLEDGMENTS

We are grateful to NARC and HARP for providing funds. Our gratitude and thanks are due to Dr BP Tripathi, Dr DN Sah, Dr BR Joshi and Mr GP Acharay, Mr RP Bari, Mrs N Sharma, Mr TB Karki, Mr D Pokharel, Mr K Chhetri, Mr RP Paudel and Mr KP Devkota for their help to achieve the anticipated outputs of the project. Special and sincere thanks are extended to Dr K Budhathoki, HRD, Khumaltar, ADOs, SMSs and Junior Technicians of Kaski, Lamjung and Syangja who collaborated in this project. Our special thanks to the farmers of Hemja, Kaski; Barbise, Syangja; and Gaonshahar, Lamjung who participated in Uptake Pathways of this project.

REFERENCES

- Bhattarai SP, PP Subedi, JP Jaiswal, S Sharma, SR Ghimire, TB Gurung, TB Gurung, NA Khan, RP Bari. 1997. The strategy for commercial vegetable research. *LARC Strategy Paper No. 97/8*. Lumle Agricultural Research Centre, Kaski, Nepal.
- Budhathoki K, GB Gurung, PP Subedi and SP Bhattarai. 1991b. Result of vegetable research activities during 1990/91 at LARC. *LRARC Seminar Paper No. 6/91*. Lumle Regional Agricultural Research Centre, Kaski, Nepal.
- Budhathoki K, PP Subedi and GB Gurung. 1991a. Vegetable crop technology recommended for the Western hills of Nepal. *LRARC Technical Paper No. 6/91*. Lumle Regional Agricultural Research Centre, Kaski, Nepal.
- Chuan song L. 1990. Nitrogen fertilizer effect on marketable yield of vegetable soybean varieties. AVRDC Top, 8th Regional Training Course in Vegetable Production and Research, *AVRDC Training Report*.
- GC YD and PP Subedi and DP Lohar. 1997. Performances evaluation of leguminous vegetable genotype during 1995/1996 LARC. *LARC Working paper No. 97/15*. Lumle Regional Agricultural Research Centre, Kaski Nepal.
- Hung TA, JH Cheng, CH Ma and H Kobayashi. 1991. *Vegetable soybean research needs for production and quality improvement*. Pp.73-81.
- Khadka BB. 1993. Vegetable soybean varietal trial. 11th Regional Training Course in Vegetable Production and Research, *AVRDC Training Report*.
- Maneechote P. 1991. Fertilizer effect on vegetable soybean yield. 9th Regional Training Course in Vegetable Production and Research, *AVRDC Training Report*.
- Manyvong V. 1997. Vegetable soybean varietal trial. 15th Regional Training Course in Vegetable Production and Research, *AVRDC Training Report*.
- Prasan V. 1994. *Vegetable soybean varietal trial*. ARC-AVRDC Training Report 1994.
- Shrestha RL. 2000. Performance of French bean genotypes in Western hills of Nepal. *Lumle Seminar Paper No. 2000/13*. Agriculture Research Station, Lumle, Kaski, Nepal.
- Tindal HP. 1998. *Vegetable in the tropics*. Mackmillan Education Ltd Mand Mills; Barigstaler, Harnp hine, RG21 2xs, London.
- Wihong G. 1997. Effect of plant regulation and foliar fertilizer on yield and quality of vegetable soybean. The 15th Regional Training Course in Vegetable Production and Research, *AVRDC Training Report*.
- Xuan Thu NT. 1993. Effect of nitrogen fertilizer rate on vegetable soybean yield. 11th Regional Training Course in Vegetable Production and Research, *AVRDC Training Report*.

Production Potential of Different Pea (*Pisum sativum* L.) Genotypes in Acid Soils of Malepatan

Madhu S Ghale, Bishnu H Adhikary, Bhoj B BC and Chiranjibi Adhikary

Agriculture Research Station, NARC, Malepatan, Pokhara

ABSTRACT

Eight pea varieties, both local and exotic, were tested for their production potential in acid soils of Agricultural Research Station, Malepatan. The experiment was designed in the randomized complete block design with four replications. The crop was planted in eight-meter square plot. All recommended fertilizers and manures were applied as a basal dose. Two years mean yield indicated that Sikkim Local variety of pea produced the highest pod yield of 8.72 t/ha, which was higher by 179.4% as compared to Early Gaint (3.12 t/ha). Illam Local and Tikot Local produced 6.25 and 6.03 t of green pods per hectare, respectively. NLP (3.56 t/ha) and PM-3 (4.77 t/ha) produced lowest pod yield at Malepatan condition.

Key words: Green pods, local and exotic pea varieties, production potential

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the important leguminous vegetable crops in Nepal. It can be used as garden pea for fresh vegetable and the field peas for its grains (Pun and Karmacharya 1998). The vegetable peas are rich in protein, vitamin A and C, calcium, phosphorus and carbohydrates. It can be grown in Nepal from Terai to high hills and in all types of soils, however, well drained loam soil is better for its growth and development. A large numbers of pea cultivars have been developed in several countries. Trebuchet et al (1953) described 113 cultivars in France on the basis of seed characters, such as round and wrinkled seed coat, yellow or green cotyledons and plant heights. Vegetative and reproductive characters of pea are horticultural importance (Singh and Joshi 1970). Many local cultivars are grown by the farmers in Nepal. Few improved pea varieties were introduced by seed entrepreneurs and farmers. Sikkim Local and Azad varieties are yielders (ARS 2001). Some varieties are early maturing; some medium and others are late maturing types. The early cultivars produce 2.5 - 4.0 t/ha of green pods and the late varieties produce 8.5-11.5t/ha of green pods (Nath 1976). Some cultivars are resistant to disease like powdery mildew, fusarium wilt and root rot and some are susceptible (Nath 1976, Chaudhary 1976, Shukla et al 1977). The production potentials of pea genotypes are different and need to be verified under different locations in the Kingdom of Nepal. Therefore, the objective is to study the production potential of pea varieties in acid soils of Malepatan.

METHOLOGY

An experiment on fresh pod production of garden pea was conducted during the two consecutive years (2000 and 2001) in acid soils (pH 5.2) of Agricultural Research Station Malepatan. A randomized complete block design with four replications was employed in the experiment. Eight pea varieties were taken (Table 1). The crop was fertilized at the rate of 40:40:40 kg N:P:K per ha. All other cultural practices were carried out as per the recommendation. Plant growth and production characters studied and analysed (Gomez and Gomez 1984). The following varieties were taken in the study:

RESULTS AND DISCUSSION

The differences in yield characters were due to the different production potentials of the pea genotypes (Table 1). The maximum plant height of 1.84m and 1.52 m was observed in the first year and second year, respectively Sikkim Local. The mean plant height of Azad (70 cm) was minimum. Mean plant height of Arkel (0.72 cm), PM 3 pod length was recorded in Early Giant (8.46 cm) and Illam Local (10.67cm) in 2000 and 2001 respectively. Maximum and minimum mean pod length was recorded with Ilam Local (9.26 cm) and Tikot Local (4.87 cm) respectively. Arkel (7.62 cm), Azad (7.71 cm), Early Giant (7.89 cm), PM3 (7.67 cm) and NLP (7.82 cm) were observed to be medium in pod length production. A maximum size of pod (5.15 cm) was observed with the variety Illam Local in the first year, where as in second year, maximum pod size (5.0 cm) was observed with the PM 3. The mean pod size (circumference) (4.57 cm) was observed to be maximum with the variety Illam Local (Table 1).

Table 1. Yield related traits of pea genotypes

Genotype	Plant height, m		Mean	Pod length, cm		Mean	Pod circumference, cm		Mean
	2000	2001		2000	2001		2000	2001	
Tikot local	1.80	1.53	1.66	4.70	4.87	4.78	3.45	4.00	3.72
Illam Local	1.15	1.06	1.10	7.85	10.67	9.26	5.15	4.00	4.57
Arkel	0.75	0.69	0.72	7.99	7.25	7.62	3.77	4.00	3.88
Azad	0.76	0.64	0.70	8.19	7.23	7.71	4.25	4.00	4.12
Early gaint	1.63	1.28	1.45	8.46	7.32	7.89	5.06	4.00	4.53
Sikkim Local	1.84	1.52	1.68	5.42	5.37	5.39	4.15	4.00	4.07
PM 3	0.83	0.70	0.76	8.39	6.96	7.67	3.95	5.00	4.47
NLP	0.77	0.81	0.79	8.35	7.30	7.82	4.25	3.00	3.62
CV, %	2.65	6.14		8.41	6.28		7.05	30.72	
F test	**	**		**	**		**	ns	
LSD (0.01)	0.08	0.17		1.68	1.20		0.81	1.80	

In both the year highest yield of pea pod (7.95 t/ha, 9.5 t/ha) were recorded with Sikkim Local. The response of the varieties on pod production was found to be highly significant in both years (Table 2). A minimum of 3.0 t/ha of green pods were produced in the first year by the minimum variety Early Gaint, while in the second year (2001) the variety Azad produced the minimum yield of 2.5 t/ha (Table 2) The mean pod yield indicated that the Sikkim Local variety was superior in pod production which produced the yield (8.72 t/ha) of green pods which was 179.48% higher than Early Giant (3.12 t/ha), the lowest producer among the varieties tested in the experiment. The varieties Arkel (4.68 t/ha), PM 3 (4.77 t/ha) and NLP (3.56 t/ha) were low yielder. The varieties Tikot Local (6.03 t/ha) and Illam Local (6.25 t/ha) were superior varieties in pod production which produced the pod yield more than 93% than Early Giant (Table 2) Illam Local which has flattened type grain arranged on one side and produced late maturing succulent, green pod and can be consumed along with pod.

Table 2. Pod yield of pea genotypes

Genotype	Pod yield, t/ha		Mean	Pod increment, %
	2000	2001		
Tikot Local	7.32	4.75	6.03	93.26
Illam Local	6.25	6.25	6.25	1000.32
Arkel	3.12	6.25	4.68	50.00
Azad	7.02	2.50	4.76	52.56
Early Gaint	3.00	3.25	3.12	00.00
Sikkim Local	7.95	9.50	8.72	179.48
PM 3	6.80	2.75	4.77	52.88
NLP	4.12	3.00	3.56	14.10
CV, %	24.22	40.55	21.47	
F test	**	**	**	
LSD (0.01)	3.72	5.03	3.12	

CONCLUSION

Plant growth was maximum in the Tikot Local, Early Giant and Sikkim Local pea genotypes. Pod size (length and circumference) was greatly affected by the pea genotypes tested in Malepatan Soil Series (MSS). The

longest pod was observed in Illam Local and the shortest one with Tikot Local. The pod circumference of 4.57 cm was observed in the Illam Local and the lowest in NLP (3.62 cm). Highest fresh green pods were produced by Sikkim Local followed by Tikot Local and Illam Local. These three cultivars seem suitable for acids soils of Malepatan.

REFERENCES

- ARS. 2001. *Annual technical report for the year 2000/2001* (BH Adhikary and RC Gauli, eds). Agriculture Research Station (Horticulture), NARC, Malepatan, Pokhara. 48pp.
- Chaudhary B. 1967. *Vegetables*. National Book Trust, New Delhi.
- Gomez KA and AA Gomez. 1984. *Statistical procedures for agricultural research*. 2nd ed. An International Rice Research Institute Book. A Wiley-Interscience Publication, John Wiley and Sons, New York. 680p.
- Nath P. 1976. *Vegetable for the tropical region*. Indian Council of Agricultural Research, New Delhi.
- Pun L and BB Karmacharya. 1988. Vegetables. **In:** *Trainer's manual*. Manpower Development Agricultural Project (MDAP), Dept. of Agriculture. Kathmandu. Pp.241-245.
- Shukla P, RP Singh and M Prasad. 1977. *Indian J. Mycol. Pl. Path* 7:157-158.
- Singh HB and BS Joshi. 1970. *Pulse crops of India*. Indian Council of Agriculture Research (ICAR), New Delhi.
- Trebuchet G, R Chopinet and J Drowsy. 1953. *Ann. Amel. Plantes* 3:147-151.

Rice Gene Pool for Mid and High Hills and its Conservation in Nepal

Bal K Joshi

Agriculture Botany Division, NARC Khumaltar, PO Box 1135 Kathmandu <joshibalak@rediffmail.com>

ABSTRACT

Study on crop gene pool helps to develop varieties, to know the potential sources for breeding materials, to develop strategy for sustainable use and conservation and to know the richness in crop genetic resources of particular country. Individual farmers value diversity within and between their crops because of heterogeneous soils and production conditions, risk factors, market demand, consumption and uses of different products from an individual crop species. Both the potential for long term genetic gain and the reduction of genetic vulnerability may depend on the genetic diversity present in the genetic base. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool, existing landraces and wild species. The objective of this research was to study the diversity of rice gene pool present in the Nepalese rice cultivars and landraces adapted to mid and high hills that could help for developing conservation and utilization strategy effectively. Pedigrees of 20 Nepalese rice cultivars were examined and surveyed the literature for distribution of landraces and wild relatives of rice adapted to mid and high hills (1000-3050 m) of Nepal. The pedigrees of rice cultivars were traced back to their ancestors that had no known relationship with each other. Crosses among indica rice gene pools are more common and use of 11 japonica and *nivara* species indicate use of wide gene pools. There are 20 improved rice cultivars, 1500 landraces and 6 wild species and relatives of rice in mid and high hills of Nepal. Mid and high hill areas have 25% of total rice area in the country. Taiwan, Philippines, India and Nepal are the origin countries for 20 cultivars. In Nepal 8 cultivars were bred and developed using local and foreign landraces for mid and high hill areas. A total of 47 ancestors originated in 12 different countries were used to develop these 20 cultivars. Highest number of ancestors was from India and Taiwan. Ancestors of both *sativa* and *nivara* species having indica and japonica types indicated the collection of wide gene pools. Most of the ancestors were *sativa* (97.87%) and indica (48.94%). Wide gene pool exist in Nepal even though modern varieties have been replacing the landraces and improved old varieties resulted in the genetic erosion. Therefore, in situ, on farm and ex situ conservations are necessary for maintaining the genetic variation in Nepalese rice. Utilization of local landraces in breeding program may be good way of genetic resources conservation. Gene pool from these landraces along with international gene pool could make towards success in developing high yielding cultivars with wide adaptability and/or site specific. In this study, cultivars and landraces surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity may be useful for further rice improvement and should be conserved both ex situ and in situ.

Key words: Ancestor, conservation, landrace, Nepalese rice cultivar, rice gene pool

INTRODUCTION

Rice has been grown since time immemorial, Vedic time (1500BC). Rice is considered as livelihood crop and most important in Nepal's economy. Different kinds of landraces and wild rice in Nepal are reported by Sherchand et al (1998), Mallick (1981/82), Rana et al (2000a, 2000b, 2000c), Adhikari et al (1995), Joshi et al (1998), Shrestha and Upadhyay (1999) and Gupta et al (2000). During mid 1960s the yield potential of semi dwarf high yielding varieties initiated a scope for raising rice production in the country. Several exotic varieties were obtained through IRRI and Taiwan (NRRP 1997). National Rice Improvement Program was established in 1972 at Parwanipur to organize the research and development works on rice as a commodity crop. Since then, there have been great achievement brought out by the consolidated efforts of rice researchers, extension workers and farmers. So far there are 48 improved rice cultivars. Among them 20 are recommended for mid and high hills of Nepal.

Genetic diversity is necessary to derive different transgenic segregants suitable for different agro-ecology to meet the needs of farmers. Both the potential for long term genetic gain and the reduction of genetic vulnerability may depend on the genetic diversity present in the genetic base. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool, existing landraces and wild rice and their relatives. The level of genetic variation present in gene pools of most important crops has been analyzed by studying the pedigree relationship between cultivars. Kinship coefficients estimation of cultivars of oat (Souza and Sorrells 1989), soybean (Cox et al 1985a), wheat (Joshi et al 2004), winter wheat (Cox et al. 1985b), rice (Dilday 1990) and barley (Martin et al 1991) has shown that a restricted number of ancestral genotypes account for a large proportion of the variation present in released cultivars. Diversity of rice considering ancestors of cultivars, wild relatives and landraces should be assessed for effective conservation and utilization of rice gene pools. Therefore I have focused here on landraces and wild rice diversity and its distribution in Nepal and countries from where genes were introduced through improved cultivars in Nepal.

METHODOLOGY

Literature related to rice exploration, improved cultivars recommended for mid and high hills and Nepalese landraces adapted to mid and high hills (Annex 1) and wild rice and wild relatives were reviewed. Two sites, National Rice Research Program (NRRP), Haridnath and Plant Genetic Resources (PGR) Section, Khumaltar were visited. PGR Section collected many rice landraces. Rice genotypes available in Nepal for mid and high hills were categorized under four groups 1. landraces, 2. improved cultivars, 3. ancestors of these cultivars and 4. wild rice and wild relatives. Unique and endangered rice landraces were compiled. Based on collection data landraces and wild species distribution were indicated in Nepal map. Landrace diversity based on different name was compiled with respect to districts. It is assumed to estimate the landrace richness that rice landrace is different if the name given by farmer was different. Frequency of rice accessions collected from different districts and conserved in PGR Section were computed. Altogether 20 cultivars had been released for mid and high hills in Nepal from 1967 to 2002. I examined the pedigrees of these 20 cultivars. Most of the cultivars were introduced either from IRRI or Taiwan. The pedigrees of these rice cultivars were traced back to their ancestors that had no known relationship each other. The source of improved cultivars, their pedigree and release dates were NRRP (1997), IRRI (1970, 1987, 1995, 2000a, 2000b), ABD (2003), IRRI (GEU). Origin of ancestors, their group and species were identified. Diversity was studied on improved cultivars based on their origin, types and number of ancestors and group of ancestors. Countries from where the genes introduced in Nepal were located in world map based on the origin of ancestors of Nepalese improved rice cultivars.

RESULTS AND DISCUSSION

The land in Nepal has the largest variations in altitude in the world. Three types of land Bari, Khet and flat and fertile with good soil depths produce rice indicating the diverse rice genotypes adapted to different production environments. Rice is grown mainly as Barkhe crop sown in June/July and harvested in Sept/Oct. It is also grown as a Hiunde and Chaite crops. Only Barkhe rice is grown in mid and high hills of Nepal. Due to the varied agroecological diversity of the country, it is possible to plant same cultivar in Barkhe, Hiunde and Chaite seasons. Nepal is original home for rice and posses many diversity in rice though under the CGIAR system Nepal received a lot of rice genotypes.

Ten international exploration missions have targeted cultivated and wild rice species in Nepal (Upadhyay and Joshi 2003). Forty exploration programs were carried out in different parts of Nepal to collect different crops species by international organizations from 1937 to 2000. The countries involved in exploration missions are Germany, Japan, UK, IRRI, FAO, IBPGR and USAID. A total of 1550 different rice varieties from Nepal have been collected from altitude of 60-3050 m and conserved at IRRI, Philippines (Shrestha and Vaughan 1989). National organizations mainly by ABD, Khumaltar had explored different crop species 22 times in different parts of Nepal. They have targeted 7 times to rice both cultivated and wild from 1981 to 2000. There are 378 landraces, which are differed by name collected from mid and high hills and conserved in ABD (Annex 1). These are collected from different altitude ranging from 1000 to 2713 m. Farmer unit of description (FUD) is generally related to their phenotype and use value. FUD also indicates the level of diversity present in rice gene pool. There may be many landraces that are genetically same but differed only by name or vise versa. These need to verify. ABD has 2963 accessions of rice landraces and 144 accessions of wild rice collected from all over the Nepal (Gupta et al 2000). These are conserved ex situ at medium term storage facility in Khumaltar.

ABD has representative rice landraces from 73 districts of Nepal (Table 1). Highest number of rice accessions among the 54 hill districts was collected from Kaski (4.49% of total accessions) followed by Tanahu (2.50%), Dhankuta and Lamjung. Collection sites of 197 accessions were not known. Kaski, Tanahu, Dhankuta and Lamjung may be the focal area in term of rice landraces diversity in mid and high hills. Lumle Agriculture Research Station (LARS) has maintained some landraces and ABD has 1585 accessions of rice adapted to mid and high hills. There may be duplicate accessions in these two places. Removing duplicate accessions and adding new one should be made continuously. Extensive survey and duplication study of accessions could help to control genetic erosion and conservation cost. Many of these landraces are still grown by farmers and are the mixtures of white, red and brown colored spikelets, amber, white and red colored grains, awned and awnless characters. These landraces have a wide range of natural adaptation to withstand varied abiotic and biotic conditions. In addition, these landraces have high tillering ability, withstand severe drought stress, have good quality grains and adapted to marginalized areas.

Table 1. Total Rice accessions and frequency (%) collected from different mid and high hill districts of Nepal and conserved ex situ

SN	District	Total accession, n	%	SN	District	Total accession, n	%
A. Mid and high hill districts							
1	Achham	25	0.84	31	Panchthar	22	0.74
2	Baglung	29	0.98	32	Parbat	47	1.59
3	Baitadi	31	1.05	33	Ramechhap	31	1.05
4	Bajhang	22	0.74	34	Rasuwa	3	0.1
5	Bajura	44	1.48	35	Rolpa	6	0.2
6	Bhaktapur	18	0.61	36	Rukum	8	0.27
7	Bhojpur	33	1.11	37	Sankhuwasabha	14	0.47
8	Dailekh	36	1.21	38	Sindhupalchok	36	1.21
9	Darchula	5	0.17	39	Solukhumbu	1	0.03
10	Dhading	51	1.72	40	Syangja	45	1.52
11	Dolkha	29	0.98	41	Taplejung	25	0.84
12	Dolpa	0	0	42	Terhathum	25	0.84
13	Gorkha	45	1.52		Sub total	1158	39.04
14	Gulmi	13	0.44	B. Districts fall in both ecoregions			
15	Humla	47	1.59	43	Argakhanchi	28	0.94
16	Jajarkot	13	0.44	44	Dandeldhura	33	1.11
17	Jumla	17	0.57	45	Dhankuta	72	2.43
18	Kabhre	33	1.11	46	Doti	39	1.32
19	Kalikot	9	0.3	47	Ilam	56	1.89
20	Kaski	133	4.49	48	Makwanpur	22	0.74
21	Kathmandu	26	0.88	49	Palpa	18	0.61
22	Khotang	36	1.21	50	Pyuthan	13	0.44
23	Lalitpur	12	0.4	51	Sallyan	21	0.71
24	Lamjung	61	2.06	52	Sindhuli	20	0.67
25	Manag	0	0	53	Surkhet	31	1.05
26	Mugu	18	0.61	54	Tanahun	74	2.5
27	Mustang	4	0.13		Sub total	427	14.41
28	Myagdi	62	2.09	C. Tarai and Inner Tarai districts			
29	Nuwakot	14	0.47		Unknown	197	6.65
30	Okhaldhunga	29	0.98		Total	2963	100

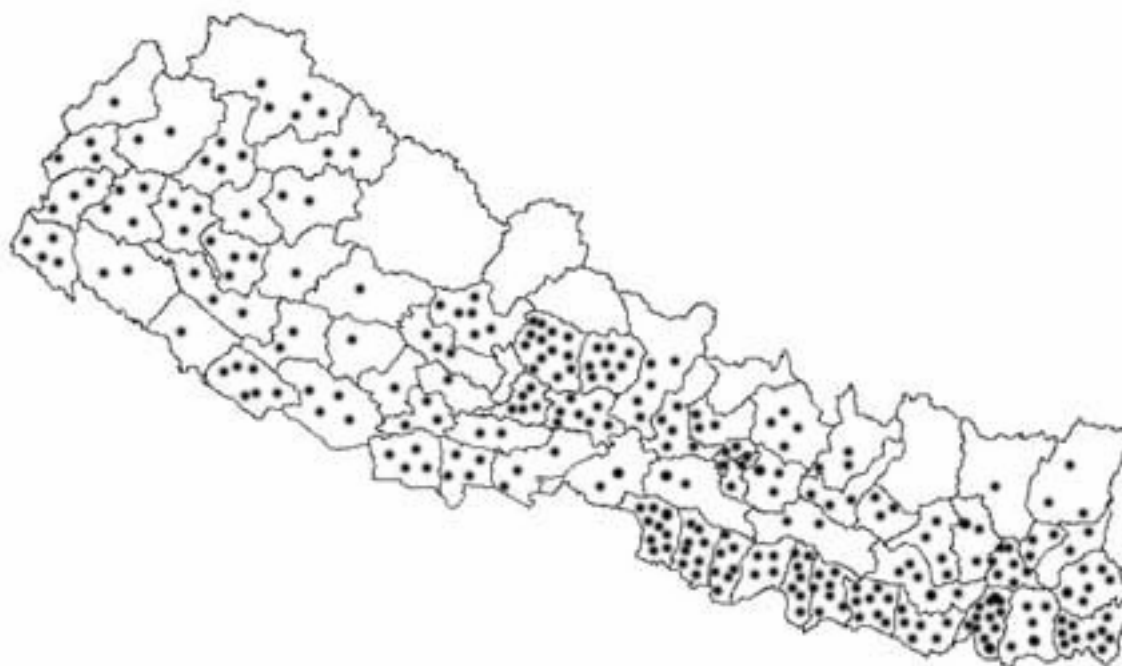


Figure 1. Distribution of rice diversity (more the number of dots more the diversity).

Nepal has many locally adapted rice but only four has been used or improved for developing Nepalese mid and high hills rice cultivars. Such trends of using local landraces are increasing which help to check genetic erosion. Due to agro ecological differences Nepalese genotypes may contain unique genes (Table 2). These genes if conserved properly could be enough to fulfill rice grain demand in Nepal for next century. Diverse ethnic groups have great knowledge about the genotypes possessing unique characters. The possibility of starting a three lines heterosis breeding using local landraces was reported. Among the 14 rice genotypes tested for their ability to restore fertility and maintain sterility, two landraces (Kature and Ratodhan) are restorers and other two (Deharadune and Chiunde) are maintainers (Joshi 2000). A set of 183 landraces were characterized and evaluated over space and time (1998-2000) (Sharma et al 2001). There was wide variation in maturity. Landraces were comparable with the improved cultivars. There is a possibility of breeding for new levels of grain yield and other economical characters using these landraces. Blast resistance was widely available in these landraces. More important genotypes should be identified and developed a strategy to use them. These genotypes may have potential role in developing suitable varieties and/or increasing national production. Clear advantages were indicated in using locally adapted parents and selection in the target environment compared to introduction from international nurseries, which usually perform poorly (Sthapit, 1992). Characterization, evaluation and utilization of these landraces in breeding program by LARS and ABD could certainly enhance the rice gene pool conservation. Landraces are mostly found in western and eastern regions (Figure 1) in Nepal. This distribution pattern could help to locate diverse rice areas and to implement in situ, on farm conservation and exploration program. This pattern suggests that there are diverse rice landraces adapted to different environments. Characterization and improvement of these landraces are necessary for long-term conservation and utilization. Due to the expansion of modern varieties these landraces are under threats of extinction. In addition, some of the landraces are under threat or extinct (Table 3) due to natural and human factors.

Twenty improved rice varieties suitable to mid and high hills of Nepal (Table 4) are real efforts of researchers to be released during the period from 1967 to 2002. More numbers of crosses involving many parental lines in cultivars like Kanchan, Khumal-4, Khumal-6 and Manjushri-2 indicate the effort of scientists to collect value genes in single genotype. Four cultivars were released in each year of 1967, 1990 and 2002. The earliest released cultivars are Tainan-1, Taichung-176, Chianan-2 and Chianung-242. Shuttling of generation lines during winter season is also possible in Nepal, which helps to develop more rice cultivars within short period of time.

A total of 47 ancestors originated in 12 different countries were used to develop 20 mid and high hills cultivars (Table 5). IRRI, Taiwan, Nepal and India are the origin countries for 20 cultivars. In Nepal 8 cultivars had been originated which is the maximum number of cultivars originated (Figure 2). Use of ancestors of both *indica* and *japonica* groups of sativa and nivara species indicated the collection of wide gene pools in Nepal. Restricted number of ancestors account for large proportion of variation present in soybean and oat cultivars. In 35 Nepalese wheat cultivars 90 ancestors were used (Joshi and Mudwari 2003).

Table 2. Some of the unique rice genetic resources cultivated in Tarai, Inner Tarai, mid and high hills of Nepal

SN	Genotype	Uniqueness
1.	Amaghauj	Multiple spikelets per node
2.	Anati	Festival rice/ sticky rice
3.	Bhati	Deep water rice
4.	Chhomrong dhan, Jumli marshi	Cold tolerance rice
5.	Ekle rice	Zn deficiency tolerance
6.	Gamadi	Panicle matured within flag leaf
7.	Ghayia	Upland rice
8.	Jarneli	Drought tolerance
9.	Kalanimak	Photo period sensitive
10.	Mansara	Adopted to very marginalized land
11.	Pakhe Masino, Radha-4, Taichung, Lahure Sahila, Gori Sahila, Makar Kandhu	Hiunde (winter) rice†
12.	Samundaphinj	Swampy land rice
13.	Wild rice	Festival rice/ perennality gene

† Hiunde rice (seeding at Mangsir and harvesting at Jeshta) has been cultivated since 35 years ago at Taruwa VDC Nawalparasi. This rice was extensively cultivated after 2042 BS (1984) in these areas. Farmer of this area, Khadka Narayan Mahato has more knowledge on Hiunde rice.

Table 3. Endangered rice landraces in Tarai, Inner Tarai, mid and high hills of Nepal

Endangered	Lost	Remarks
Tauli, Thapachinia, Marsi, Mansara, Siraunla, Masind, Nathani, Khalte Kolo, Biramphool, Samundaphinj, Jhinuwa, Bayarni, Ramani, Pahlenle ghayia, Bichare, Basmati, Dudhe marange, Pakhe Masino, sindhuli, Pakhe Sali, Jabaka, Charinangre, Pakhe Jhinuwa, Basaune Jhinuwa, Pahlenle, jhinuwa, Gudura, Bardari, Battisara, Pokhrela Jhinuwa, Pagate Jhinuwa, Phente silange (30)	Lahure Sahila, Gori Sahila, Makar Kandhu, timaha, Tauli, Darmali, germani, Koili, Budho thakale, Ghote, Salidhan, Jhauri, Thapachinia, Bhamger (14)	This information is mostly from western development region

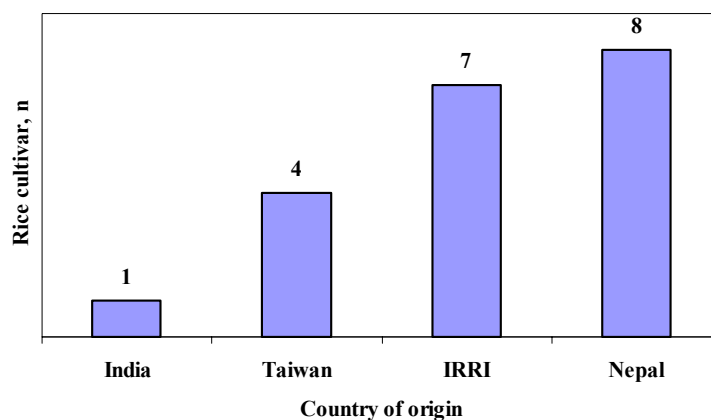


Figure 2. Countries of origin of 20 mid and high hills improved rice cultivars in Nepal.

Currently Nepal has genes of 47 internationally value rice landraces adapted to mid and high hills (Table 5). These genes were mainly from Asian countries (Figure 3). Maximum ancestors were from India and Taiwan followed by China and Nepal. Thanks to India, Taiwan, China and Indonesia. Involvement of ancestors from 12 countries indicates the introduction of genes adapted to different geographic locations. Even though contributions of Nepalese rice landraces in the world is not known, world contribution is recognized in rice development in Nepal. A single landrace of each of six countries (Figure 3) have been used in developing rice cultivars probably because of having value genes with them. It can be concluded that breeders can develop best varieties by reshuffling the genes from these wide collections.

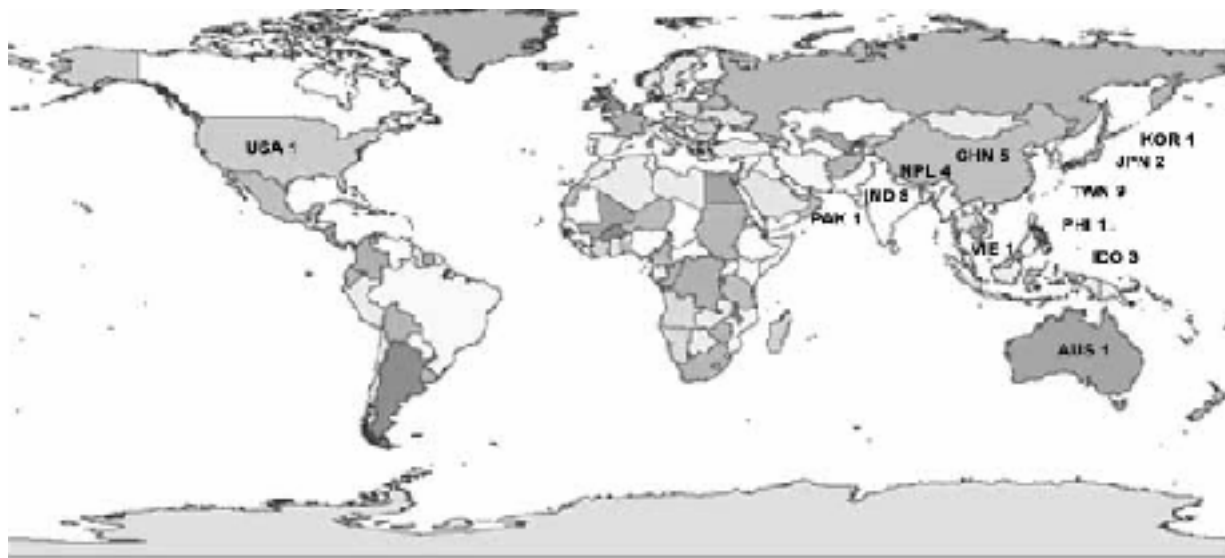


Figure 3. Countries where the ancestors of Nepalese improved rice cultivars recommended for mid and high hills were originated. Origins of 9 ancestors are not known.

Use of 47 ancestors from 12 different countries represent the great diversity in built in 20 Nepalese rice cultivars. The origins of 9 ancestors are not known. Ancestors were with different groups eg indica (48.94%) and japonica (23.40%). Groups of 27.66% ancestors are not known. There were 97.87% sativa and 2.13% nivara ancestors species (Figure 4). Such diversity in species, origin and groups in ancestors have certainly enriched Nepalese rice biodiversity.

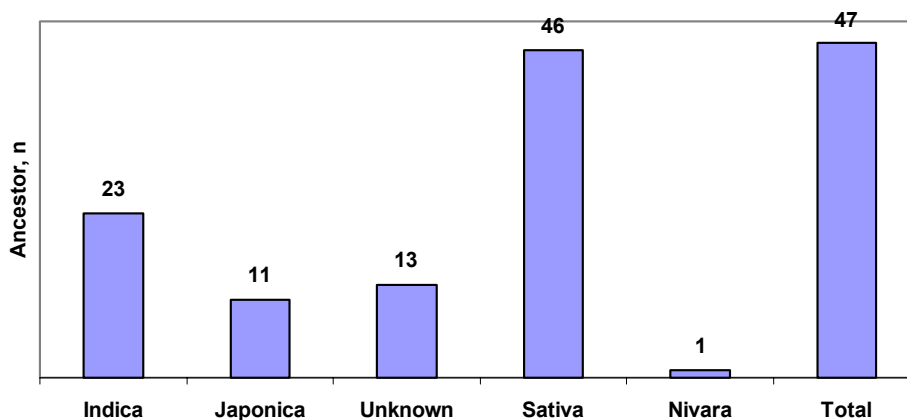


Figure 4. Ancestors' groups used to develop 20 Nepalese rice cultivars for mid and high hills.

Nepal being the center of origin of rice, harbor the wild rice and its relatives in addition to diverse forms of landraces. Four wild rice species, *Oryza nivara*, *O. rufipogon*, *O. granulata* and *O. officinalis* are found in different areas of Nepal (Figure 5). Some of these areas are Ghodagodhi tal, Ajigara tal, Lothar, Jhapa, Illam, Sundarpur, Surkhet, Nijgada, Janakpur, Nepalgunj, Bara, Dang, Kapilbastu, Rupendehi, Birendranagar, Kaski, Palpa, Banke, Bardiya, Kancanpur etc (Table 6). Weedy rice, *O. sativa* f. *spontanea* is found in rice field across the country. *Hygrooryza aristata* and *Leersia hexandra* are other two species in related genera found in Nepal. These species are adapted to different ecological conditions in terms of height and water requirements, and distributed across the Tarai. They are more competitive than landraces and cultivars (Joshi et al 2001). *O. rufipogon*, one of the natural parents of the present day cultivated rice is reported to have found in the Northern most limit and the highest altitude in Nepal in the world. This extraordinary biological diversity in Nepal is due to geological, geographical and cultural factors. Very little attention has been given to wild rice diversity in Nepal. Nepal was considered as area of potentially new and useful genes for rice breeders. Since wild germplasm is a valuable source for improving rice productivity and durability, explorations on those wild relatives are suggested followed by their proper characterization and utilization in the breeding program. Cultivated landraces of indica and japonica type, wild rice and wild relatives of rice are found in Nepal (Mallick 1981/82, Shrestha and Upadhyay 1999). Gene pool from these landraces along with international gene pool could make to success in developing high yielding cultivars with wide adaptability. Developing cultivars possessing desired period of maturity, height and yield is seemed possible using these gene pools.

Table 4. Improved rice varieties recommended for mid and high hills of Nepal (NRRP 1997, Updated)

SN	Variety	Abb	Pedigree	Parentage	Year released	Area of adaptation
1.	Chianan-2	CHAN2		O-luamchu/Shiniri-Aikoku//Taichung 65	1967	Warm Temperate
2.	Chianung-242	CHNUG242		Hsinchu 4/Taichung 150//Taipei7/T45	1967	Warm Temperate
3.	Chandhanath-1	CHDNT1	Jinling 78-102	Selection from Jinling 78-102	2002	Jumla, warm temperate
4.	Chandhanath-3	CHDNT3	Yunlen-1	Selection from Yunlen-1	2002	Jumla, warm temperate
5.	Chhommrong	CHMM	Ghandruk local	Selection from Ghandruk local	1991	Warm Temperate
6.	Himali	HIM	IR 2298-PLPB-3-19-2-1-1B	Cica 4/Kulu	1982	Warm Temperate
7.	Kanchan	KAN	IR 3941-4 PL-P28	CR 126-42-5/IR 2061-213	1982	Warm Temperate
8.	Khumal –4	KH4	NR 10078-76-1-1	IR 28/Pokhreli Masino	1987	Warm Temperate
9.	Khumal –5	KH5	NR 10067-8-2-2-2	Pokhreli Masino/KN-1B-361-BLK-2-8	1990	Warm Temperate
10.	Khumal –7	KH7	IR 7167-33-2-3-3-1	China 1039-DWF-MUT/KN-1B-361-1-8-6-10	1990	Warm Temperate
11.	Khumal-11	KH11	NR 10375-14-2-1	Akiyudaka/Barkat	2002	Kathmandu
12.	Khumal-2	KH2	NR 10068-60-3-2	Jarneli/KN-1B-361-BLK-2-8	1987	Warm Temperate
13.	Khumal-3	KH3	K 39	China 1039/IR 580	1983	Warm Temperate Chaite & Barkhe
14.	Khumal-6	KH6	NR10172-2B-12-4-1-3-2	IR13146/IR17492	1999	Kathmandu
15.	Khumal-9	KH9	IR 15579-135-2	K-28-76-B-1/KN 1B-214-1-4-3	1990	Warm Temperate

SN	Variety	Abb	Pedigree	Parentage	Year released	Area of adaptation
16.	Machhapuchhre-3	MCHPCH	LR 88001-80-OL	Fuji 102/Chhomrong	1990	Warm Temperate
17.	Manjushri-2	MJS2	NR10291-6-1	Fuji 102/NR10157-2B-7-1-1	2002	Jumla, warm temperate
18.	Palung-2	PLG2	NR 10073-167-3-1-3	BG 94-2/Pokhreli Masino	1987	Warm Temperate
19.	Taichung-176	TCG176		Tsai-Yuanchung/DGWG	1967	Warm Temperate
20.	Tainan-1	T1		Tsai-Yuanchung/DGWG	1967	Warm Temperate

Table 5. Ancestors of improved rice cultivars recommended for mid and high hills of Nepal (1965-2002)

SN	ANCESTOR	ABB	ORIGIN	ABB	GROUP	SPECIES
1.	AKIYUDAKA	AKDK	KOREA	KOR	JAPONICA	SATIVA
2.	BPI 76	BPI76	PHILIPPINES	PHL	INDICA	SATIVA
3.	CENTURY PATNA	CP	USA	USA	INDICA	SATIVA
4.	CHINA 1039	CH1039	INDIA	IND	INDICA	SATIVA
5.	CHINA 971	CH971	CHINA	CHN	?	SATIVA
6.	CHINA-1039-DWF-MUT	CH1039	CHINA	CHN	INDICA	SATIVA
7.	CINA	CINA	CHINA	CHN	?	SATIVA
8.	CO 18	CO18	INDIA	IND	INDICA	SATIVA
9.	DEE GEO WOO GEN	DGWG	TAIWAN	TWN	INDICA	SATIVA
10.	DUNGHAN SHALIL	DUG	?	?	INDICA	SATIVA
11.	FUJI-102	F102	JAPAN	JPN	JAPONICA	SATIVA
12.	GEB 24	GEB24	INDIA	IND	INDICA	SATIVA
13.	GHANDRUK LOCAL	GDKL	NEPAL	NPL	JAPONICA	SATIVA
14.	GP-15	GP15	?	?	?	SATIVA
15.	HR 21	HR21	INDIA	IND	INDICA	SATIVA
16.	HSINCHU-4	HSC4	TAIWAN	TWN	JAPONICA	SATIVA
17.	JARNELI	JNL	NEPAL	NPL	INDICA	SATIVA
18.	JERAK	JRK	?	?	?	SATIVA
19.	JINLILNG-78-102	JNLG78	CHINA	CHN	JAPONICA	SATIVA
20.	JUMLI MARSHI	JUM	NEPAL	NPL	JAPONICA	SATIVA
21.	K-28-76-B-1	K28	INDIA	IND	JAPONICA	SATIVA
22.	KN-1B-214-1-4-3	KN1B214	INDONESIA	IDO	INDICA	SATIVA
23.	KULU	KULU	AUSTRALIA	AUS	INDICA	SATIVA
24.	LATISAIL	LAS	PAKISTAN	PAK	INDICA	SATIVA
25.	LD-66	LD66	?	?	?	SATIVA
26.	MCVA	MCVA	?	?	?	SATIVA
27.	MUDGO	MUDGO	INDIA	IND	INDICA	SATIVA
28.	O. NIVARA	ON	?	?	?	NIVARA
29.	O-LUAMCHU	OLU	?	?	?	SATIVA
30.	POKHRELI MASINO	PKMS	NEPAL	NPL	INDICA	SATIVA
31.	PTB-18	PTB18	INDIA	IND	INDICA	SATIVA
32.	PTB-21	PTB21	INDIA	IND	INDICA	SATIVA
33.	R. HEENATI	RH	?	?	?	SATIVA
34.	REMADJA	REM	INDONESIA	IDO	INDICA	SATIVA
35.	SHINEI	SHN	JAPAN	JPN	?	SATIVA
36.	SHINIRI AIKOKU	SA	?	?	?	SATIVA
37.	SIGADIS	SGD	INDONESIA	IDO	INDICA	SATIVA
38.	SLO	SLO	INDIA	IND	INDICA	SATIVA
39.	TADUKAN	TDKN	TAIWAN	TWN	INDICA	SATIVA
40.	TAICHUNG NATIVE-1	TN1	TAIWAN	TWN	INDICA	SATIVA
41.	TAICHUNG-150	T150	TAIWAN	TWN	JAPONICA	SATIVA

SN	ANCESTOR	ABB	ORIGIN	ABB	GROUP	SPECIES
42.	TAICHUNG-45	T45	TAIWAN	TWN	JAPONICA	SATIVA
43.	TAICHUNG-65	T65	TAIWAN	TWN	JAPONICA	SATIVA
44.	TAIPEI-7	TP7	TAIWAN	TWN	?	SATIVA
45.	TETEP	TETEP	VIETNAM	VTN	?	SATIVA
46.	TSAL YUAN CHUNG	TYC	TAIWAN	TWN	INDICA	SATIVA
47.	YUNLEN-1	YN1	CHINA	CHN	JAPONICA	SATIVA

Table 6. Wild rice and wild relatives of rice found in different districts of Nepal (Shrestha and Updhyaya 1999, Updated)

SN	Wild /relative	Local name	Districts†
1.	<i>Oryza nivara</i> Sharma et Shastry		Banke, Kapilbastu, Lumbini, Bardiya, Kailali, Kanchanpur, Kaski , Dang, Rupandehi
2.	<i>O. rufipogon</i> Griff. (<i>O. perennis</i> Moench.)	Nabo ghans, Anga, Salidhan	Banke, Kapilbastu, Kailali, Kanchanpur, Surkhet, Kaski, Palpa , Rupandehi, Dang
3.	<i>O. granulata</i> Nees et Arn. ex Watt.	Ban dhan, Jangali dhan, Sitarani dhan	Chitwan, Jhapa, Ilam, Makawanpur
4.	<i>O. officinalis</i> Wall ex Watt.		Kanchanpur, Bara, Janakpur
5.	<i>O. sativa</i> f. spontanea (weedy rice)	Navo, Thima, Jara	All rice growing districts, Rupandehi, Kapilbastu, Banke, Bardiya, Kanchanpur, Lamjung
6.	<i>Hydroryza aristata</i>		Kaski, Kailali, Kathmandu
7.	<i>Leersia hexandra</i>		Kaski, Lamjung, Kathmandu

† Bold districts are mid and high hills of Nepal.



Figure 5. Distribution of wild rice and related species in Nepal.

Despite high yielding attributes of improved cultivars compared to those of local types improved varieties were found to be susceptible to diseases and lodging (Shrestha 1976). There are many examples of improved varieties gaining popularity within a short period of time but later become susceptible to biotic stresses. Such trend was not reported in landraces. In this study, cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity may be useful for further rice improvement. The results of this study may help in the selection of the most diverse cultivars and greatly expand genetic variation for rice improvement. Measures of genetic diversity can be used to maximize the level of variation in segregating populations by intermating cultivars with greater genetic distance. Modern varieties replaced the landraces and improved old varieties resulted in the genetic erosion. Therefore, in situ, on farm and ex situ conservations are necessary for maintaining the genetic variation in

Nepalese rice. These approaches should be treated as complementary. Government, semi governmental and private agencies should take action to conserve and utilize rice genetic variations present in Nepal.

There is need of identifying least cost *in situ* and *ex situ* conservation for rice landraces and wild rice gene pools and policy instruments most suitable for supporting conservation of these gene pools. Participatory Varietal Selection (PVS) methodology has been selected to increase diversity in addition to increase the adoption rate of variety (Joshi et al 2003). A prerequisite of conservation is genetic assessment of rice populations in the area that are likely to constitute rare, unique and distinctive genetic resources. Based on available information and genetic analysis, prediction of the future value of these genetic resources is needed in the extent to which they have high genetic value in improving yield potential and sustaining future rice productivity in the changing pest endemics, climate change and changes in market demand. We don't have favorable policy, legal for the protection of habitats. Nepal has introduced 47 ancestors originated in 12 different countries through improved rice cultivars, harbor many landraces and wild relatives. For effective conservation least cost methodologies for *in situ*, on farm and *ex situ* systems should be developed. Utilization of local landraces should be the first priority to conserve them in addition to increase the yield. Potentiality of native species should be made available. Varieties developed using local landraces will perform and adapt better than others. Duplicate accessions of ABD and LARS should be removed and gene bank must be updated through regular exploration program. To release cultivar ancestors and number of crosses for that cultivar should be considered. For the conservation of wide gene pool, site specific trial rather than coordinated trial is recommended. Conservation work be initiated after genetic assessment of rice populations in the area that are likely to constitute rare, unique and distinctive resources. Specific technological options (plant breeding, biotechnology) for utilization of genes and appropriate economics instruments for providing incentives to community are suggested for conservation and utilization of rice diversity. For recommendation of any varieties microenvironment effects be considered. For Nepalese agro biodiversity conservation and utilization plant breeding work should get first priority any where at any time. We have still many traditional farming systems. Based on the locality needs, these systems should be improved through participatory approach.

ACKNOWLEDGEMENTS

Krishna P Shrestha, Sudarshan Bista, Bina Dongol and IRRI for providing pedigree information. Dedicated to Ganga Shrestha.

REFERENCES

- ABD. 2003. *Annual Report–2058/59 (2001/2002)*. Agriculture Botany Division, NARC, Khumaltar, Lalitpur, Nepal.
- Adhikari NP, MM Plaikhe and RN Devkota. 1995. Status of rice, maize and wheat genetic resources in Nepal. **In: Plant genetic resources: Nepalese perspective** (MP Upadhyay, HK Saiju, BK Baniya and MS Bista, eds). Proceedings of National workshop 28 Nov-1 Dec 1994. NARI, IPGRI. Pp.74-77.
- Cox TS, YT Kiang, MB Gorman and DM Rogers. 1985a. Relationship between coefficient of parentage and genetic similarity indices in the soybean. *Crop Sci.* 25:529-532.
- Cox T, GL Lokhart, DE Walker, LG Harrell, LD Albers and DM Rogers. 1985b. Genetic relationships among hard red winter wheat cultivars as evaluated by pedigree analysis and gliadin polyacrylamide gel electrophoretic patterns. *Crop Sci.* 25:1058-1062.
- Dilday RH. 1990. Contribution of ancestral lines in the development of new cultivars of rice. *Crop Sci.* 30:905-911.
- Gupta SR, MP Upadhyay and DM Dongol (eds). 2000. *Nepalese germplasm catalogue – 2000*. Agriculture Botany Division, NARC, Khumaltar.
- IRRI. 1970. *Catalog of rice cultivars and breeding lines (Oryza sativa L.) in the world collection of the International Rice Research Institute*. IRRI Philippines.
- IRRI. 1987. *Final report of the twelfth international rice cold tolerance nursery*. IRRI, Philippines.
- IRRI. 1995. *The twentieth international rice cold tolerance nursery*. INGER, IRRI, Philippines.
- IRRI. 2000a. *The first international temperate rice observation nursery*. INGER IRRI, Philippines.
- IRRI. 2000b. *The twenty seventh international rice blast nursery (IRBN 2000)*. INGER, IRRI, Philippines.
- IRRI. GEU. *Parentage of IRRI crosses IR1-IR30000*. International Rice Research Institute, Philippines.
- Joshi BK and A Mudwari. 2003. Wheat gene pool and its conservation in Nepal. Paper presented in *International Conference on Himalayan Biodiversity*, 26-28 Jan 2003 Kathmandu, Nepal.
- Joshi BK, A Mudwari, MR Bhatta and GO Ferrera. 2004. Genetic diversity in Nepalese wheat cultivars based on agromorphological traits and coefficients of parentage. *Nepal Agric. Res. J.* (in press).
- Joshi BK, KP Shrestha, KD Joshi, A Mudwari, SP Khatiwada, P Chaudhary, RB Yadav, D Pandey, PR Tiwari, BK Baniya and BR Sthapit. 2003. Process documentation of deployment of rice and buckwheat diversity through participatory varietal selection

- for specific adaptation. **In:** *On farm management of agricultural biodiversity in Nepal*. Proceedings of National workshop, 24-26 April 2001, Lumle, Nepal. BR Sthapit, MP Upadhyay, BK Baniya, A Subedi and BK Joshi, eds. NARC, LIBIRD and IPGRI. Pp.229-232.
- Joshi BK. 2000. Assessment of the potential of Nepalese rice cultivars and landraces for hybrid production. *Master Thesis*. IAAS Rampur, Nepal.
- Joshi BK, S Gyawali, SN Sah and RR Chaudhary. 2001. Wild rice performance in mixture with landrace, improved cultivar and F₁ hybrid. Paper presented **in** *International Conference on Wild Rice*, 4-6 Nov 2001 Kathmandu, GEM Nepal.
- Joshi KD, M Subedi, KB Kadayat and BR Sthapit. 1998. Factors and processes behind the erosion of crop genetic diversity in Nepal. **In:** *Managing Agrobiodiversity* (T Partap and B Sthapit, eds). ICIMID, IPGRI Pp.183-197.
- Mallick RN. 1981/82. *Rice in Nepal*. Kala Prakanshan Kathmandu.
- Martin JM, TK Balke and EA Hockett. 1991. Diversity among North American spring barley cultivars based on coefficients of parentage. *Crop Sci.* 31: 1131-1137.
- NRRP. 1997. *25 Years of rice research in Nepal (1972-1997)*. NARC, National Rice Research Programme, Kathmandu.
- Rana RB, CL Paudel, PR Tiwari, D Gauchan, A Subedi, BR Sthapit, MP Upadhyay and DI Jarvis. 2000a. In situ crop conservation: Findings of agro-ecological, crop-diversity and socio-economic baseline survey of Talium ecosite, Jumla, Nepal, *NP working Paper No 3/2000*. NARC/LIBIRD, IPGRI.
- Rana RB, DK Rijal, D Gauchan, BR Sthapit, A Subedi, MP Upadhyay, YR Pandey, DI Jarvis. 2000b. In situ crop conservation: Findings of agro-ecological, crop-diversity and socio-economic baseline survey of Begnas ecosite, Kaski, Nepal, *NP working Paper No 2/2000*. NARC/LIBIRD, IPGRI.
- Rana RB, P Chaudhary, D Gauchan, SP Khatriwada, BR Sthapit, A Subedi, MP Upadhyay and DI Jarvis. 2000c. In situ crop conservation: Findings of agro-ecological, crop-diversity and socio-economic baseline survey of Kachorwa ecosite, Bara, Nepal, *NP working Paper No 1/2000*. NARC/LIBIRD, IPGRI.
- Sharma RC, SM Shrestha, NK Chaudhary, MP Pandey, AK Tiwari, L Yadav, BR Ojha, BK Joshi, S Gyawali, MP Upadhyay, S Sakrunga and H Leurg. 2001. Characterization and improvement of Nepalese rice using molecular techniques. *Terminal Report*. The Rockefeller Foundation.
- Sherchand KK, NP Adhakari, SP Khatriwada, AC Shrivastav, J Bajracharya, KD Joshi, KB Kadayat, M Chaudhary, P Vhaudhary, SS Vishwakarma, and S Yadav. 1998. Strengthening the scientific basis for in situ conservation of agrobiodiversity: Findings of site selection in Bara, Nepal, *NP working Paper No 2/98*. NARC/LIBIRD/IPGRI.
- Shrestha GL and MP Upadhyay. 1999. Wild relatives of cultivated rice crops in Nepal. **In:** *Wild relatives of cultivated plants in Nepal* (R Shrestha and B Shrestha, eds). Proceed. National conference, June 2-4, 1999 Kathmandu, GEM-Nepal, pp.72-82.
- Shrestha RB. 1976. Wheat production technology in Nepal. *Nepalese Journal of Agriculture* 6:18-24.
- Souza E and ME Sorrells. 1989. Pedigree analysis of North American oat cultivars released from 1951 to 1985. *Crop Sci.* 29:595-601.
- Sthapit BR. 1992. Chilling injuring of rice crop in Nepal: A review. *J. Inst. Agric. Anim. Sci.* 13: 1-32
- Shrestha GL and DA Vaughan. 1989. The wild relatives of rice in Nepal. *Proc. 6th Internat'l Congress of SABRAO*. Pp.171-174.
- Upadhyay MP and BK Joshi. 2003. *Status of plant genetic resources in Nepal*. ABD NARC.

Annex 1. Landraces of mid and high hills of Nepal (Modified from Gupta et al 2000)

A. Mid and high hill districts					
<u>District</u>	<u>Landraces</u>				
Achham	Salaujo	Dolkha	Thule	Lalitpur	Ramsali katka
Baglung	Pyuthari seto		Banghe masino		Setharo
Baitadi	Bhure dhan		Basmati anpjhutte		Suvana
Bajura	Lanmanya		Charikote marsi		Bighadewa
	Manhara		Chotangre marsi		Pokhreli, Aaghani,
	Phale		Dande marsi		Chhote marsi,
Bhaktapur	Agacha		Dolkhe marsi		sano marsi,
	Biganpa		Gudure marsi		Banse, Pahale
	Gunte		Jeena masino		marshi
	Gunte tauli		Jeph masino		Gudgude
	Pokhareli sathiya		Kayachha		Purano masino
	Rato masino		Lahare marsi		Rato aga
	Sathiya	Gorkha	Likhole marsi	Lamjung	Thankote marsi
	Swanwa		Sapinge marsi		Akali
	Togawa		Akele masino		Dale
	Ulaka		Larey		Gardi
Bhojpur	Aau		Maju rato		Gudule
	Bate		Panthi		Jhapka
	Chari dhan		Sano chobo		Jhuli
	Sulsiane masino		Sovan/Sal dhan		Jodi
			Thathar		Madeso
Dailekh	Dailekhe	Gulmi	Thathar bagari		Manamuri
	Dhaya		Chaureli		Manbo
	Gade		Madesi chhote		Manusara
	Goode	Jajarkot	Sete jaran		Thodo chobo
	Gude dhan		Dotiyali dhan	Myagdi	Thulo gudrabeli
	Gure	Jumla	Jhyali dhan		Bikase
	Kaili jado		Jadan marsi		Masino gauriya
	Kalo seto gude		Kalo maheli		Sano gauriya
Darchula	Rado dhan		Meheli	Nuwakot	Boudha massi
	Rajmati	Kabhre	Bagha tauli		Jhinuwa agahani
	Temase dhan		Bolakhe		Jira sarange
Dhading	Anadi masino		Buddhabir		Kalaykathi
	Asrange		Chhote marsi		Kali kathe
	Banghe dudhe		Chuplung		Limbutare masino
	Chherlinge		Dolkhe masino		Narjali gole
shiwuwa		Kaski	Ramali chhote		Samundrbakhi
	Cholikathe		Batise	phim	
	Chowa		Bayarni jhinuwa	Okhaldhunga	Ahe
	Dudhe mansaro		Jhawi		Bhatti
	Edle masino	Kathmandu	Jhimse		Bhuimali
	Garue ghaiya		Bigin		Dudhe marsi
	Hathi chhera		Tauli, Marshi,		Laldob
	Himadi dhan		Thapachiniya	Panchthar	Sovara
	Jini bengani		Chhote gunte		Barkhe tauli
	Juneli		Chhote pahenlo		Choirakha
	Kalo kathe		Chiniya marsi		Dhanasiri
	Kalokals dhan		Chiniya seto		Dhoosar
	Kanjira pahenlo		Dansi	Parbat	Kanti masino
	Krishnabeli		Duraj		Archoty zrura
	Lahare ghaiya		Hakuwa		Bhasey grura
	Lidi ghaiya		Hariyo marsi		Lumlati kalo
	Manahari		Jire asarange		Masara
	Manasara		Kalo basmati		Thulo pahenlo
	Masino basmati		Kathe marsi		Toli anadi
	Pahenlo anpjhuppa		Lamo pahenlo		Zerman
	Pakhe sale		Nepali puwa	Ramechhap	Zola
	Palpali		Puwa		Basmati masino
	Rajbhog masino	Khotang	Tayasiva		Bhotange marsi
	Salyan dudhe		Atte pachele		Gauriya masino
	Sano begani chhiya		Bage tauli		Jira sari masino
	Silly		Bhotange		Jogini masino
	Sirwa		Dumsi		Kalo jumli
	Tauli ghaiya		Jodi chand		Katikasali
	Thade masino		Kumale marsi		Katuwa kumale
	Thosar ghaiya		Lathi jhavar		Phode jagannathiya
			Motange pahenlo		Purano jagar
			Okhaldhunga		Rakshe

Rasuwa	Saro mumale		Jore		Mobhanga
Rukum	Thinga mali		Lalgadi dhan		Morange
	Khareli	mari	Nawn gouldoo		Rambeli
	Sagun, Big,				Santara
	Simjira, Ghaiya,				Seto masino
	Basmati, Dalsing,	Ilam	Nimdi	Surkhet	Sobara
Sankhuwasaba	Marse, Jyali		Baidai		Hansa
	Tauli, Manipure,		Bairani		Nimai
	Tulsi, Dalbir,		Bhumi dhan		Sothari
	Masino, Halpude,		Champasari	Syangja	Badhari
	Masri, Juwa,		Chimasari		Bhaisegola
	Aanapasi, tahniya,		Chimase		Chaite dhan
Sindhupalchok	Budhe, Neuli,		Chyanse dhan		Chove
	Himali		Dashara dhan		Gazali
	Karkali jukari		Dudhuwa		Jarpari
thapachiniya	Nepali		Kakhauri		Makuwa
	Pahenlo jharakathe		Makhmali dhan		Sejali
	Sano chhotte		Mangsuli		Thema
Taplejung	Bhote tauli		Nangere		Zaruda
	Chhitange		Nania	Tanahun	Badbade
	Eyeder		Niranphul		Masino madesi
	Gadbade		Pahade basmati		
	Khoranse seto		Pakha tauli	Unknown	
	Kobhang		Phaudal		Bangali
	Namsule		Phodel		Bartalo dhan
Terhathum	Bango masino		Ruduwa		Bharai
	Chiruakha		Sindhu marsi		Chanaphor
	Hukpa		Takmaru		Chyangula
	Kaduwa		Tapre		Deukhoria dhan
	Karele		Thandre		Goguwa dhan
	Khyamti	Makwanpur	Thangre masino		Gokul dhan
	Manksula		Achhame masino		Gorhna dhan
	Masino bhangere		Baglung		Gorra dhan
	Yaksen		Chhoti marsi		Gundrikbhog
			Gazali ghaiya		Jalmani
			Gola ghaiya		Jaunthari
			Jute masino		Jernali
			Motisari		Kalo timure
			Phalame		
			Purbiya/kalamsar	masino	
			Seti ghaiya		Kamuli
			Seto ghaiya		Karauli
			Thulo marsi		Khoile
		Palpa	Madi		Kholasin
			Masino zolo		Kirmala
			Pauata		Lale
			Seto kathe		Lamani
		Pyuthan	Bombay jarhan		Madhuwa karaiya
			Jarneli chaureli		Makhmal mehi
			Suga pankhi		Matkan
		Sallyan	Ath hageri jarahan		Matkut dhan
			Bagari jarahan		Pahenlo phalame
			Chinne		Pakistani
			Desi dhanahawa		Pameli
			Guraura		Raimanowa
			Pubde jhinuwa		Saonthari dhan
			Rimali jarahan		Sauthari dhan
			Sano marsi		Seto atte
			Seto jarahan		Sidali
			Seto jhanuwa		Sohabat
		Sindhuli	Bhat kanya		Suhawat
			Darjilinge		Takle
			Dhuse		Thakali
			Gahume masino		Thuli begano china
			Ghiew kumari		Tinasari
			Jarneli masino		Yangkhuke
			Karme masino		Zenna masino
			Kharpali		Zungali
			Kharpali masino		
			Kumale		
B. Districts lies in both Tarai and Hill ecoregions					
Arghakhanchi	Chhotki asram				
	Dedi				
	Deori				
	Estmali				
	Hawa				
	Jedia				
	Lame jadan				
	Laure				
	Lave				
	Silame				
	Sunmune				
Dandeldhura	Modora dhan				
	Syamjiro				
Dhankuta	Bhain marse				
	Bhutan dhan				
	Dude masino				
	Ghomota				
	Jire mansara				
	Juwa				
	Katak marse				
	Rangeli dhan				
	Saraj				
	Takmare rato				
	Tauli masino				
Doti	Bharadya				
	Chucheri				
	Gazi				
	Gurthonglo				
	Hapali				
	Jhunjhunya				

Status of Agrobiodiversity in Upper Arun River Valley, Shankhuwashabha

Krishna B Karki and Bal K Joshi

Nepal Agriculture Research Council, Khumaltar

ABSTRACT

Availability of numbers of different plants species has attracted several animals and birds in Arun River Valley. Due to increased population pressure exerted on forest environment, there are 11 mammals and numerous plant species either endangered or threatened globally are found in this area. An exploratory research was carried out on agriculture biodiversity of Num, Pawakhola and Hatiya VDCs of Upper Arun River Valley adjoining Makalu-Barun National Park. Very little influence of the modern agriculture technology has been observed in these VDCs following traditional agriculture. Wide scale slash and burn agriculture practised for cereals cultivation deteriorated inherent soil fertility and large numbers of indigenous vegetation. Indigenous varieties of cereals, legumes and vegetables are cultivated including indigenous fruits. Recent introduction of cardamom may be one of the causes of threatening wild rock bees that was indigenous to Pawakhola area. Extension of tea has negative impact on native plants, animals and birds species. Among the endangered cereals Anadi and Jademarshi varieties of rice and Kauno (bajra) millet has been already extinct. Among the fishes Jalakapoor is no more available in the Koshi river in this area.

Key words: Agricultural biodiversity, slash and burn agriculture, traditional farming

INTRODUCTION

Biodiversity is important to local community since it provides soil regeneration, nutrient cycling, plant pollination, and provision of clean water and maintenance of the functioning of ecosystems, which yields harvestable resources. It is also potential sources of genetic materials for commercial crops, provides natural enemies for biological control of crop pest and diseases including wild relatives of domestic plants and animals that can thrive severe drought and floods (Joshi and Rasali 1998, Joshi et al 1998). Out of the 9000 species of vascular plants reported in Nepal 370 are the endemic to this country sowing richness of biodiversity (Upadhyay 1998).

Arun River Valley covers wide biological diversity and hence, said this area to be rich in biodiversity. There are 11 mammals and numerous plant species either endangered or threatened globally found in this area (Bhandari 2002). Because of wide spread rainfall through out the year that promoted numbers of different plants species in this valley has attracted several animals and birds (Gurung and Gurung 2001, Kuwar et al 2001, Kuwar 2000). These days there has been disturbance in the bio-diversity of this region due to increase in poverty led by increased population pressure, lack of knowledge in sustainable use of natural resources, such as slash and burn agriculture, bush fires, timber logging, construction-wood and fuel wood extraction including unsustainable honey harvesting and hunting (Shrestha and Gupta 1993). At present the rate at which the forest is denudating by the rate of 1.7% per anum in Nepal, indicate biodiversity of this region are endangered (Jha et al 2001).

Numbers of study in general biodiversity of this region have been already conducted but no information regarding agricultural diversity, which supported the livelihood of the local community directly, is available. Therefore, an exploratory research on this area was conducted so that some of the endangered crop varieties could be preserved.

METHODOLOGY

Desk study to collect relevant information regarding the agro-biodiversity was conducted. Library of The Mountain Institute, ICIMOD, IUCN, NARC and KMTNC were visited. Based on the information a checklist of the information to be collected in the field was developed. An exploratory field research was conducted during the month of July/August 2002. In the field, farmers were collected in one place and information that we needed were discussed and collected following Rapid Rural Appraisal. Women members were invited to contribute in gathering information and participated in discussion. After the field work (verification of information collected during desk study) the information were discussed among the team members and analysed logically. Maps of study site are given by Joshi and Karki (2004, in this proceedings).

FINDINGS

Geographical distribution and climate

This study was conducted in Num, Hatiya and Pawakhola Village Development Committees (VDCs) of Sakhuwashabha District of Koshi zone in Eastern Development Region of Nepal. The area lies between 27.30° to 27.40° N latitude and 87.15° to 87.27° E longitude. It was the extreme north of the district that is close to the Tibetan boarder. Altitude ranges from 837 m above mean sea level (asl) to 4000 masl. The highest settlement Bhotegaun of Pawakhola in the study lies at an altitude of 2472 masl (Figure 1.).

This region enjoys cool temperate type of climate with very high rainfall that is regarded highest next to the Annapurna region. Kuwar (2000) reported 6000 mm of rainfall in some years. The rainy season is warm and humid. Precipitation pattern indicates the wide distribution of rainfall during the whole years and enough humidity and temperature is available especially in summer and rainy season, promoting good vegetation growth, promoting diverse animals and bird species. Winter temperature in lower altitude is chill with occasional frost and snow at higher altitude.

Natural vegetation

Altitude plays a major role in the temperature control of this region. Since the study area ranges from 838 m Phaksenda of Num to 4200 m Gojure Danda of Pawakhola, natural vegetation also ranges in the same way. Based on the vegetation composition and climate they are categorised in five different groups. They are as follows:

- a. Tropical belt (<1000 masl), Gorge forest: The dominant forest vegetation are *Bombax cieba*, *Schima walichi*, *Castanopsis* spp, *Albezia* spp, *Bauhunia* spp and *Alnus* spp. Among the shrubs *Maesa chisia* and *Eupatorium adenoforum* are observed.
- b. Subtropical belt (1000-2000 masl), Castanopsis forest: The dominant species of forest plants are *Castonopsis indica*, *Schima wallichii*, *Eurya acuminata*, *Persea odoratissima*, *Quercus semecarpifolia*, *Quercus lanata*, *Macaranga indica* and *Maesa chisia*. Among the shrubs observed in this area are *Eupatorium adenophorum*, *Maesa macrophylla* and *Artemisia dubi*.
- c. Temperate belt (200-3000 masl), Schima-Castanopsis forest: Other species found in this forest type are Oak forest, *Alnus*, *Castonopsis*, *Macaranga*, *Pinus roxburghii* mixed with *Schima wallichii*, *Eurya acuminata*, *Engelherdtia spicat*, *Quercus lamellose*, *Castanopsis hystrix*, *Persia* spp, *Alnus nepalensis*, *Betula alnoides*, *Michelia*, *Lithocarpus spicata*, *Lindera pulcherrima*, *Lyonia ovalifolia*, *Rhus succedanea*, *Cinnamom* spp, *Rhododendron arboreum*. Shrubs available in this region are *Eupatorium*, *Maesa macrophylla*, *Viburnum erubescens*, *Berberis asiatica*, *Daphne bholua*, *Hymenodyctiona* spp, *A. naphalis*, *Helwingia himalaic* and *Elscholzia*.
- d. Sub-alpine (3000-4000 masl), Fir forest: The main species of natural vegetations are *Tsuga dumosa*, *Betula utilis*, *Rhododendron hodgsonii*, *Juniperus recurva*. Lower vegetations are *Berberis* spp, *Neelia* spp, *Rhododendron* spp and *Abies spectabilis*.
- e. Alpine belt (>4000 m), Juniper forest: *Rhododendron* scrub, *Juniperus recurva*, *Myricaria* sp, *Berberis* sp, *Caltha*, *Fragaria*, *Anaphalis*, *Potentilla microphylla*, *Potentilla nepalensis*, *Senecio*, *chrysanthemoides* and *Arisaema griffithii*.

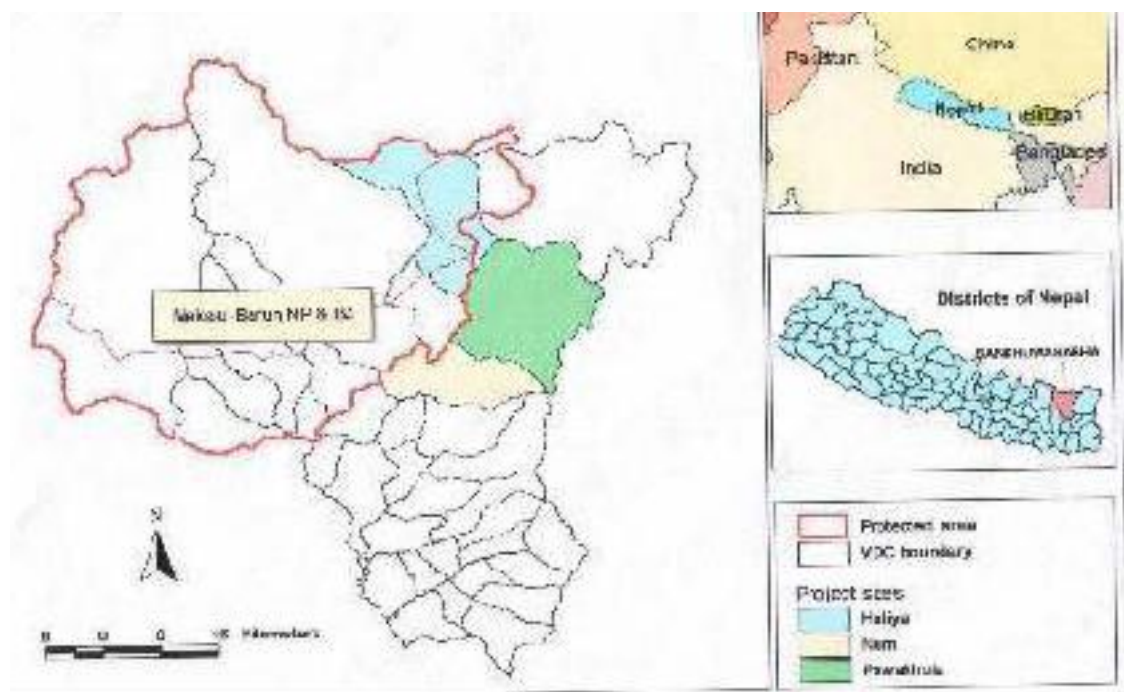


Figure 1. Location of study sites.

Soil and soil fertility

The high mountain physiographic region tends to have highly metamorphic rocks such as gneiss and garnetiferous mica schist (LRMP 1986). All valleys in this region are from the glacial deposits. Due to the glaciations and cooler climate soil weathering is very limited. Comparatively older soils are observed in the gentle knolls and ridges at mid elevation through out the area. Soils developed on glacial till is common but colluvial action has greatly altered the till matrix. In general soils developed on schist and gneisses are observed. They are shallow, coarse textured soils with acidic in reaction. Three subgroups of soils as described by LRMP (1986) such as Dystrochrepts, Eutrochreptd and Ustorthents are observed in this study area, which is presented in Table 1.

Table 1. Soil and soil characteristics of the study areas

Soil	Parent materials	Available areas	Fertility
Dystrochrepts	Acidic gneiss, mica schist, concalcerious	Upper part of Num VDC Mostly sloppy anthropogenic terraces	Low pH, high organic matter medium in texture and medium in fertility
Eutrochrepts	Alluvial deposit, phyllites, schist and quartzite	Lower part of all the three VDCs,	Highly erosive, shallow depth, low fertility
Ustorthents	Colluvial, variable parent materials	Slopes >35°, recent river deposits and landslides scars of all the three VDCs	Very low in fertility and only tree crops are recommended

Wherever possible the fields are terraced to maintain soil fertility and conserve soil erosion. Farmers cultivate even the steep slopes of 52° using slash and burn practice. This accelerates the soil erosion and due to burning soil humus is also burnt reducing the soil fertility. Farmers collect dry litters and *Eupatorium* from the forest that is used as bedding materials for their cattle to increase the amount of FYM. In situ fertilisation from the cattle and sheep in the winter is a common practice. Green manure with high nitrogen containing vegetations such as *Titepati* (*Artemesia* spp), *Eupatorium* spp, *Khirro* and *Siris* that are widely available in the areas are not practised. But mulching of the standing maize crops during Shravan is found in Hatiya and some parts of Pawakhola VDC. This helps in addition of organic matter and nutrients recycling. It also helps in reducing kinetic energy of raindrops and conserves soil from erosion.

It is so unfortunate that even in such an inaccessible area chemical fertiliser has penetrated up to the remote parts of Hatiya VDC. Farmers those having excess to Khandbari transport small amount of urea are applied to the maize crops.

Population and agricultural production situation

These are sparsely populated areas. Num VDC has only 3172 people whereas Hatiya and Pawakhola further remote areas have 3112 and 3095 respectively. Average population growth rate is only 1.16% per annum. Lowest rate being in Hatiya (0.93%).

Land use in these 3 VDCs shows much variation. Although there has been enough land suited for agricultural crops, only a part is cultivated. Comparatively cultivated land in Num VDC is much larger than the other two VDCs but pasture area is largest in Hatiya VDC (Table 2). Similarly food production in Num is also higher ie 142.80 t. Hatiya and Pawakhola have comparatively lower 16.53 t 27.33 t of food production respectively. Large amount of grain is fermented for local alcohol production.

Table 2. Land use in Num, Pawakhola and Hatiya VDC

VDC	Agriculture	Pasture
Num	2.04	0.27
Pawakhola	1.97	1.05
Hatiya	2.07	4.32

The district as such is food deficit and needs to import from outside. Usually, food is supplied from the Tarai and distributed to other region of the district. Highest amount of rice (25200 kg) is produced in Num VDC (Table 3). The other two VDCs produce very little amount of rice because of limitation of suitable land for rice cultivation. Hatiya VDC is famous for potato cultivation. Most of rice and edible oil is supplied from Kahndbari market. The other grains are balanced in exchange from the neighbouring VDCs. Data regarding finger millets, maize and wheat production is not available and these grains production is sufficient to meet the local demand.

Table 3. Food situation in the study areas

Crop	Food production and requirement in kg					
	Num		Hatiya		Pawakhola	
	Production	Import	Production	Import	Production	Import
Rice	25200	20,000	748	3300		24650
Wheat	13	500	NA	2360	NA	
Maize	25,800	1000	NA		NA	
Finger millets	17,700	1000	NA		NA	
Potato	745		15,000		10,000	
Mustard	500					
Soybean	222		250		220	

Source: District Development Committee, Shankhuwashabha.

Crop diversity

Due to wide range of altitude in this study area all crops can be grown. In the lower altitude rice is grown where as in the higher altitude wheat, maize and potato are common. Buckwheat, wheat and other legumes are also cultivated. Regarding the varieties, many varieties are unidentified and they are only known as local varieties. However, improved rice varieties like Khumal 4 and Malaya (might be Masuli) have been recently introduced and gaining popularity. Some of the varieties grown in these areas have been mentioned in Table 4. Most of the crop varieties grown in this locality could be important gene pool for further study. Legumes mostly soybeans and black gram are grown but not for commercial purpose. Potato seed is famous in Honghong village of Hatiya, which is exported to other VDCs as well. Though, there has been huge potential for fruits and vegetables growing, farmers have not paid much interest on these cultivation. Local varieties of guava in the lower altitude, citrus in middle and pears and peaches in higher altitude have been noticed. For vegetables improved varieties of Kentucky beans, cowpeas and radish have been introduced by some NGOs. Among the domestic animals all of them were local and low yielding breeds.

Rice is grown only where irrigation is available and mostly as mono crop with no additional manure. In a small area it is rotated with wheat and some times with garlic in winter. The succeeding crops (winter/spring) get enough manure mostly FYM. Maize is relayed with finger millets. In slash and burn practices solo crops of

maize and finger millets are also practised. Maize is generally rotated with wheat, barley, potato and finger millets in all the study areas.

Table 4. Crop diversity and their varieties in the study areas of Sahkuwashabha

SN	Crop	Crop varieties		
		Num	Hatiya	Pawakhola
1.	Rice	Atte, (medium-fine), Takmare, Jademarshi	Atte, (medium-fine), Takmare, Jademarshi	Belbote, Madale, Takmare, Yangsare, Jademarshi
2.	Maize	Seto, Panhelo, Teen Maha (three months)	Seto, Panhelo	Seto, Panhelo
3.	Buck wheat	Tite, Mithe	Tite, Mithe	Tite, Mithe
4.	Potato	Red, white, oblong	Red, white, oblong	Red, white, oblong
5.	Soybean	Small, and bigger	Small, and bigger	Small, and bigger
6.	Cow peas	Tane Bodi, Boda, Mashyang	Tane Bodi, Boda, Mashyang	Tane Bodi, Boda, Mashyang

Cash crop diversity

Chiraito (*Swertia chiraita*) has been available as indigenous to this locality. It has been harvested since the farmers knew it as medicinal plant and had been exported to Tibet to the North India to the South. Since domestication of this crop has recently been started exact amount of area under this crop and production is not yet known.

Highest amount of cardamom (137500 kg) was produced in Num VDC. Chilly, ginger and turmeric are also produced as cash crops but the amount was for local consumption only. Tea has also been popularly grown in these DVCs but exact area under this crop is not known. Cardamom and tea in these areas have been recently introduced. These crops cultivation needed clearance of forest. This has led to the extinction of the indigenous species of fauna and flora. Some of the species that has been exogenous might have allelopathy effect on other indigenous species that disappear slowly. During the course of introduction of new crop varieties, very important local gene pool has already disappeared. Some of the disappeared species are as follows:

1. Among the cereals Anadi, a blast resistant variety, and Tademarshi, locally popular dark variety are extinct. The same is the case with Kauno (bajra), and Junelo, local sorghum are no longer available.
2. Rock bees (*Apis mellifera*), indigenous to Pawakhola have been extinct and blame cardamom cultivation for this extinction.
3. Local species of shrub especially grasses have been disappearing due to Eupatorium invasion.
4. Lokta (Danphe), Allo (Nettle), Nigala (small bamboo) have been already threatened.
5. Jalkapoor, a popular fish is not available at all in the rivers.

CONCLUSION

Agriculture diversity in this area is still in infant stage. There is lot to be done. A short study revealed plenty of information regarding availability of local crop varieties and the their cultivation practices. Introduction of improved crop varieties have threatened local germplasms. Characterization of these locally available species were very important before introduction. Locally available chicks seems to be very important gene pools for breeding poultry birds if not taken care it could also be disappeared before something is done. Lack of local knowledge on biodiversity conservation has been the main cause of threat. Therefore, awareness creation is necessary.

REFERENCES

- Bhandari S. 2002. Environmental law and conservation of mountain biodiversity in Nepal. *Proc. International Seminar on Mountain*. Royal Nepal Academy of Science and Technology (RONAST), Kathmandu. Pp.64-68.
- DDC. 2002. *District and village profile*. District development committee (DDC). Khandbari.
- Gurung G and J Gurung. 2001. *Vegetation dynamics of herbaceous plants in lower Arun River Basin of Makalu Barun Buffer Zone Eastern Nepal*. ICIMOD, Kathmandu, Nepal.
- Jha PK, SR Baral and SB Karmacharya. 2000. Forest and biodiversity in South Asia: An overview. In: *Ecological Society (ECOS) Nepal* (PK Jha, SR Baral, SB Karmacharya, HD Lekhak, P Lacoul and CB Baniya, ed). Kathmandu, Nepal.

- Joshi BR and DP Rasali. 1998. On-farm conservation of indigenous animal genetic resources and livestock development: some issues. *Proc. Working paper on managing agricultural diversity for sustainable mountain agriculture: Issues and experience*. Local Initiation Biodiversity Research and Development (LIBIRD). Pokhara Nepal. Pp.42-47.
- Joshi KD, M Subedi, KB Kadayat and BR Sthapit. 1998. Genetic diversity and erosion of indigenous arable crops and green manuring species in the mountain of Nepal: Some conservation strategies. *Working paper on managing agricultural diversity for sustainable mountain agriculture: Issues and experience*. Local Initiation Biodiversity Research and Development (LIBIRD), Pokhara Nepal. Pp.29-37.
- Kuwar RM, UNP Gupta, OR Vetas and RP Chaudhary. 2001. Pterodophyte of Arun River Basin of Makalu-Barun National Park and Buffer Zone Eastern Nepal. *Proc. International Symposium on the Himalayan Environment*.
- Kuwar N. 2000. Biodiversity strategies and its significance for sustainable agriculture. **In:** *Environment and agriculture at the cross road of new millennium* (PK Jha, SB Karmacharya, SR Baral and P Lacaul, eds).
- LRMP. 1986. *Land resources mapping project: Land system report*. Integrated Survey, Department of Land Reform/ HMG of Nepal/ Kenting Earth Ltd. Canada.
- Shrestha TB and VNP Gupta. 1993. Biodiversity profile and conservation strategies. **In:** *Environment and sustainable development: Issues in Nepalese perspective* (MK Dahal and DR Dahal, ed). Nepal Foundation of Advanced Studies, (NFES). Kathmandu. Pp.1-4.
- Upadhyay MP. 1998. Biodiversity and bio-wealth of Nepal: NARC's role and programme. *Proc. Working paper on managing agricultural diversity for sustainable mountain agriculture: Issues and experience*. Local Initiation Biodiversity Research and Development, Pokhara. Pp.24-28.

Varietal Performance of Boro Rice at Regional Agriculture Research Station, Parwanipur

KP Bhurer, ML Sah, MP Sah and DB Gharti

RARS, NARC, Parwanipur, Bara, Nepal

ABSTRACT

Different rice varieties were tested in a varietal trial for yield performance and suitability to boro condition, during winter season of 2000/01, 2001/02 and 2002/03 at Regional Agricultural Research Station, Parwanipur. Significant differences among varieties were found for days to heading, maturity, plant height, productive tillers/m², panicle length, number of filled grains/panicle, test weight and grain yield during the three years. Parwanipur Masuli (Morang selection), BRRI DHAN 36 and Gautam were promising as boro rice during the first year. Gautam (6066 kg/ha), Saroj (5606 kg/ha) and BRRI DHAN 36 were significantly superior in terms of grain yield over rest of the varieties in the second year. In the third year DR 11, Jyoti Prasad, BRRI DHAN 36, Khumal 11, DR 1, DR 17, Chaite 2, NR 10285-15, DN 5-2-3, Jaya and DR 16 were also promising for boro season. Sugaha local produced 653 tillers/m², but was susceptible to lodging over the years. Days to heading and maturity ranged from 182-204 and 190-209 and 178-212 days in 3 consecutive years respectively. Parwanipur Masuli (Morang selection), Gautam, Sugaha Local, Jaya and BRRI DHAN 36 produced 4324, 5029, 4093, 3782 and 5307 kg/ha, respectively over the years. Based on two years data Richariya (3568 kg/ha), Saroj (4962 kg/ha) and Jaya were promising for boro season rice.

Key words: Boro rice, grain yield

INTRODUCTION

The term boro is originated from the Sanskrit word 'Borob' that refers to a special rice cultivation in low lying areas during November to May taking advantage of the residual water in field, longer moisture retentivity of the soil and surface water stored in the near by ditches. It is cultivated since time immemorial and it has been mentioned in Sita puran as one of the offerings to the God (Gupta 2000).

Of the total rice area, 51% is rain fed and 49% irrigated in Nepal. Rice is cultivated in rainy (June/July–October/November) and spring (February/March–June/July) seasons. There are 2-3 times flood every year in Central and Eastern Nepal. Monsoon starts at the harvesting time of Chaite rice and farmers get problem during threshing and loose straw. By the year 2020, there is need of more than 6 million tones of rice, for this average production should be 4.0 t/ha or even more (Chaudhary 2002).

Drought and flood are major constraints for rice production. Last year in first week of Shrawan flood caused havoc in 46 districts of the country, which resulted in the average low yield of rice. Among the probable opportunities, boro rice is an alternative by which we can increase the rice production to a great extent in these areas where due to excess water, even wheat cultivation is not possible. With the increased availability of irrigation facilities, this technology could be extended to nontraditional areas where boro (winter) rice would help to solve the unemployment, to generate income, to alleviate poverty and to sustain food security.

MATERIALS AND METHODS

The varietal testing of boro rice was carried out at Regional Agriculture Research Station, Parwanipur, Bara, during the boro season of 2000/2001, 2001/2002 and 2002/2003. Only five rice varieties were tested during the

1st year, 11 rice varieties were included in the second year and 19 varieties in the third year. The experiment was laid out in a randomized complete block design with three replications, which comprised of five to nineteen varieties including one Sugaha Local (standard check) in the consecutive years. The soil of experimental site was sandy loam, neutral (pH-6.5) in reaction, low in organic matter content and available N and medium in P and K. The seeds were sown on 1 November and transplanted on 2 and 14 February of 2002 and 2003. The fertilizer was applied at the rate of 80:40:30 kg NPK/ha. Half of the N and full dose of phosphorus and potash were applied before transplanting. Remaining half of the N was applied in two equal splits, one at 25 days after transplanting and the rest at panicle initiation stage. Fertilizer was applied 120:60:40 kg NPK/ha in the third year. Transplanting was done at a spacing of 15- × 15-cm with 2-3 seedlings/hill. For weed management butachlor was applied @ 1.5 kg ai/ha within 4 days of transplanting. Continuous water was managed during the crop period. For steam borer, Furadon 3-G was applied @ 12 kg/ha. Thiodan 35 EC was sprayed 2-3 times @ 1.5 ml/l of water for control of Gundhibug and Grasshopper. The rainfall of growing season was 182.8 mm (20 rainy days) and 483.7 mm (29 rainy days) in 2002 and 2003, respectively (Figures 1, 2, 3). Agronomical characters like days to heading, days to maturity, plant height, panicle length, panicles number, grains number, test weight and grain yield were recorded and analyzed by using MSTAT-C package.

RESULTS AND DISCUSSION

Influence of varieties on agronomical characters like days to heading, days to maturity, plant height, Panicles/m², filled grains/panicle, test weight and grain yield kg/ha were highly significant during the three years. During 00/01 and 01/02 straw yield was highly significant. Days to maturity varied from 186-202 over the years. Jaya matured in 210 days followed by Parwanipur Masuli. Plant height and panicle length ranged from 66-127 cm and 18.2-23.6 cm, respectively. The maximum panicles /m² was with Sugaha Local (653/m²) and minimum with CH45 (191/m²). Filled grains/panicle were observed highest during 02/03 and ranged from 46.46-143.73. Highest 1000-grain weight was recorded in DN-5-2-3 (28.71 g). BRRI Dhan 36 ranked first and Gautam second by producing 5307 and 5093 kg/ha over the years. But in 02/03 DR11, BRRI DHAN 36, Jyoti Prasad and Khumal 11 yielded 5291, 5196, 5058 and 5013 kg/ha respectively. Sugaha Local was very susceptible to lodging followed by Chandannath 1 and NR 10288-15J-1J-1 due to weak stem and these varieties have no dormancy and germinated to some extent before harvesting. Khumal 11, DR 1, DR 11, DN-5-2-3, Saroj, DR 16, Jyoti Prasad, Gautam, NR 10285-18-3-2-3-1, Prabhat BRRI DHAN 36 and Jaya were preferred by the farmers during The First Farmer Field Day on Boro Rice In Nepal celebrated on 23 May 2003. For quality purposes Saroj, DR 1 and DR 11 were liked where as Khumal 11 was liked for Chiura (beaten rice). The seedlings faced cold injury due to temperature below 10°C in January. Below this temperature like 9.6 to 6.3°C seedling turned yellow and brown spot increased due to devoid of photosynthesis. When temperature comes below 10°C photosynthesis is disturbed (Mishra 2000). Boro rice is cultivated where there is 1000 mm annual rainfall among which 10% occurs during October to May (Ray 2000). Gautam is the first boro rice variety released by Rajendra Agricultural University in 1994 (Thakur 2000). Singh (2001) reported that Gautam was excellent cold tolerance, IR-36 and Jaya moderate cold tolerance by producing 8.5, 4.0 and 5.5 t/ha in boro season (Table 1). He also reported that boro rice varieties like Prabhat, Dhan Laxmi, Richharia and Saroj gave 6.5, 6.0, 6.0 and 6.5 t/ha respectively (Tables 2a, 2b, 2c, 2d, 2e).

Disease, insect pests in boro rice at Parwanipur 2002/03

One terminal disease and insect pest scoring was done on 2 May 2003 using different scales when most of the early and promising boro rice varieties were at stages between milk to late dough. Brown spot (*Helminthosporium oryzae*) was found in all varieties but at low severity (Table 3). Narrow brown spot (NBS) was observed in few varieties that too in low severity. BLB at very low severity was recorded only in Chandannath-1, Parwanipur Masuli and Sugaha Local. Over all disease severity was very low. Borer infestation was highest in Richharia (4%) while Gundhi bug was highest in NR 10288-15J-, NR 10285-15, DN-5-2-3 and Richharia (3).

Table 1. Cold tolerance score of boro rice varieties grown at RARS, Parwanipur 2002/03

SN	Variety	Cold tolerance score	Sources
1	Chandannath 1	1	Agric. Botany Division, Khumaltar
2	NR 10285-18-3-2-3-1	1	"
3	Khumal-11	1	"
4	NR 10288-15j-1j-1	1	"
5	SAN-Pao-Tao	1	"
6	Palung-2	9	"
7	Jyoti Prasad	3	BHU, Vanaras UP, India
8	DR 1	3	"
9	DR 11	3	"
10	DR 16	3	"
11	DR 17	3	"
12	DR 5-2-3	3	"
13	Gautam	3	RAU, Pusa, Samastipur, Bihar, India
14	Saroj	3	"
15	Richharia	3	"
16	Dhan Laxmi	3	"
17	Prabhat	5	"
18	BRR1 DHAN 36	3	Bangladesh
19	Jaya	3	"
20	Ghaiya-2	3	"
21	Chaite 2	3	"
22	CH 45	3	"
23	PR 101	7	"
24	Parwanipur Masuli†	3	"
25	Chaite 6	9	"
26	Radha-4	7	"
27	BG 1442	7	"
28	Sugaha Local	1	Motihari East Champaran, Bihar, India

† Parwanipur Masuli is Morang selection.

Table 2a. Maturity days of boro rice varieties during 2000/01, 2001/02 and 2002/03

SN	Variety	Days to heading				Days to maturity			
		00/01	01/02	02/03	Mean	00/01	01/02	02/03	Mean
1	Parwanipur Masuli	167	179	177	174	196	202	208	202
2	Gautam	160	163	162	162	190	193	193	192
3	Sugaha Local	154	165	162	160	182	190	187	186
4	Bans	173	-	-	162	204	-	190	-
5	BRR1 Dhan 36	156	169	161	156	182	198	180	194
6	Richharia		159	153	163		190	194	185
7	Saroj		161	165	180		191	212	192
8	Jaya		181	179			209		210
9	BG 1442		170				199		
10	Dhan Laxmi		166				198		
11	Philips		161				191		
12	CH 45		168				196		
13	Prabhat		161				191		
14	Chandan Nath-1							178	
15	Khumal 11							193	
16	NR 10285-15							187	
17	NR 10288-15j-1j-1							176	
18	DR 1							194	
19	DR 11							195	
20	DR 16							195	
21	DR 17							193	
22	Jyoti Prasad							195	
23	DN 5-2-3							190	
24	Chaite 2							195	
25	Ghaiya-2							190	
F test		ns	**	**	-	ns	**	**	-
CV, %		0.46	1.73	1.25	-	0.59	1.14	0.72	-
LSD (0.05)		1.10	4.92	3.37	-	1.70	3.76	230	-

Table 2b. Panicles and plant height of boro rice varieties during 2000/01, 2001/02 and 2002/03

SN	Variety	Panicles per m ² , n				Plant height, cm			
		00/01	01/02	02/03	Mean	00/01	01/02	02/03	Mean
1	Parwanipur Masuli	323	268	241	277	132	122	128	127.33
2	Gautam	434	352	256	347	76	79	83	79.33
3	Sugaha Local	836	600	522	653	69	95	107	90.33
4	Bans	490	-	-	-	88	-	-	-
5	BRRI Dhan 36	454	331	311	365	73	75	83	77
6	Richharia		315	254	284		66	71	68.5
7	Saroj		337	268	302		81	88	84.5
8	Jaya		344	260	302		89	93	91
9	BG 1442		210				84	-	
10	Dhan Laxmi		262				85	-	
11	Philips		280				66	-	
12	CH 45		191				100	-	
13	Prabhat		238				68	-	
14	Chandan Nath-1			245				70	
15	Khumal 11			225				92	
16	NR 10285-15			302				79	
17	NR 10288-15j-1j-1			256				111	
18	DR 1			280				87	
19	DR 11			272				92	
20	DR 16			289				97	
21	DR 17			248				93	
22	Jyoti Prasad			279				88	
23	DN 5-2-3			279				92	
24	Chaite 2			290				81	
25	Ghaiya-2			277				81	
F test		ns	**	**	-	ns	**	**	-
CV, %		20	11.42	8.48	-	12.3	4.4	15.29	-
LSD (0.05)		24	11.46	47.25	-	16	6.26	22.89	-

Table 2c. Panicle length and filled grains of boro rice varieties during 2001/02 and 2002/03

SN	Variety	Panicle length, cm			Filled grains/panicle, n		
		01/02	02/03	Mean	01/02	02/03	Mean
1	Parwanipur Masuli	23.2	24	23.6	90.93	143.73	104.88
2	Gautam	19.66	21	20.33	68	95.8	74.26
3	Sugaha Local	18.2	20	19.1	37.46	46.46	41.96
4	Bans	-	-	-	-	-	-
5	BRRI Dhan 36	20.8	23	21.9	63.13	91.73	74.28
6	Richharia	19.06	20	19.53	78.7	68.33	58.51
7	Saroj	21.86	23	22.43	58	144.53	86.26
8	Jaya	22.4	-	-	54	124.13	89.06
9	BG 1442	22.4	-	-	31.5	-	-
10	Dhan Laxmi	22.46	-	-	59.86	-	-
11	Philips	19.06	-	-	61.83	-	-
12	CH 45	21.73	-	-	52.3	-	-
13	Prabhat	19.4	-	-	55.2	-	-
14	Chandan Nath-1		21	-	-	72.93	
15	Khumal 11		20	-	-	104.86	
16	NR 10285-15		23	-	-	83.13	
17	NR 10288-15j-1j-1		23	-	-	69.93	
18	DR 1		27	-	-	75.33	
19	DR 11		23	-	-	132.13	
20	DR 16		26	-	-	85.46	
21	DR 17		25	-	-	133.13	
22	Jyoti Prasad		25	-	-	104.53	
23	DN 5-2-3		15	-	-	94.6	
24	Chaite 2		21	-	-	142	
25	Ghaiya-2		23	-	-	101	
F test		**	ns	-	**	**	
CV, %		7.02	10.19	-	11.42	5.18	
LSD (0.05)		2.48	5.13	-	11.46	8.41	

Table 2d. Yield of boro rice varieties during 2000/01, 2001/02 and 2002/03

SN	Variety	Test weight, g				Yield, kg/ha			
		00/01	01/02	02/03	Mean	00/01	01/02	02/03	Mean
1	Parwanipur Masuli	20.6	19.62	22.43	20.88	5562	3587	3824	4324
2	Gautam	21.5	22.39	22.64	22.17	4508	6066	4718	5097
3	Sugaha Local	21.1	25.86	23.11	23.35	4050	3956	4272	4093
4	Bans	17.7	-	-	-	2062	-	-	-
5	BRRI Dhan 36	23.5	24.96	24.18	24.21	5346	5440	5136	5307
6	Richharia		21.96	21.4	21.68		3810	3327	3568
7	Saroj		24.03	22.9	23.46		5606	4318	4962
8	Jaya		24.63	25.14	24.88		3810	3753	3782
9	BG 1442		21.9	-	-		2830	-	-
10	Dhan Laxmi		24.33	-	-		4290	-	-
11	Philips		24.43	-	-		3623	-	-
12	CH 45		24.06	-	-		3086	-	-
13	Prabhat		26.53	-	-		4326	-	-
14	Chandan Nath-1			23.22	-		-	2527	-
15	Khumal 11			26.12	-		-	5013	-
16	NR 10285-15			23.78	-		-	4897	-
17	NR 10288-15j-1j-1			28.56	-		-	3478	-
18	DR 1			27.95	-		-	4920	-
19	DR 11			24.19	-		-	5291	-
20	DR 16			24.8	-		-	4094	-
21	DR 17			25.73	-		-	4920	-
22	Jyoti Prasad			25.02	-		-	5058	-
23	DN 5-2-3			28.71	-		-	4892	-
24	Chaite 2			22.44	-		-	4903	-
25	Ghaiya-2			24.92	-		-	4864	-
F test		ns	**	**	-	ns	**	**	-
CV, %		4.6	5.36	2.95	-	21.3	13.12	8.48	-
LSD (0.05)		1.4	2.15	1.20	-	1416	933.56	622.66	-

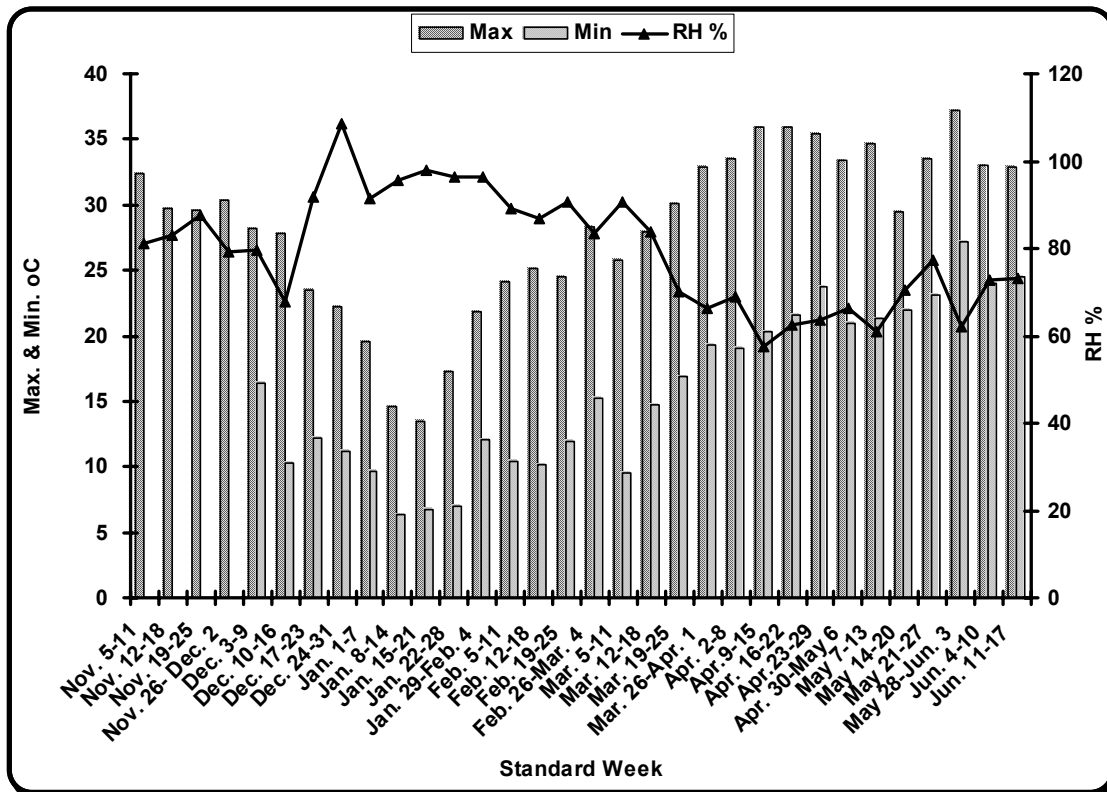
Table 2e. Straw and harvest index of boro rice varieties during 2000/01, 2001/02 and 2002/03

SN	Variety	Straw yield, kg/ha	Grain: straw ratio	Harvest index
		02/03	02/03	00/01
1	Parwanipur Masuli	5203	0.74	41.6
2	Gautam	3316	1.42	44.5
3	Sugaha Local	3756	1.13	39.5
4	Bans	-	-	19.8
5	BRRI Dhan 36	3597	1.44	50.70
6	Richharia	2378	1.40	-
7	Saroj	2824	1.53	-
8	Jaya	4980	0.73	-
9	BG 1442	-	-	-
10	Dhan Laxmi	-	-	-
11	Philips	-	-	-
12	CH 45	-	-	-
13	Prabhat	-	-	-
14	Chandan Nath-1	2583	0.98	-
15	Khumal 11	4552	1.09	-
16	NR 10285-15	2657	1.84	-
17	NR 10288-15j-1j-1	2898	1.22	-
18	DR 1	3047	1.62	-
19	DR 11	4236	1.25	-
20	DR 16	3801	1.07	-
21	DR 17	3697	1.33	-
22	Jyoti Prasad	3196	1.60	-
23	DN 5-2-3	2824	1.75	-
24	Chaite 2	3456	1.42	-
25	Ghaiya-2	3363	1.44	-
F test		**	ns	-
CV, %		5.18	0.22	21.1
LSD (0.05)		545	-	13.1

Table 3. Disease and insect pests score in boro rice at Parwanipur, 2002/03

SN	Variety	Disease rating†				Insect pests rating		
		Brown spot (0-9)	NBS (0-9)	ShR, %	Alternaria Podwikii (0-9)	BLB (0-9)	Borer, %	GB (0- 9)
1	ChandanNath1	1	3	0	0	1	0.1	0
2	Saroj	3	0	0	0	0	1	0
3	Gautam	1	0	0	0	0	0.1	0
4	NR 10288-15j- 1j-1	3	1	0	1	0	1	3
5	BG 1442	3	0	0	1	0	1	1
6	NR 10285- 18-3-2-3-1	3	1	0	1	0	1	3
7	Jaya	Late	Late	Late	Late	Late	Late	-
8	DN-5-2-3	3	1	0	0	0	0.50	3
9	BRRI DHAN 36	3	1	0	0	0	0.5	1
10	Richharia	3	1	1	1	0	4	3
11	Jyoti Prasad	3	1	0	0	0	0.5	1
12	Ghaiya-2	1	0	0	0	0	0.2	1
13	Khumal 11	1	0	0	0	0	1	1
14	Chaite2	1	0	0	0	0	0.1	1
15	DR 11	1	0	0	0	0	2	1
16	DR 1	1	0	0	1	0	0.1	1
17	DR 16	1	0	0	0	1	0	0
18	Parwanipur Masuli	1	Late	-	-	-1	-	-
19	Sugaha Local	1	0	0	0	-	-	-
20	DR 17	1	-	-	-	-	-	-

Late = Booting stage, † NBS, Narrow brown spot. ShR, Sheath rot. BLB, Bacterial leaf blight. GB, Gandhi bug.

**Figure 1. Meteorological data of boro rice season at RARS, Parwanipur 2002/03.**

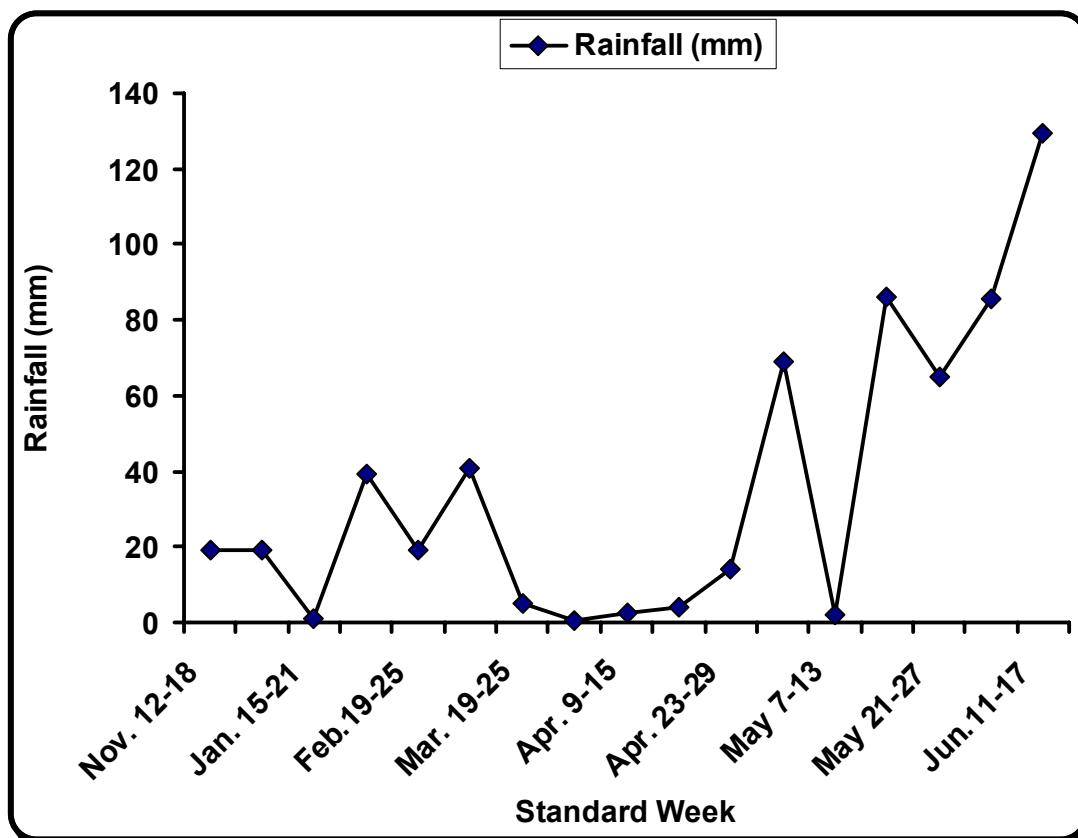


Figure 2. Growing season rain of boro rice at RARS, Parwanipur 2002/03.

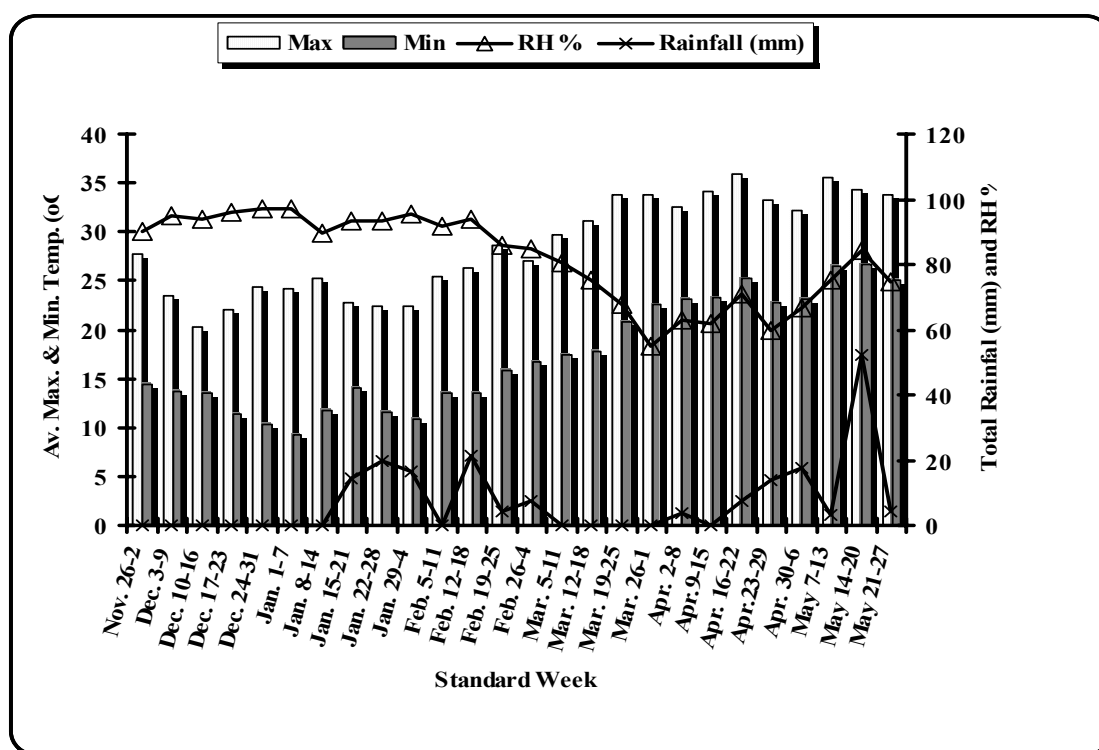


Figure 3. Meteorological data recorded at RARS, Parwanipur during boro rice season 2001/02.

CONCLUSSION

Based on three years data Gautam, BRRI DHAN 36 and Sugaha local is recommended for commercial cultivation as boro season rice.

ACKNOWLEDGEMENTS

We would like to give special thank to Dr. Peter Hobbs, CIMMYT, Nepal for giving idea to start work on boro rice eight year ago. Thanks are due to Mr. Scott Justice for keen interest and providing BRRI DHAN 36 boro rice variety from Bangladesh and for initiation of on farm verification and financial support from New Zealand ODA project. We fail to find words for expressing our profound sense of gratitude to Mr R Mishra, RARS Parwanipur for providing materials and giving valuable suggestions during the experimentation and (S Bistha for making availability of hill rice seeds??). Special thanks go to Dr R Thakur, Emeritus Scientist Rice ICAR, India, Dr JN Ray and UP Singh, BHU, UP India for making availability of five boro rice varieties. Thanks also go to Dr SB Mishra for making availability of hand out of collaborative training course on boro rice production technology. Thanks are due to Mr L Raut, Mr Muni Lal Sah, Mr Shivanandan Prasad Yadav, Nagina Ray and all the staff of RARS, Parwanipur for their dedication during the span of the crop. Special thanks are to HM Thakur and R Mandal for computer typing, analysis and graphics.

REFERENCES

- Chaudhary BN. 2002. Rice coordinator report. *Paper presented at the 26th summer crops workshop* 2-3 July, 2002. NARC, Khumaltar
- Gupta VP. 2000. Exploiting boro rice yield potential for increasing rice production. *State Level Collaborative Training Course on Boro Rice Production Technology*, March 27-31, 2000. Rajendra Agricultural University, Bihar Pusa (Samastipur) 848125.
- मिश्रा, एस बिं । २००० । बोरो धानमे. पौध प्रबन्ध ए.व शीत प्रतिरोधिता के लिए चुनाव । *State Level Collaborative Training Course on Boro Rice Production Technology*, 27-31 March 2000. Rajendra Agricultural University, Bihar Pusa (Samastipur) 848125.
- राय, जे एन । २००० । बोरो धान पर प्रत्यक्षण और उनका प्रसार । *State Level Collaborative Training Course On Boro Rice Production Technology*, 27-31 March 2000. Rajendra Agricultural University, Bihar Pusa (Samastipur) 848125.
- Singh, JRP. 2001. Scope of boro rice. *Paper presented during boro rice tour* of Nepalese scientists at Department of Plant Breeding, RAU, Pusa – 848125 on 11th October 2001.
- Thakur R. 2000. Recent advances in varietal improvement for boro season. *State Level Collaborative Training Course On Boro Rice Production Technology*, 27-31 March, 2000. Rajendra Agricultural University, Bihar Pusa (Samastipur) 848125.

Assessment of *Helminthosporium* Leaf Blight of Wheat under different Resource Conserving Technologies in Rice-Wheat System

Dhana B Gharti¹, Ganesh Sah² and JB Prasad¹

¹ Regional Agriculture Research Station, Parwanipur

² Agriculture Implement Research Centre, Ranighat, Birgunj

ABSTRACT

This study was undertaken in farmers' field of Belwa (Parsa) and Agriculture Implement Research Centre (AIRC), Ranighat during 2000/01 and 2001/02 with a view to assess the effect of various resource conserving technologies (RCTs) on *Helminthosporium* Leaf blight (HLB) of wheat in Rice-Wheat system under central terai of Nepal. HLB was scored on flag and flag leaf minus 1 leaf of 10 randomly selected tillers and expressed in percent diseased leaf area (% DLA). Two year mean HLB severity was least (22% DLA) in furrow irrigated raised bed (FIRB) seed drill followed by Chinese seed drill (CSD, 27.5% DLA). Zero Till Seed Drill (ZTD) had the highest HLB severity (39.3% DLA) followed by conventional wheat sowing (32.1% DLA). In another set of experiment at Belwa out reach research site during 2000/01 and 2001/02 Land preparation + CSD had the least HLB severity (14.55% DLA) followed by CSD alone (19.46%) compared to 40.78% DLA in Land preparation + ZTD. Comparison between FIRB and flat planting at AIRC revealed lower HLB severity (4.5% DLA) in FIRB than that of flat planting (7.75% DLA). Comparisons between flat, bed and farmers' practice of planting wheat in crop diversification experiment at Belwa ORR site did not show any clear cut effect of planting methods on HLB severity and also the interactions among HLB, grain yield and thousand grain weight were not significant under different planting methods. HLB severity under different wheat sowing methods is presented.

INTRODUCTION

HLB of wheat caused by *Bipolaris sorokiniana* (Sacc. in Sorok, *Helminthosporium sativum* Pamm, King and Bakke) and *Pyrenophora tritici-repentis* (died.) Drechs, has now become a number one biotic constraint in wheat production especially in Tarai and inner Tarai regions of Nepal. In recent years it is also gradually spreading toward hills. Most of the currently grown commercial wheat varieties in Nepal have inadequate resistance to HLB (Bhatta et al 1998). In the context of Nepal's efforts to enter into WTO agricultural mechanization might play a crucial role in minimizing cost of cultivation of various agricultural produce. On the other hand present era is an era of mechanization and Nepal also needs to keep pace with the global change in agricultural mechanization. In recent years different resource conserving technologies (RCTs) are being tried in farmers' fields of Nepal to ensure sustainable use of natural resources, minimize cost of production and optimize profit from wheat cultivation. Chinese seed drill is gaining popularity among the farmers in few terai districts notably Rupandehi, Nawalparasi, Bara, Parsa and Rautahat (AIRC 2002). Similarly, Zero Till Seed Drill (Pantnagar Seed Drill), Satpharwa (six discs animal drawn harrow) and surface/relay seeding are also emerging as viable wheat sowing methods under diverse agro-eco systems. Present paper deals with the consequences of using different seed drills for wheat sowing and different tillage and crop establishment methods on HLB of wheat.

MATERIALS AND METHODS

Foliar blight evaluation was undertaken in experiments entitled "Performance Evaluation of Different Seed Drills in Farmers' Field" and "Tillage and Crop Establishment Methods in Wheat" conducted by AIRC, Ranighat, Birganj at Belwa VDC of Parsa district during winter season of Fiscal Year 2000/2001 and 2001/2002. The first set of experiment consisted of five treatments viz. Chinese Seed Drill (CSD), Furrow Irrigated Raised Beds (FIRB), Zero-Till Seed Drill (ZTD), Animal Drawn Seed Drill (ADSD) and Traditional Wheat Sowing

(TWS) conducted at four farmers' field. Tillage and crop establishment experiment consisted of 5 treatments namely Chinese Seed Drill, Land Preparation+ CSD, Zero Till Seed Drill, Land Preparation + Zero Till Seed Drill and Land Preparation + Seed Broadcasting. Individual farmer was considered as one replication. Wheat variety used was Bhrikuti sown @ 120 kg/ha. Fertilizers were applied @ 100:60:40 N: P₂O₅: K₂O kg/ha. Land preparation for FIRB, ADSD and TWS was done with tractor + nine tine cultivator. In ZTD and FIRB treatments DAP was applied with drills while urea and muriate of potash were applied manually for basal application. For rest of the treatments all fertilizers were broadcasted manually. Disease scoring was also done in wheat planted in crop diversification experiment at Belwa and AIRC, Ranighat. The experiment consisted of flat planting, bed (FIRB) and farmers' practice (behind the plough). Two varieties Bhrikuti and Rohini were planted @ 150 kg/ha in four farmers' field. Fertilizers were applied @ 100:50:25 N: P₂O₅: K₂O kg/ha. Irrigations were given as per need. Disease scoring was done on flag (F) and flag minus 1 (F-1) leaves on the basis of percent diseased leaf area (DLA) at growth stage (GS) ranging between 73-77 during 2000/01 and 2001/02 on Zadoks' scale as modified by Tottman and Makepeace (1979). Ten plants were randomly selected diagonally in the test plots for disease appraisal.

RESULTS AND DISCUSSION

Mean HLB severity was the least (22.1% DLA) in FIRB seed drill planted wheat followed by CSD (27.6%) and ADSD (30.9%) in the experiment entitled "Performance Evaluation of Different Seed Drills in Farmers' Field" in a single terminal score toward growth stages 73-77 (Table 1, Figure 1). Least HLB severity in FIRB could be attributed to more air drainage and less humid environment in wheat phylloplane. Wheat grain yield was also the highest in this particular treatment. Two year mean disease severity was the highest in ZTD (39.3% DLA). Krupinsky et al (1998) observed higher leaf spot severity with no additional N and low N treatments under zero tillage than conventional tillage, but at the higher N treatments the differences in the leaf spot severity among tillage treatments was greatly reduced or eliminated.

Table 1. Grain and other traits in wheat sown with different seed drills at Belwa during 2000/2001 to 2001/2002

SN	Treatment	Grain yield, kg/ha	1000 grain weight, g	HLB, % DLA
1	Chinese Seed Drill (CSD)	3586.6	38.26	27.6
2	FIRB Seed Drill (FIRB)	3892.5	36.84	22.1
3	Zero Till Seed Drill (ZTD)	2860.7	37.48	39.3
4	Animal Drawn Seed Drill	3079.2	36.55	30.9
5	Traditional Wheat Sowing.	3646.9	35.96	32.2

Disease data are mean of 4 and 3 farmers' field during 2000/01 and 2001/02, respectively.

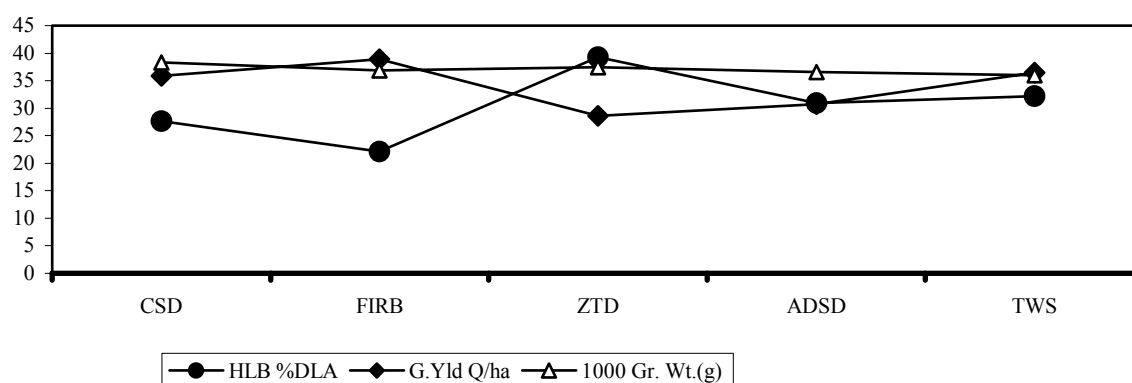


Figure 1. HLB (% DLA), grain yields quintal/ha and thousand-grain weight in wheat sown with different seed drills.

In the experiment entitled "Performance of Different Tillage and Crop Establishment Methods in Wheat" least HLB was found in Land preparation + CSD treatment (14.55%) followed by CSD (19.46%) and ZTD (21.58%). Two-year-mean grain yields were at par (Table 2). No definite interaction between grain yield and HLB severity could be established. Since HLB pathogen is very much sensitive to variations in crop management and other environmental conditions it is difficult to interpret the results in agronomical experiments and hence the results are inconsistent.

Table 2. Grain and other traits of wheat in different tillage and crop establishment at Belwa, 2000/01 to 001/02

SN	Treatment	Grain yield, kg/ha	1000 grain weight, g	HLB, % DLA
1	Chinese Seed Drill (CSD)	3522.77	40.76	19.46
2	Land preparation+ CSD	3248.24	40.96	14.55
3	Zero Till Seed Drill (ZTD)	3571.99	41.48	21.58
4	Land preparation + ZTD	3205.96	41.3	40.78
5	Land preparation + Seed broadcasting.	3323.27	42.15	23.75

Mean data of 3 farmers' field during 2002/01 and one farmer field in 2001/02.

Table 3. HLB severity in bed vs flat planting at AIRC, Ranighat

SN	Treatment	HLB, % DLA	Grain yield, kg/ha	1000-grain wt, g
1	Bed planting	4.5	3787.48	38.66
2	Flat planting	7.75	5283.02	39.88

Comparison between bed versus flat planting revealed higher HLB severity in flat than that in bed (Table 3). In crop diversification experiment at Belwa ORR site least HLB severity (13% DLA) in Bhrikuti was observed in bed planting compared to 21.5% DLA in Rohini. However, the difference among different planting methods was too little to consider in Bhrikuti. Flat planting had highest HLB in both varieties (Table 4). No definite correlation between HLB, yield and thousand-grain weight could be observed under different planting methods.

Table 4. Mean HLB severity, grain yield and thousand grain weight in crop diversification experiment at Belwa 2001/02

SN	Treatment	Bhrikuti			Rohini		
		HLB, %DLA	Grain yield, kg/ha	TGW, g	HLB, %DLA	Grain yield, kg/ha	TGW, g
1	Flat	16.5	4468.75	39.46	28	4500	42.81
2	Bed	13	4230.76	39.16	21.5	3397.11	41.45
3	Farmers' practice	14.5	4581.25	37.9	20.5	4125	38.95

CONCLUSION

Since no concrete conclusion could be drawn as to the effect of different RCTs on HLB severity except FIRB which is not cost effective in itself it might call for careful watch on micro-climatic conditions and overall crop management aspects for studying clear cut differences in HLB severity among different RCTs.

ACKNOWLEDGEMENTS

The authors express their sincere thanks to Mr R Mishra for his constant encouragement to initiate this work. Similarly they are grateful to Dr CB Karki, Dr E Duveiller, CIMMYT and Mr S Justice, CIMMYT for their constant support to carry out this study. Thanks are due to Mr D Chaudhary, S Chaudhary, A Mandal and A Sah for their full co-operation in the course of this study. Last but not the least sincere thanks go to Mr HM Thakur for preparation of this presentation.

REFERENCES

- AIRC. 2002. *Annual report 2001/2002*. Agricultural Implement Research Centre, Ranighat, Birgunj.
- Bhatta MR, DR Pokharel, RN Devkota, HJ Dubin, A Mudwari, HP Bimb, BR Thapa, BP Sah and D Bhandari. 1998. Breeding for resistance to *Helminthosporium* blights in Nepal: Strategies and genetic gains. **In:** *Helminthosporium blights of wheat: Spot blotch and tan spot* (E Duveiller, HJ Dubin, J Reeves and A MacNab, eds). Pp.188-195. Mexico, DF CIMMYT.
- Dubin HJ and HP Bimb. 1991. Effects of soil and foliar treatments on yield and disease of wheat in lowland Nepal. **In:** *Wheat for the non-traditional warm areas* (DA Saunders, ed). Mexico, DF CIMMYT.
- Krupinsky JM, AD Halvorson and AL Black. 1998. Leaf spot disease of wheat in a conservation tillage study. **In:** *Helminthosporium blights of wheat: Spot blotch and tan spot* (E Duveiller, HJ Dubin, J Reeves and A MacNab, eds). Pp.322-326. Mexico, DF CIMMYT.
- Shrestha KK, RD Timila, BN Mahato and HP Bimb. 1998. Disease incidence and yield loss due to foliar blight of wheat in Nepal. **In:** *Helminthosporium blights of wheat: Spot blotch and tan spot* (E Duveiller, HJ Dubin, J Reeves and A MacNab, eds). Pp.67-72. Mexico, DF CIMMYT.
- Stubbs RW, JM Prescott, EE Saari and HJ Dubin. 1986. *Cereal disease methodology manual*. CIMMYT, Mexico. 46pp.

Diversity and Population Dynamics of Soil Fungi in Resource Conserving Technology of Rice-Wheat System in Nepal

Sharala Sharma¹, E Duveiller², M Rutherford³, Ganesh Shah¹, D Sharma⁴ and Dhana B Gharti¹

¹ Nepal Agricultural Research Council, Kathmandu

² CIMMYT, South Asia, Kathmandu

³ CABI Bioscience, Egham, UK

⁴ IAAS, Rampur

ABSTRACT

In order to understand prevalence of soil fungi and their population in different tillage practice in rice- wheat system, soil sampling, isolation and identification of fungi was done during 2000-01 and 2001-02 rice season and 2001-02 and 2002-03 wheat season. Rice-wheat system covers 500,000 ha and produces five million tons of food in Nepal. Several researches on foliar disease in rice and wheat have been done but little attention has been paid to soil borne pathogen and fungi. Several researches on resource conservation tillage practice are becoming popular among farmers of central and western Terai but situation of soil fungi and pathogens in this condition has not been studied yet. So field monitoring was done in each two location of Rautahat and Bara and three location of Parsa district. Isolation and population count of soil fungi was done by dilution plate method in Dichloram- Rose Bengal –Chloramphenicol agar (DRBC) media and from plant, direct observation was done. Isolated fungi were identified using keys in National and Internal laboratories. The pathogenic fungi of rice of major importance were *Rhizoctonia solani* and *Bipolaris oryzae* occurring in high frequencies. The other fungi of minor importance were *Rhizoctonia oryzae* –sativae, *Nigrospora oryzae*, *Curvularia lunata* and *Curvularia pallescens*. The pathogenic fungi of wheat isolated from root were *Bipolaris sorokiniana* and *Sclerotium rolfsii*. From soil bio-control fungi isolated were *Trichoderma harzianum*, *Trichoderma koningii* and *Gliocladium roseum*. The fungi occurred most frequently in soil were *Myrothecium roridum*, *Thielavia terricola*, *Fusarium solani* and *Fusarium oxysporum*. In most of the locations population of fungi in conventional tillage was found higher than resource conserving tillage practice.

Key words: Conventional minimum, diseases, soil health

INTRODUCTION

Soil is a dynamic living resource whose condition is vital to both the production of food and fiber and to a global balance and ecosystem function. The fertility status of soil has great impact on the health of crops, animals and human being. A healthy soil contributes to high quality crops and livestock through its biological activity and remains productive over long period of time.

The soil contains living organism, mineral, organic matter water and air. Microorganism plays an important role in organic matter decomposition. The Microorganism responsible for organic matter decomposition is bacteria, yeast, fungi, algae and protozoa. Fungi are responsible for decomposition of many complex plant polymer in soil and compost. Certain fungi also contribute to soil health by its antagonistic activity to many harmful organisms. Some times soil health is deteriorated due to presence of poor organic content and micronutrient as well as depositions of pathogens. High level of soil borne pathogen are indicator of poor soil health (Pankhurst 1994). This is presumably because of the occurrence of threat of disease. The most commonly reported soil and seed borne pathogen are fungi although there are occasional bacteria and nematode. Level of pathogens in the soil may depend on cropping system, tillage, field sanitation and other various other agronomic practices. A cropping system affect both detrimental and beneficial organism in the rhizosphere, which in turn influence root health and crop yield. It has been noted that tillage practice also influence the disease in certain cases such as minimum tillage a useful conservation practice favors growth of *Rhizoctonia solani* in Australian soil (Pankhurst, 1994).

Some time cropping system imposed for longer than a year increased root disease. Monoculture also often increase root disease.

In Nepal rice- wheat system is practiced in on about half million ha in Tarai and mid hills and produce more than five million tons of food for country every year. It is most important cereal producing system in Nepal (Hobbs and Adhikari 1997). Earlier experiment done by Bimb and Dubin (1994) revealed decreased root necrosis and increase in yield in solarized plot at Bhairahwa experimental station indicating presence of soil borne pathogens in rice-wheat system. Potentially important soil related disease attacking wheat crop are common root rot caused by *Bipolaris sorokiniana* and Fusarium root rot (Saari 1998). There is strong association of leaf blight disease and rice wheat system and this could be due to increase of inoculum potential or a predisposition of the disease (Saari 1998). The frequency of occurrence of *Bipolaris sorokiniana* is very high in foliar blight complex as well as in root and is key pathogen (Bimb and Dubin 1994). Regarding rice crop sheath blight (*Rhizoctonia solani*), root/ rot and foot rot (*Fusarium moniliforme*) are important soil related disease. Foot rot is widespread and popular variety Khumal 4 recorded with high incidence in different parts of country including Kathmandu valley. New varieties and technologies have been released in rice as well as wheat but there is yield stagnation. New resource conserving tillage practice has been introduced and become popular but no information is available on soil micro-flora profile (pathogenic and nonpathogenic) in rice wheat particularly on those under zero/minimum and conventional tillage. Soil borne pathogen may affect rice and wheat through damage to seeds/ seedling root and lower leaf sheath. Low yield is recorded through reduction in emergence /stand density, plant vigor, water and nutrient assimilation, and tillering and photosynthetic area. New tillage is intended to conserve the natural resource base and reverse declining input productivity and yield stagnation in rice wheat cropping pattern. This present work focuses on monitoring soil micobiota and possible soil health constraints under these new practices.

MATERIALS AND METHODS

Farmers and site selection was done during mid August 2001 at Bara Parsa and Rautahat districts. Two farmers were selected one adopting conventional and other adopting zero/minimum tillage at each district. Four samplings were done, two during rice season at Sept, 2001 and 2002 and others during wheat season March 2002 and 2003. The village development committees selected were Belwa (Parsa district), Santapur (Rautahat district) and Benauli of (Bara district) and Ranighat (Parsa). Belwa VDC is 10 km north of Parwanipur. Santapur is a VDC of Rautahat and is 42 km south from Chandanighapur. Rice is the main summer crop and lentil and wheat are the major crops in winter season after rice. The third village selected is Benauli, approximately 20 km far from Birgunj.

For each field 10 samples were taken randomly along a diagonal transect. Incidence and severity of disease was taken in field condition by team of scientist of NARC, CABI and CIMMYT. Disease assessment in each plant was done after bringing the samples to laboratory using 0-5 scales. (Bridge et al 2000). Fungi in root, stem and leaves was isolated by placing pieces of plant part with lesions in water agar after cleaning in running tap water to remove dust and other materials. Pieces of plant parts were surface sterilized in solution of 1% NaOCl for 1 min and rinsed in sterile distilled water, and placed onto water agar. Samples were incubated utilizing available laboratory light at 22 to 26 and examined after four to six days for fungal growth using stereomicroscope. Different types of fungi were recorded in situ by conidial characteristics. Identification of several different fungi was not possible and they were preserved in PDA tubes for further identification in plant pathology laboratory and laboratory of CABI bioscience.

About one kg of soil sampled from ten places and was made composite sample. The media used were Malt extract, Malt extract- benomyl- malic acid agar, Dichloroan-Rose Bengal-chloramphenicol agar, Acidione-keratinbait-tap water and Tapwater agar hemp seed bait. After thorough mixing one gram of soil was taken from each bulk sample and made 10^{-1} , 10^{-2} and 10^{-3} dilution. The media were inoculated with 0.1ml of suspension using micropipette in two replicates and spreaded immediately using L shaped spreader. Growing colonies of fungi on each media were counted after two days and successive counting were done for 2-3 times. Then total fungal colony was counted for each dilution and each media and fungus population per gram of soil was calculated. Several typical different fungal colony of each media was re-cultured in PDA/Malt Agar. Identification to genus level was done at Plant Pathology Division and up to species level it was done at CABI, UK.

RESULTS AND DISCUSSION

Field observation in 2000-01 and 2001-02 year revealed sheath blight (*Rhizoctonia solani*) and brown leaf spot (*Bipolaris oryzae*) as the potentially important diseases of rice. Aggregate sheath spot (*Rhizoctonia oryzae-sativae*) was observed to be associated with sheath blight symptom on lower part. The symptom of the disease was noted on lower part of the leaf sheath at the water level. Occasionally the fungi do culms rot or infect the panicle rachis, resulting a sterile grain or partially filled heads (APS 1992). At Ranighat direct seeded rice had higher percentage of this disease than transplanted rice (Table 1). Hashiyoka and Makino (1969) reported occurrence of *Rhizoctonia oryzae* from sheath spots on rice. Sheath blight disease was found more at Benauli village where Sona mansuli variety was grown. The variety Kasturi and Sabitri exhibited low level of sheath blight disease. The incidence of brown leaf spot was medium at Belwa and one field of Benauli and the incidence was below economic thresh hold level. High frequency of occurrence of *Nigrospora oryzae* was observed in leaf of rice under sterio microscope placed on water agar media (Figure 1). The frequency of occurrence was high in all leaf collected from conventional tillage.

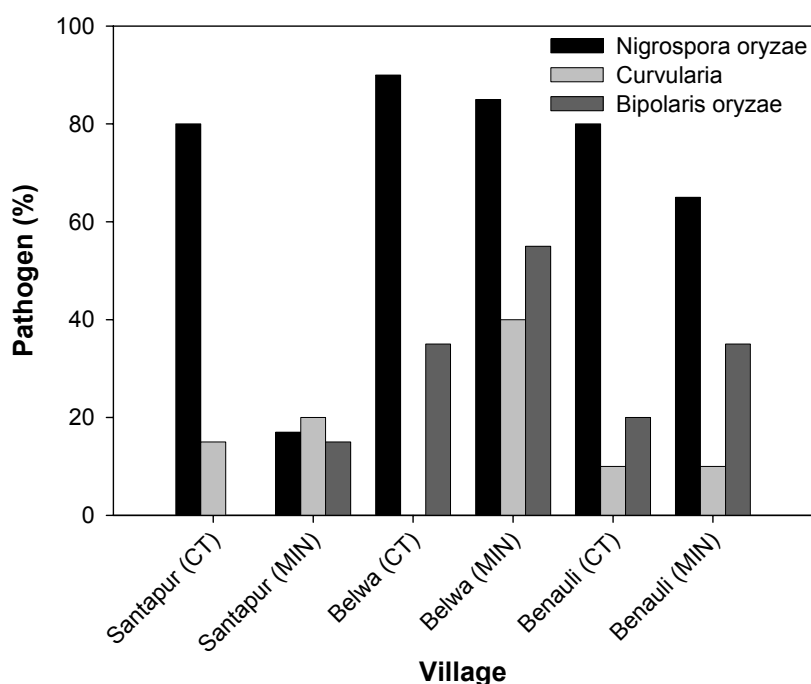


Figure 1. Occurrence of fungi recorded in situ on leaf of rice during 2001-02 rice season.

It is weak parasite and causes grain discoloration. Under special condition this fungus incite blight and brightening of ear. This fungus was recorded in the leaves of rice collected from Ranighat even though the leaf was very clean. The second important fungus was *Bipolaris oryzae*. It causes brown leaf spot of rice and is second most important disease of rice in Nepal next to blast (Manandhar 1987). In 2000-01 rice-growing season *Nakataea irregularae* was isolated from the stem of rice grown at Santapur and Benauli. This pathogen causes stem rot disease and was reported long back in early literature to cause heavy damage to rice crop (Ou 1985). In Nepal it was reported long back (Khadka et al 1968).

From rice root collected from Santapur, Belwa and Benauli, *Curvularia lunata* was isolated. However, other pathogenic fungus was not found prevalent in rice root. At Santapur it was found in conventional and minimum tillage while at Belwa it was prevalent in minimum tillage. This organism is one of the pathogen causing seedling blight disease of rice (Anonymous, 1992). Black mass of spore of this pathogen was found in grains of rice at Ranighat. From soil diverse fungi were isolated and identified. They were *Penicillium spinulosum*, *Aspergillus niger*, *Aspergillus niveus*, *Aspergillus terreus*, *Humicola fuscoatra*, *Thielavia terricola*. The fungi *Aspergillus niger*, *Aspergillus niveus* occurred in both year in rice cultivated soil however, the frequency of occurrence of *Aspergillus niger* was higher in rice (Table 2).

Table 1. Field observation of fungi in leaf and leaf sheath of rice plant during 2001-2002

Variety	Field	Tillage variety	Sheath blight <i>R. solani</i>		Aggregate sheath spot <i>R. oryzae-sativae</i>	Brown leaf spot		Narrow brown leaf spot		BLB	
			Inc	Sev	Inc	Inc	Sev	Inc	Sev	Inc	Sev
Sabitri	Santapur	CT	0	0	10	100	2	100	1	0	0
Sabitri	Santapur	SS (min)	0	0	10	100	1	50	1	0	0
Sona masuli	Belwa	CT	80	2	5	100	5	100	3	100	5
Kasturi	Belwa	CSD (min)	20	1	0	100	5	80	1	60	3
Sona	Benauli	CT	100	7	35	100	5	100	3	0	0
Sona	Benauli	SS(min)	90	6	50	100	3	50	1	0	0
	Ranighat	Bed TPR	0	0	0	TR	0	0	0	0	0
	Ranighat	Bed DSR	0	0	7	TR	0	0	0	0	0
	Ranighat	Flat TPR	0	0	0	TR	0	0	0	0	0
	Ranighat	Flat DSR	0	0	20	TR	0	0	0	0	0

CT= Conventional, CSD and SS= Minimum tillage. Bed TPR= Bed transplanted rice, Bed DSR= Bed direct seeded rice, Flat TPR= Flat transplanted rice, Flat DSR= Flat Direct seeded rice.

The frequency of occurrence of *Thielavia terricola* and *Aspergillus flavus*, *Myrothecium roridum* was also higher. *Myrothecium roridum* was found dominant in the soil of Benauli as revealed in plate observation. *Fusarium nygamai* was isolated in 2000-01 rice season from soil of Ranighat. Series of *Trichoderma* spp isolated from soil were *Trichoderma harzianum*, *Trichoderma pseudokoningii*, *Trichoderma koningii*, *Trichoderma longibrachiaetum*, *Trichoderma polysporum* (Table 2).

Table 2. Occurrence of different fungi isolated from soil of rice field during 2000-2001 and 2001-2002 rice season

Fungi	Origin	Origin									
		Santapur (Con)	Santapur (Min.)	Belwa (CSD)	Belwa (Con)	Benauli (Min.)	Benauli (Con)	Ranighat (BD)	Ranighat (BT)	Ranighat (FT)	Ranighat (FD)
<i>Aspergillus terreus</i>	Soil	1	1+			1+	1	1	+	1	1
<i>Aspergillus fumigatus</i>	Soil		1	1	1	+	1		+		
<i>Aspergillus niger</i>	Soil	1+	1	1+	1+	1+	1+	1	1+	1+	1
<i>Acromonium</i>	Soil			1	1+	+	1+		1+	+	1
<i>Trichoderma koningii</i>	Soil			1	1	1	1	1	1		
<i>Talaromyces flavus</i>	Soil		1	1	1						
<i>Chaetomium cf jodhpurens</i>	Soil			1	1	1	1				
<i>Thielavia terricola</i>	Soil		1+	1	1	1	1	1	1+	1	+
<i>Pycnidophora dispersa</i>	Soil		1	1	1	1	1		1		1
<i>Penicillium spinulosum</i>	Soil	1	1	1	1	1			1		1
<i>Penicillium aculeatum</i>	Soil			1	1	1	1		1		
<i>Aspergillus flavus</i>	Soil	1	1+	1	1	1+	1	1	1+	1	1
<i>Gliocladium roseum</i>	Soil			1				+	+		+
<i>Fusarium oxysporum</i>	Soil	+	+	1	1	+		+	+		1
<i>Fusarium pallidroseum</i>	Soil										
<i>Rhizopus macrospous rhizopodiformis</i>	Soil			1				1			1
<i>Gongronella butleri</i>	Soil		1	1	1	1					1
<i>Trichoderma harzianum</i>	Soil			1	1	1	1	1	1		
<i>Robillarda sessillis</i>	Soil			1		1					
<i>Aspergillus niveus</i>	Soil	1	1+	1	1	1	1+	1		1	1
<i>Myrothecium leucotrichum</i>	Soil	+	1+	1		1	1+				

Fungi	Origin	Santapur (Con)	Santapur (Min.)	Belwa (CSD)	Belwa (Con)	Benauli (Min.)	Benauli (Con)	Ranighat (BD)	Ranighat (BT)	Ranighat (FT)	Ranighat (FD)
<i>Myrothecium roridum</i>	Soil	1+		1	1	1	1	1+	1		1
<i>Acrophylophora fusispora</i>	Soil					1+	1			1	1
<i>Fusarium proliferatum</i>	Soil				1		1				
<i>Chaetomium indicum</i>	Soil			1							
<i>Alternaria longissima</i>	Soil							1			
<i>Trichocladium opacum</i>	Soil	+						1			1
<i>Phoma</i>	Soil	1	1	1	1	1	1	1	1	1	1
<i>Cochliobolus lunata</i>	Soil	1			+		+		1		
<i>Neocosmospora vasinfecta</i> var <i>vasinfecta</i>	Soil								1		1
<i>Microspaeopsis</i> sp	Soil								1		
<i>Cladosporium sphaerospermum</i>	Soil	1		1				1			
<i>Fusarium solani</i>	Soil				1		+				1
<i>Fusarium equeseti</i>	Soil					+					
<i>Humicola fuscoatra</i>	Soil										1
<i>Fusarium nygamai</i>	Soil										1
<i>Fusarium subglutinans</i>	Soil	+	+	+				+	+	+	+
<i>Pestalotia</i>	Soil		+								
<i>Acremonium</i>	Soil				+	+	+				
<i>Curvularia</i>	Soil						+				+
<i>Alternaria longissima</i>	Stem	1		1	1						
<i>Curvularia lunata</i> (<i>Cochliobolus lunata</i>)	Root	1+	+	+		+	+	+			
<i>Curvularia pallescens</i>	Stem	1		+				1			1
<i>Nigrospora oryzae</i> (<i>Khuskia oryzae</i>)	Stem	+		+	1	1+	1+	1	1+	+	+
<i>Nigrospora oryzae</i> (<i>Khuskia oryzae</i>)	Leaf	1+		1+	1+	+	1+	1	+	1+	+
<i>Bipolaris oryzae</i> (<i>Cochliobolus miyabeanus</i>)	Leaf	1	1+	1+	1+	1+	1+	1	1+	1	1+
<i>Alternaria longissima</i>	Leaf	1	1	1	1	1	1	1	1	1	1
<i>Nakataea irregularis</i>	Stem		1			1	1				
<i>Rhizoctonia solani</i>	Stem	1	1	1+	1+	1+	1+				
<i>Phoma setosae</i>	Stem	1	1		1						
<i>Penicillium spinulosum</i>	Root										
<i>Rhizoctonia oryzae-sativae</i>	Stem	+	1+	1	+	1+	+	+			+
<i>Helminthosporium tetramera</i> (<i>H. specifera</i>)						+					

1= present in first year, += present in second year.

In field condition, leaf blight caused by complex fungi (*Bipolaris sorokiniana*, *Cercospora* sp, *Drechslera tritici-repentis*, and *Alternaria* sp) was found most important disease of wheat crop.

Table 3. Field observation of different fungi of wheat during 2002-2003 wheat season

Variety	Location	Tillage/ variety	Leaf rust intensity	Leaf severity	Leaf blight flag leaf	Leaf blight whole plot	Loose smut	Root rot
Achuyut	Santapur	CT (Min in 2002)	1-2	Tr	10	35	0	Sclerotium rolfsii
Bhrikuti	Santapur	CT	1-2	Tr	82	87	0	
UP262	Belwa	CT	10	10MS	60	87	0	
BL	Belwa	CSD	0	0	2	51	Tr	
BL1724		(Min)						
NL 297	Benauli	CT	10	10MS	76	87	0	Nematode swelling Nematode swelling
Bhrikuti	Benauli	CSD	0	0	24	51	0	
Bhrikuti	Ranighat	Bed no mulching	0	0	5	83	0	
Bhrikuti	Ranighat	Bed mulching	0	0	5	75	0	
Bhrikuti	Ranighat	Flat no mulching	0	0	14	85	0	
Bhrikuti	Ranighat	Flat mulching	0	0	5	75	0	

CT= Conventional, CSD and SS= Minimum tillage.

The severity of the disease was found dependent on variety and BL 1724 had very low score in flag leaf and whole plant. In 2002-03 the percentage of occurrence of *Drechslera tritici-repentis* was found less than previous year. The frequency of occurrence of *Cercospora* spp. was found increased than last year in wheat. Regarding effect of tillage in leaf blight disease, flag leaf had low disease severity in bed planting method and mulching treatment (Table 3).

During 2002 wheat season monitoring of wheat crop *Fusarium subglutinans* was noted in root collected from most of the locations while *Bipolaris sorokiniana* was recorded only in conventional tillage of Benauli and Santapur (Sharma et al 2002). In 2002-03 wheat season incidence of *Bipolaris sorokiniana* in root was found increased than previous year and was isolated from all field with variation of percentage depending on location and varieties. It was found more in conventional tillage than minimum tillage (Figure 2). However it needs more study to confirm this finding. *Bipolaris sorokiniana* was recorded on the root pieces placed in water agar and PDA media while both *Fusarium* spp was observed on PDA media only (Table 4). Root health study at Ranighat in tillering and mid dough stage showed that root infected by *Bipolaris sorokiniana* was low in bed planting than flat planting. The pathogen *Bipolaris sorokiniana* was also isolated from soil of Santapur (Conventional tillage), Benauli (Minimum) and Ranighat (Bed no mulching). Bimb and Dubin (1994) recorded more *Bipolaris sorokiniana* in sub crown internode and *Fusarium* spp more in root. While root health monitoring in foothill and river basin area of Kavre and Sindhupalchok district revealed frequency of occurrence of *Fusarium* spp. was found higher than *Bipolaris sorokiniana* in root (PPD 2002).

Another soil borne pathogen *Sclerotium rolfsii* was isolated from root of Achyut variety at Santapur with trace percentage. This pathogen caused seedling rot in rice variety in other parts of Nepal but it was absent in surveyed area. The fungi isolated from soil in wheat field were *Fusarium heterosporum*, *Fusarium pallidoroseum*, *Gliocladium roseum*, *Trichoderma pseudokoningii*, *Trichoderma polysporum*. Biocontrol fungi *Trichoderma harzianum* had high frequencies of occurrence than other *Trichoderma* spp (Table 6).

Fungus observation in leaf situ revealed frequency of occurrence of *Bipolaris sorokiniana* was high. *Drechslera tritici repentis* had lower frequency of occurrence than last year however. Occurrence of *Cercospora* sp was found increased. In 2000-01 rice season and 2001-02 wheat season total fungal colony were higher in conventional tillage while in 2001-02 and 2002-03 they were higher only at Santapur in rice (Figure 3). In wheat Belwa and Benauli recorded higher population of fungi in conventional than minimum tillage (Figure 3) in both year. As the farmer of Santapur is changing tillage practice it is difficult to interpretate the effect of tillage in population dynamics.

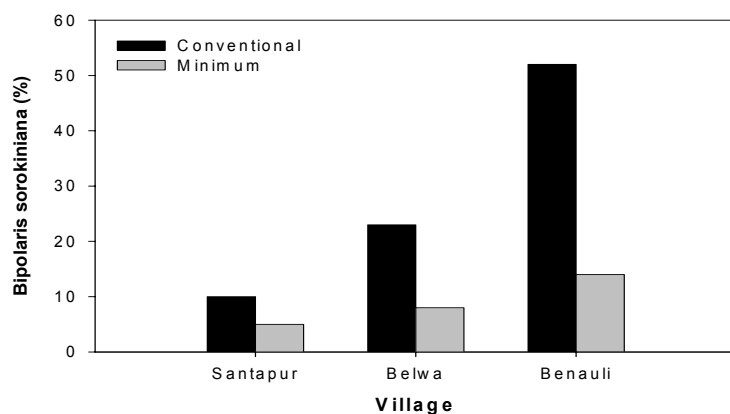


Figure 2. *Bipolaris sorokiniana* isolated from root in difference tillage system.

Table 4. Percentage of *Bipolaris sorokiniana* and *Fusarium* spp recorded in root of wheat in different tillage system

Table 4. Percentage of <i>Bipolaris sorokiniana</i> and <i>Fusarium</i> spp recorded in root of wheat in different tillage system						
	Field	Tillage	<i>B. sorokiniana</i> in situ on water agar	<i>Bipolaris</i> & <i>Fusarium</i> spp on PDA		
				<i>Bipolaris</i> spp	<i>Fusarium</i> spp.	% of total isolate
Achyut	Santapur	CT (Min in 2002)	10	83.3	16.7	100
Bhrikuti	Santapur	CT	5	62.5	37.5	100
BL 1724	Belwa	CSD (Min)	8	45.5	54.5	100
UP262	Belwa	CT	23	76.5	23.5	100
Bhrikuti	Benauli	CSD (Min)	14	20	80	100
NL297	Benauli	CT	52	57.1	42.9	100

Table 5. Occurrence of different fungi of wheat recorded in situ under sterio microscope, 2002/2003 wheat season

Field	Tillage	Variety	HS	HTR	Cercospora	Alt	EPI	HT
Santapur	CT (Min in 2002)	Achyut	100	10	60	50	15	0
Santapur	CT	Bhrikuti	100	15	55	65	20	0
Belwa	CSD (Min)	BL 1724	100	10	12	60	60	0
Belwa	CT	UP262	85	25	30	50	35	0
Benauli	CSD (Min)		95	10	25	25	15	0
		Bhrikuti						
Benauli	CT	NL297	100	0	45	45	10	0
Ranighat	Bed Mulching	Bhrikuti	100	10	70	55	0	0
Ranighat	Bed No mulching	Bhrikuti	100	25	25	85	15	5
Ranighat	Flat Mulch	Bhrikuti	100	10	10	90	15	0
Ranighat	Flat no mulching	Bhrikuti	100	30	10	60	20	0

CT= Conventional, CSD= Chinese Seed drill. HS *Bipolaris sorokiniana* HTR, *Drechslera tritici repentis*, Alt= *Alternaria*, Epi=*Epicoccum*, HT= *Helminthosporium tetramera*, Cer=*Cercospora*.

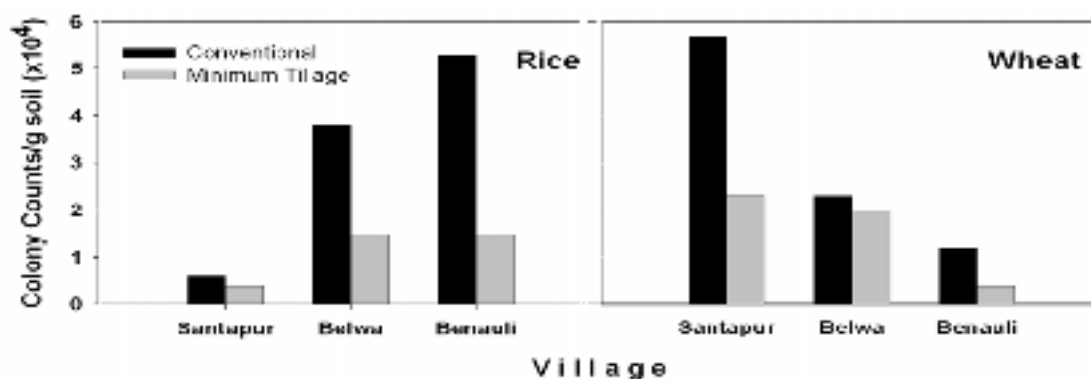


Figure 3. Fungal colony counts in soil of rice (Sept 2001) and wheat (March 2002).

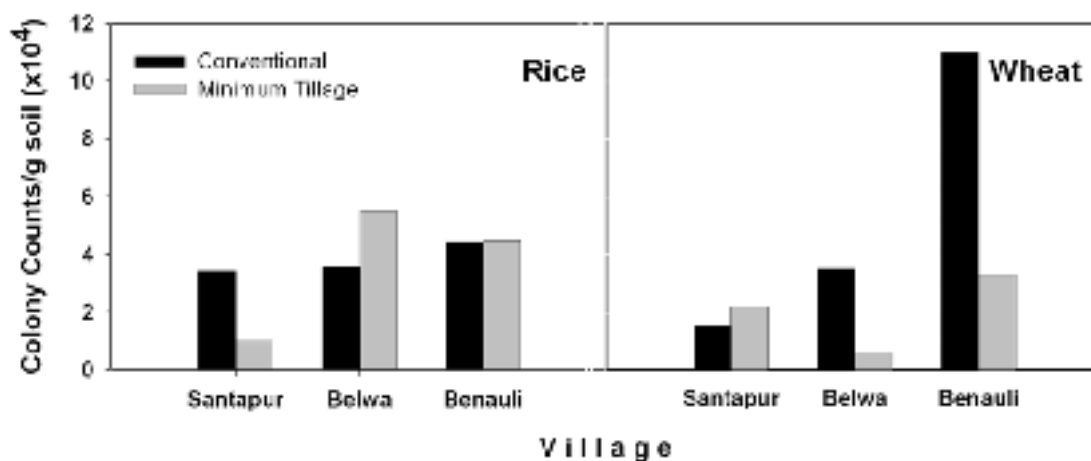


Figure 4. Fungal colony counts in soil of rice (Sept 2002) and wheat (March 2003).

Table 6. Occurrence of different fungi isolated from soil of wheat field, 2001-2002 and 2002-2003 wheat season

Fungi	Origin	Santapur (Con)	Santapur (Min.)	Belwa (CSD)	Belwa (Con)	Benauli (Min.)	Benauli (Con)	Ranighat (BD)	Ranighat (BT)	Ranighat (FT)	Ranighat (FD)
<i>Aspergillus flavus</i>	Soil	1	1		1	1	1		1	1	1
<i>Thielavia terricola</i>	Soil		1		1+	+	1		1+	1	
<i>Fusarium oxysporum</i>	Soil	1		1	1+	1+	1+				
<i>Trichoderma harzianum</i>	Soil			1	1	1	1	1		1	1
<i>Fusarium subglutinans</i>	Soil	1			1	1	1	1	1	1	
<i>Fusarium verticilloides</i>	Soil	1			1	1	1	1		1	1
<i>Trichoderma pseudokoningii</i>	Soil	1	1+	1	1	1	1			1	1
<i>Aspergillus niger</i>	Soil					1		1		1	1
<i>Aspergillus niveus</i>	Soil		1			1				1	
<i>Aspergillus terreus</i>	Soil		1		1					1	
<i>Fusarium solani</i>	Soil	1					1	1	1	1	1
<i>Fusarium equiseti</i>	Soil									1	
<i>Fusarium heterosporum</i>	Soil		1		1+	+	1+			1	
<i>Epicoccum nigrum</i>	Soil								1		
<i>Mucor amphibiorum</i>	Soil	1	1+		1			1+	1		
<i>Phoma</i>	Soil	1				1		1	1	1	1
<i>Gliocladium roseum</i>	Soil					1	+		1	1	1
<i>Myrothecium roridum</i>	Soil		+		+	1+	+			+	1
<i>Acrophlyophora fusispora</i>	Soil	1	+		+					1	1
<i>Trichoderma longibrachiatum</i>	Soil				1						
<i>Trichoderma polysporum</i>	Soil				+					1	
<i>Bipolaris sorokiniana</i>	Soil	+			+		+				
<i>Curvularia lunata</i>	Soil					+					
<i>Bipolaris sorokiniana</i>	Soil	+			+	+					
<i>Trichocladium opacum</i>	Soil		+				+				
<i>Fusarium subglutinans</i>	Root		1	1	1	1	1		1		1
<i>Alternaria longissima</i>	Stem	1									
<i>Fusarium pallidoroseum</i>	Stem		1+			1		1	1	1	1
<i>Alternaria</i>	Leaf	1+	1+	1+	1+	1+	1+		1		
<i>Drechslera tritici repentis</i>	Leaf	1+	1+	1+	1+	1	1+		1		
<i>Bipolaris sorokiniana</i>	Leaf	1+	1+	1+	1+	1+	1+		1		
<i>Bipolaris sorokiniana</i>	Root	+	+	+1	+1	1+	+		1		
<i>Stemphylium</i>	Leaf	1							1		
<i>Bipolaris sorokiniana</i>	Root	+	+	+1	+1	1+	+		1		

Fungi	Origin	Santapur (Con)	Santapur (Min.)	Belwa (CSD)	Belwa (Con)	Benauli (Min.)	Benauli (Con)	Ranighat (BD)	Ranighat (BT)	Ranighat (FT)	Ranighat (FD)
<i>Stemphylium</i>	Leaf	1							1		
<i>Helminthosporium tetramera</i>	Root			1							
<i>Acremonium</i>	Soil	1			1	1	1			1	
<i>Pestalotia</i>	Soil		1								
<i>Cercospora</i>	Leaf	1+	+	+	+	+	1+				
<i>Curvularia</i>	Stem							1			
<i>Epicoecium</i>	Leaf	1+	1+	1+	+	1+	1+	1			
<i>Fusarium subglutinans</i>	Root	1	1	1	1	1	1	1			1
<i>Fusarium equiseti</i>	Root			1						1	
<i>Fusarium oxysporum</i>	Root	1				1	1				
<i>Fusarium verticilloides</i>	Root					1				1	1
<i>Fusarium pallidoroseum</i>	Stem		1			1			1	1	1
<i>Alternaria longissima</i>	Root	1									

Direct Seeded = (BD). Bed Transplant = (BT). Flat Transplant = (FT). Flat Direct seeded = (FD).

It is very interesting to note that *Fusarium verticilloide* was found prevalent in wheat cultivated soil of Benauli (Conventioanl and Minimum), Belwa (conventional) and Santapur (Conventional)

CONCLUSION

Rhizoctonia solani was identified as potential fungi of rice. The other pathogenic fungi isolated were *Rhizoctonia oryzae –sativae*, *Bipolaris oryzae*, *Nigrospora oryzae* and *Curvularia lunata*. The effect of different tillage in occurrence of these fungi was not remarkable except *N. oryzae*, which occurred more in conventional tillage. More study is needed to verify this finding. In wheat crop the effect of minimum and conventional tillage did not exhibit any difference in disease severity, as the variety cultivated were different. At Ranighat Bed planting and mulching treatment had certainly shown low blight disease severity in flag leaf. Similarly *Bipolaris sorokiniana* incidence was also found low in root in bed planted wheat crop. This is only one-year observation and more monitoring is needed in future. The finding of this study suggests that resource-conserving technologies does not adversely affect soil biology. The results encourage the promotion of zero tillage and other resource conserving technologies in future. More study is needed in four to five years' continuous cultivation to get valid conclusion.

ACKNOWLEDGEMENT

We are grateful to Dr CB Karki, Plant Pathology Division for his help and encouragement in completing this work and paper. Dr SK Sherestha deserves thanks for his full support in initiating this research work. The authors are grateful to Dr J Bridge for his encouragement and support in this research work. Special thanks goes to Mr TK Lama for his help in continuing this soil health research work. We are highly thankful to Mrs S Joshi, Mrs G Gurung, Mrs RD Timila, Mr GP Parajuli, Dr BN Mahato, Dr CL Shrestha, Mr D Bhandari and S Bajracharya for their help in isolating soil fungi in the lab. Special thanks goes to Dr BR Khadge for his help in *Trichoderma* sp work. We are highly thankful to Dr SM Shrestha, and his team for their excellent work in determining population estimation of soil microflora. They are equally thankful to Dr G. Kinsey, Dr D Brayford, Dr P Kark, Dr J Laurence, CABI Bioscience for fungi identification and several other help. The work of Mr S Pradhan and Mr PN Dawadi is worth for appreciation for their help in computer work. Special thanks goes to Mr BM Maharjan and Mr M Khatri for their work in laboratory management.

REFERENCES

- APS. 1992. *Compendium of rice diseases*. APS, Press American Phytopathological Society.
- Bhatta MR, DR Pokharel, RN Devkota, HJ Dubin, A Mudwari, HP Bimb, BR Thapa, BP Singh and D Bhandari. 1998. Breeding for resistance to *Helminthosporium* in Nepal: strategies and genetic gains. In: *Helminthosporium blight of wheat: Spot blotch and tan spot*. Proceedings of an International Workshop, CIMMYT ElBatan, Mexico. CIMMYT/UCL/BADC PP 37-51.

- Bimb HP and HJ Dubin. 1994 . Studies of soil borne diseases and foliar blight of wheat at the National Wheat Research Experiment Station, Bhairahawa, Nepal. *Wheat special Report 36*. CIMMYT Wheat Programme.
- Bridge J, M Holderness, G Kinsey, RA Plowright, M Rutherford, SL Stone. 2000. *Technical protocols for crop disease assessment, plant and soil sampling isolation and Extraction of fungi and nematodes*.
- Hashioka Y and M Makino. 1969. Rhizoctonia group causing the rice sheath spot in the temperate and tropical regions, with special reference to pellicularia sasakii and *Rhizoctonia oryzae*. *Research Bulletin. Faculty of Agriculture*. Gifuken Prefectural University 28:51-63 .
- Hashioka Y and M Makino. 1969 Rhizoctonia group causing the rice sheath spot in the temperate and tropical regions, with special reference to pellicularia sasakii and *Rhizoctonia oryzae*. *Research Bulletin*. Faculty of Agriculture. Gifuken Prefectural University 28:51-63.
- Hobbs PR and BR Adhikari. 1997. The importance of Rice- wheat systems for food security in Nepal. **In:** *Proceedings of the Rice-Wheat Research End-of project Workshop*. NARC, CIMMYT, Rice wheat system research consortium.
- Khadka BB, SM Shah and K Lawat. 1968. Plant diseases in Nepal: A supplementary list. *FAO Plant Protection Technical Document No 66*.
- Manandhar HK. 1987. *Rice diseases in Nepal*. Plant Pathology Division, Department of Agriculture His Majesty's Government and AR and Production Project Win rock International/USAID.
- Maskey SL, RK Shrestha, B Shrestha, BP Tripathi, RC Munankarmi, YG Khadka, S Bhattarai and SP Shrestha. 2000. *Strategies for soil fertility research in hills of Nepal*. Soil Science Division, NARC Khumaltar, Nepal.
- Ou SH. 1985. *Rice diseases*. Common Wealth Mycological Institute (Ferry Lane, Kew, Surrey TW93A), UK Resilience and Sustainable Land Use. CAB International, Wellingford, UK. Pp.331-335.
- Pankhurst CE. 1994. Biological indicators of soil health and sustainable productivity. **In:** *Soil* (DJ Greenland and I Szabolcs, eds).
- PPD. 2001. *Annual report FY2056/57(1999/2000)*. Plant Pathology Division, Nepal. Agricultural Research Council Khumaltar Lalitpur Nepal.
- Saari EE. 1998. Leaf blight diseases and associated soil borne fungal pathogens of wheat in south and south East Asia. **In:** *Helminthosporium blight of wheat: Spot blotch and tan spot*. Proceedings of an International Workshop, Batan, Mexico. CIMMYT/UCL/BADC. Pp.37-51.
- Sharma S, E Duveiller, M Rutherford and DB Gharti. 2002. Soil health research at Parwanipur. *Paper presented at DFID End Workshop*, Out Reach Command Area 16-17 May 2002. Narayani Hotel (Proceedings under publication). 1

Guava Decline or Wilt Caused by *Fusarium oxysporium* fsp. *spidii* in Pokhara, Nepal

Tej K Lama

Plant Pathology Division, NARC, Khumaltar

ABSTRACT

Recent out break of guava decline or wilt after citrus decline in Pokhara valley is thought to be most destructive disease which killed thousands of guava plants in the orchards. The causal organism of guava decline or wilt was identified as soil pathogen *Fusarium oxysporium* fsp. *spidii*. This disease killed thousands of bearing guava trees in the orchards in the Pokhara valley.

Key words: Guava, soil pathogen, wilt

INTRODUCTION

The guava plants are introduced in Pokhara valley immediately after citrus trees decline in the valley. Earlier there is no mass plantation of guava plants in the Pokhara valley. Few trees are kept by growers in their home garden. The Pokhara valley has sub-tropical climate with a dry winter and hot humid summer. Maximum and minimum temperature in summer went up to 37-38°C during May and June. The minimum temperature went down up to 4°C in January. The average rainfall is 3835 mm, with the highest height in July (1705 mm). The valley as a whole frequently gets hail stone damage from February – March and occasionally in September-October. The soil of this valley is sandy loam with a pH 4.9-6.3. The soil is well drained and thought to be a cause of large loss of soil nutrients through surface run-off and leaching. The Horticulture Research Station was established in 1961 with a noble view to develop horticulture crops in hills especially citrus in mid-hills. It was situated at Malepatan of Pokhara Sub-municipality of Kaski district at an altitude of 850 m, 200 km west of Kathmandu the capital of Nepal and 212 km north of Sunouli Southern boarder of kingdom of Nepal.

MATERIALS AND METHODS

A wide spread of citrus decline was observed in Pokhara valley and its vicinities around mid sixties which killed million of citrus trees in the country, particularly in Pokhara valley. The causal organism of citrus decline was caused by citrus decline, citrus greening disease, a vector borne pathogen. Then immediately authorities of the and then Horticulture Department and Ministry of Agriculture thought in place of citrus to introduce good varieties of guava from India (UP). So that growers gets at least alternative fruit crop to see their further performance in the valley. In the beginning all the varieties were well in Pokhara Research Station and around it. Later on the guava trees were began to decline with wilt symptoms in the orchards.

The pathologist based in Horticulture Research Station began to investigate the problems of wilting of guava trees in the Research Station. The preliminary finding indicated that pathogenic fungus *Fusarium* sp was the primary cause of guava tree decline in Pokhara valley. Good varieties of guava were introduced ie, Allahbad, Safeda, Lucknow-49, Red flesh, Chitidar, Apple guava and seedless. But there was no any cultivar seemed to be tolerance or resistance against decline pathogen.

RESULTS AND DISCUSSION

The guava trees decline or wilt was observed in Horticulture Research Station, Pokhara in 1993-94. By the end of 1994, the causal organism of wilt was *Fusarium oxysporium* f.sp. *spidii*, a soil inhabiting fungus pathogens which was seemed very destructive. By the year of 1995-96, whole plantation of guava trees were completely declined due to these pathogenic fungi. In the first year of observation only slight symptoms of wilt was observed in the orchards. In the next year out of whole plantation 40.4% trees were declined. In the third year the disease severity was gone up to 66.0%, by the end of forth year observation the rate of decline or wilting was reached 100%. No single tree was observed healthy in the orchards. Whole plantation of guava expressed severe wilting symptoms, followed by drying of trees in the orchards.

Table 1. Guava declined or wilt in ARS, Pokhara (1993-1997)

SN	Site	Total plant	2051-52 (1994-95)				Total plant	2052-53 (1995-96)				Total plant	2053-54 (1996-97)			
			H	P	D	%		H	P	D	%		H	P	D	%
1	Main office	450.0	268	74	108	40.4	450	150	118	182	66.6	400	0.0	50	400	100
2	Citrus block	380.0	260	45	75	31.5	380	150	120	110	60.5	380	0.0	59	321	100
3	Jamir khor block	150.0	75	50	25	50.0	150	22	52	75	84.6	150	0.0	40	111	100
4	Jumari bot block	200.0	50	60	90	75.0	200	25	55	120	70.25	200	0.0	30	170	100
5	Pani Tanki Jumaribot	90.0	15	50	35	83.3	90	7	40	43	92.22	90	0.0	19	71	100
		1270				56					75.83					100

H, Healthy. P, Partial decline. D, Decline in orchard.

The guava plants introduction was done in Pokhara valley. But with the outbreaks of guava decline or wilt problems, whole plantation of guava were ultimately declined in the orchards within 3-4 years.

Identification of Suitable Approaches for Controlling Blue Mould Disease in Cellar Store

Kalika P Upadhyay, Khadga B Paudel, Ishwori P Gautam, Deep N Sah, Jeet N Chaudhary and Bhogendra Khatri

RARS, Lumle, Kaski

ABSTRACT

An experiment was conducted at the Regional Agricultural Research Station, Lumle during 2001/2002 to find out the effectiveness of fruit stalk, yellowness and chemicals for controlling blue mould disease in mandarin orange in cellar store. This experiment was conducted in a three-factor RCBD with three replications. Twenty treatments were set with 20 fruits for each treatment. Observations were recorded on the number of healthy fruits at different intervals (30, 40, 60, 70, 100 and 120 days after storage). Fruits infected with blue mould were avoided after the disease occurrence. Fruits were kept in the cellar store for 120 days. After 120 days, total juice, equatorial and polar diameters, the TSS and TA %, were recorded. The application of acetic acid fumigation @ 2.5µl/litre of water on the stalked fruits with 50% yellow color was found better for controlling blue mould in cellar store. Similarly, the by dipping the fruits for ten minutes in garlic extract (1% solution) was also found effective in controlling the blue mould for long term storage (120 days).

INTRODUCTION

Mandarin orange (*Citrus reticulata*) is the most important and highly commercialized fruit crop in Nepal. The area under citrus in Nepal is 18,009 ha with 1,06,118 fruit bearing tree and production of 107,451 mt. Mandarin contributes 58.35% of total citrus production in Nepal and it is followed by sweet orange (20.86%). Mandarin is a priority cash generating commodity for the mid hill farmers (APP 1995). The area under this crop is increasing in the RCA of the RARS, Lumle that is mainly due to the good cash income from mandarin cultivation (Subedi et al 1994).

Mandarins are harvested from late Kartik (mid November) to mid Paush (January) and are sold from Rs0.75 to 1.00 per fruit. Many farmers sell the fruits while they are on the tree. Some mandarin growers retain fruits on tree for a long period (Falgun-Chaitra) to get a higher price. This practice affects the fruit bearing capacity of the tree in the following year. It has been noted that the price of the fruit increases by 300-350% at 100 days after harvest (Year round price record of whole sale market, Pokhara 2001). During the harvesting season, there is a glut in the market leading to low rates. Where as, during lean periods there will be shortage in mandarin supply, consequently the price goes up. This situation can only be avoided by the phased selling of the produce (Rajput and Haribabu 1990). This is possible when there is an aid of appropriate storage facility. The hill farmers are compelled to sell their produces at the time of harvest at very low price because of unavailability of proper storage techniques. There is a need of a sustainable low cost storage technique for citrus grower's environment to prolong the shelf life of the fruits so that the income of the growers could be increased by selling the mandarin fruits during the lean period.

The main cause of loss of mandarin orange in the cellar store was due to fruit rot caused by blue mould (*Penicillium italicum*). Low temperature and high humidity are the prime factors that must be maintained while storing the fruits. Low temperature (4-5 °C), high humidity (>80%), wax coating, use of plant hormones and fungicides have been found effective in many post harvest experiments (Rajput and Haribabu 1990). The identification of suitable storage approaches for Nepalese context are required to prolong the shelf life of mandarin orange. There is still a need of better storage methods and treatments suitable for a longer shelf life with less loss of the mandarin fruits. If it will be, the Nepalese market will be regularly supplied with Nepalese oranges for long periods of the RARS and the large amount of Nepalese currency will be retained in the nation

instead of flooding outside the country particularly in India. Therefore, this experiment was conducted to identify suitable approaches for controlling blue mould in cellar store

MATERIALS AND METHODS

Experiment was conducted in a randomized complete block design with three factors in a simple cellar store at the RARS, Lumle. Twenty treatment combinations were tested and twenty fruits for each treatment were arranged on the shelves in a single layer. The following are the details of factors and their treatment combinations.

Factor A: Stalk on fruit: A₁: Fruits with stalk, A₂: Fruits without stalk

Factor B: Yellowness on fruit: B₁: Fruits with 50% yellow color, B₂: Fruits with 100% yellow color

Factor C: Chemical treatments

C₁: Fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water

C₂: Fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6% paraffin wax for half an hour.

C₃: Fruit surface treatment with sodium hypochloride @ 0.5 %.

C₄: Fruit surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes.

C₅: No fruit surface treatment

Treatment combinations

1. Fruit with stalk + 50 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water
2. Fruit with stalk + 50 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6 % paraffin wax for half an hour.
3. Fruit with stalk + 100 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water.
4. Fruit with stalk + 100 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6 % paraffin wax for half an hour.
5. Fruit without stalk + 50 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water.
6. Fruit without stalk + 50 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6 % paraffin wax for half an hour.
7. Fruit without stalk + 100 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water.
8. Fruit without stalk + 100 % yellow fruit + fruit surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6 % paraffin wax for half an hour.
9. Fruit with stalk + 50 % yellow fruit + fruit surface treatment with sodium @ 0.5 %.
10. Fruit with stalk + 100 % yellow fruit + fruit surface treatment with sodium hypochloride @ 0.5 %.
11. Fruit without stalk + 50 % yellow fruit + fruit surface treatment with sodium hypochloride @ 0.5 %.
12. Fruit without stalk + 100 % yellow fruit + fruit surface treatment with sodium hypochloride @ 0.5 %.
13. Fruit with stalk + 50 % yellow fruit + fruit surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes.
14. Fruit with stalk + 100 % yellow fruit + fruit surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes.
15. Fruit without stalk + 50 % yellow fruit + fruit surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes.
16. Fruit without stalk + 100 % yellow fruit + fruit surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes.
17. Fruit with stalk + 50 % yellow fruit + no fruit surface treatment.
18. Fruit with stalk + 100 % yellow fruit + no fruit surface treatment.
19. Fruit without stalk + 50 % yellow fruit + no fruit surface treatment.
20. Fruit without stalk + 100 % yellow fruit + no fruit surface treatment.

A cellar store constructed in the terrace riser at Lumle was used for the experiment. The store was having double-wall system in which the inner and outer walls were of stones joined with clay soil. The thickness of inner wall was 30 cm and outer wall was 45 cm. The sand layer between the walls was of 5 cm. Ventilators were provided by fixing the fine wire mesh to exclude rats and insects. Bamboo shelves were constructed inside the cellar. The distance between the shelves was 30 cm. There were 60 shelves for 20 treatments in 3 replications. The cellar store had a rodent proof door. A perforated polythene pipe was inserted to the sand layer for water supply to the sand. Water was supplied through the perforated polythene pipe to the sand layer in the wall. The water seepage from the sand layer wets the entire wall of the cellar. Due to the airflow in the store, water droplets on the wall are evaporated and the vapor is expelled through ventilation. The water droplets also absorb the heat energy created by air motion in the wall. Water droplets maintain a cool environment in the cellar store so that the temperature falls down than that of outside ambient temperature. Vaporization of water is the process

of increasing humidity in the store where the vapor pressure deficit between the surrounding environment and the surface of the fruit is minimized. This process is very important to minimize the transpiration loss from the fruit and prolong the fruit quality for a long time. The door was opened over night and water was supplied as per need on the roof in the morning to maintain temperature and humidity.

Records were taken on the number of healthy fruits on 30,40, 60, 70, 100 and 120 days after storage. The fruits were stored in 3rd week of November and kept for 120 days. The diameters, total juice, TSS and TA, were recorded before and after storage. The diameters were recorded by the use of a vernier caliper. The TSS was recorded with the use of a hand refractometer. Juice of mandarin fruits was analyzed in the lab to find the total titratable acidity percentage. The juice of the mandarin fruits was extracted and weighed in gram on an electronic balance. The organoleptic taste was carried out by the team of 11 members, including senior scientists and technicians of the RARS, Lumle. The sourness, juice content, marketability and overall performance were rated from 1-3 scale, ie 1-low, 2- medium and 3- high. Sweetness was rated from 1-3 scale ie 1-sweet, 2- medium and 3- poor. The fruits kept in the cellar store were compared with Indian mandarin fruit and rated from 1-2 scale ie 1 is inferior and 2 is superior. Daily temperatures in the store were recorded and water was supplied as required to maintain temperature and humidity.

RESULTS

Effect of treatments on recovery percentage of mandarin fruits at 30 days after storage

The results of the experiment revealed that there was no effect of treatments on the number of healthy fruits at 30 days after storage. However, the highest recovery of healthy fruits was found in T-17 (98.5%) ie 50% yellow fruits with stalk and not treated with chemicals (Table 1).

Effect of treatments on recovery percentage of mandarin fruits at 40 days after storage

There was a significant effect of chemicals and stalk level at 40 days after storage. Both chemicals and fruits with stalk were found effective for prolonging the shelf-life of the fruits up to 40 days and thereafter. The yellowness and interactions of the stalk, yellowness and chemicals to each other were found non-significant.

Table 1. Effect of treatments on number of healthy mandarin fruits in cellar store at the RARS, Lumle, 2001/02

Treatment Factor	Acid fumigation	Acid fumigation+ dip in parafin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV, %	P value	LSD
30 days after storage									
Stalk + 50% yellow	19.3 (96.5)	18.3 (91.5)	17.3 (86.5)	18.7 (93.5)	19.7(98.5)	18.66(93.3)		Stalk ^{Ns}	
Stalk +100% yellow	17.3 (86.5)	17.7 (88.5)	15 (75)	19 (95)	17.3 (86.5)	17.5 (86.5)		Yellowness ^{Ns}	
No stalk +50 %yellow	17.3 (86.5)	16.7 (83.5)	17.3 (86.5)	17.7 (88.5)	16.7 (83.5)	17.1 (85.5)	8.55	Chemical ^{Ns}	
No stalk+100 %yellow	15 (75)	14.3 (71.5)	16.3 (81.5)	15.3 (76.5)	16.7 (83.5)	15.5 (77.5)		Interactions ^{Ns}	
Mean	17.2 (86.1)	16.7 (83.5)	16.5 (82.5)	17.7 (88.5)	16.6 (88)				
40 days after storage									
Stalk + 50% yellow	19.3 (96.5)	18 (90)	17 (85)	18.7 (93)	19.7 (98.5)	18.5 (91.5)		Stalk *	1.881
Stalk +100% yellow	17.3 (86.5)	17.3 (86.5)	14.7 (73.5)	19 (95)	17.3 (86.5)	17.1 (85.5)		Yellowness ^{Ns}	
No stalk +50 %yellow	17 (85)	16.7 (83.5)	16.7 (83.5)	17.7 (88.5)	15.3 (76.5)	16.7 (83.5)	8.84	Chemical *	1.238
No stalk+100 %yellow	15 (75)	14 (70)	15.7 (78.5)	15 (75)	15.7 (78.5)	15.1 (75.5)		Interactions ^{Ns}	
Mean	17.2 (86)	16.5 (82.5)	16.0 (80)	17.6 (88)	17 (85)				
60 days after storage									
Stalk + 50% yellow	19 (95)	17.7 (88.5)	16.7 (83.5)	17.7 (88.5)	19.7 (98.5)	18.2 (91)	9.29	Stalk *	1.797
Stalk +100% yellow	17 (85)	16.7 (83.5)	13.7 (68.5)	18.3 (91.5)	16.7 (83.5)	16.5 (82.5)		Yellowness ^{Ns}	
No stalk +50 %yellow	15.3 (76.5)	15 (75)	15.7 (78.5)	16.7 (83.5)	15 (75)	15.6 (78)		Chemical *	1.243
No stalk+100 %yellow	14.3 (71.5)	13 (65)	14 (70)	14 (70)	15 (75)	14.1 (70.5)		Interactions ^{Ns}	

Treatment Factor	Acid fumigation	Acid fumigation+ dip in paraffin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV, %	P value	LSD
Mean	16.4 (82)	15.6 (78)	15.0 (75)	16.7 (83.5)	16.6 (83)				
70 days after storage									
Stalk + 50% yellow	19 (95)	17 (85)	16.7 (83.5)	17.7 (88.5)	19.3 (96.5)	17.9 (89.5)		Stalk *	2.142
Stalk +100% yellow	17 (85)	16.3 (81.5)	13.7 (68.5)	17.7 (88.5)	16.7 (83.5)	16.3 (81.5)		Yellowness ^{Ns}	
No stalk +50 %yellow	15.3 (76.5)	14.3 (71.5)	15.7 (78.5)	16.7 (83.5)	14.7 (73.5)	15.3 (76.5)	9.41	Chemical *	1.239
No stalk+100 %yellow	14.3 (71.5)	12.7 (63.5)	13.7 (68.5)	14 (70)	14.3 (71.5)	13.8 (69)		Interactions ^{Ns}	
Mean	16.4 (82)	15.1 (75.5)	14.9 (74.5)	16.5 (82.5)	16.3 (81.5)				
100 days after storage									
Stalk + 50% yellow	18.7 (93.5)	16.2 (81)	16.7 (83.5)	17.7 (88.5)	18.6 (93.0)	17.6 (88)		Stalk **	0.872
Stalk +100% yellow	16.7 (83.5)	15.7 (78.5)	12.7 (63.5)	17.3 (86.5)	15.7 (78.5)	15.6 (78)		Yellowness *	1.363
No stalk +50 %yellow	15 (75.0)	13.7 (68.5)	15 (75.0)	17 (85.0)	14.3 (71.5)	15 (75)	10.69	Chemical *	1.355
No stalk+100 %yellow	13 (65.0)	12.7 (63.5)	12.3 (61.5)	13.3 (66.5)	12 (60)	12.7 (63.5)		Interaction ^{Ns}	
Mean	15.8 (79.2)	14.6 (73)	14.2 (70.8)	16.3 (81.5)	15.1 (75.7)				
120 days after storage									
Stalk + 50% yellow	18.7 (93.5)	15.7 (78.5)	16 (80.0)	17 (85.0)	18.3 (91.5)	17.1 (85.5)		Stalk **	1.291
Stalk +100% yellow	16.3 (81.5)	15.3 (76.5)	12.3 (61.5)	17.3 (86.5)	15.7 (78.5)	15.4 (77)		Yellowness **	0.745
No stalk +50 %yellow	14.7 (73.5)	13 (65.0)	15 (75)	16.7 (83.5)	13.7 (68.5)	14.6 (73)	11.42	Chemical **	1.174
No stalk+100 %yellow	12.3 (61.5)	11.7 (58.5)	11.7 (58.5)	13 (65.0)	11 (55.0)	11.9 (59.5)		Interaction ^{Ns}	
Mean	15.5 (77.5)	13.9 (69.5)	13.7 (68.5)	16 (80)	14.7 (73.5))				

Number of healthy fruits is out of the bracket and recovery % is in the bracket.

Effect of treatments on recovery percentage of mandarin fruits at 60 days after storage

The results at 60 days interval were some how similar to the results at 40 days. The highest recovery percent (98.5%) on healthy fruits was found in T17 ie 50% yellow fruits with stalk and not treated with chemicals. The lowest recovery percent (65%) was found in T8 ie fruit without stalk + 100% yellow fruit + surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6% paraffin wax for half an hour.

Effect of treatments on recovery percentage of mandarin fruits at 70 days after storage

At 70 days, the result showed that there was a significant effect of stalk and chemical on the mandarin fruits for prolonging their shelf life. The yellowness and interactions of the factors were found having non-significant effect. However, the highest recovery percent (96.5%) on healthy fruits was found in T17 ie 50% yellow fruits with stalk and not treated with chemicals. The lowest recovery percent (63.5%) was found in T8 ie fruit without stalk + 100% yellow fruit + surface treatment of acetic acid fumigation @ 2.5µl/litre of water and dipping in 6% paraffin wax for half an hour.

Effect of treatments on recovery percentage of mandarin fruits at 100 days after storage

At 100 days after storage, the effect of stalk, yellowness and chemical treatment was found significant on the recovery percentage of the fruits. The highest recovery percentage (93.5%) was found in T1 ie fruit with stalk + 50% yellow fruit + surface treatment of acetic acid fumigation @ 2.5µl/litre of water followed by T17 (90%) ie stalked fruits with 50% yellowness without surface treatment and T13 (88.5%) ie Fruit with stalk + 50% yellow fruit + Surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes. The lowest recovery percentage (60%) was observed in T20 ie fruit without stalk + 100 % yellow fruit + no surface treatment.

Effect of treatments on recovery percentage of mandarin fruits at 120 days after storage

At 120 days after storage, the individual effect of yellowness, stalk and chemicals was found highly significant on the recovery % of the fruits. The highest recovery percentage (93.5%) was found in T1 ie fruit with stalk +

50% yellow fruit + Surface treatment of acetic acid fumigation @ 2.5µl/litre of water. The lowest recovery percentage (55%) was recorded in T20 ie fruit without stalk + 100% yellow fruit + no surface treatment.

Table 2. Effect of treatments on equatorial diameter at 120 days after storage

Treatment Factor	Acid fumigation	Acid fumigation+ dip in paraffin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV, %	P value	LSD
Stalk + 50% yellow	60.11	61.28	62.71	60.63	61.52	61.25		Stalk *	1.306
Stalk +100% yellow	57.37	59.00	57.55	55.55	58.71	57.63		Yellowness **	1.306
No stalk +50 %yellow	60.27	58.59	58.09	58.63	57.48	58.61	4.3	Chemical ^{Ns}	
No stalk+100 %yellow	59.00	54.61	58.74	58.91	55.26	57.30		Interactions NS	
Mean	59.18	58.37	59.27	58.43	58.24				

The results showed that there was a significant effect of stalk and highly significant effect of yellowness on equatorial diameter of mandarin fruits in cellar store (Table 2). Chemicals and their interactions with other factors were non-significant. The largest fruit size (62.71 mm) was recorded on T9 ie stalked fruits with 50% yellowness treated with 0.5% sodium hypochlorite solution which was at par with T 17 (61.52 mm) stalked fruits with 50% yellowness and no chemical treatment.

Table 3. Effect of treatments on polar diameter at 120 days after storage

Treatment Factor	Acid fumigation	Acid fumigation+ dip in parafin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV, %	P value	LSD
Stalk + 50% yellow	53.79	53.08	56.00	53.62	53.11	53.92		Stalk*	1.602
Stalk +100% yellow	51.18	51.08	51.05	49.01	53.05	51.07		Yellowness **	1.602
No stalk +50 %yellow	51.85	50.65	51.19	52.68	51.77	51.62	4.3		
No stalk+100 %yellow	51.57	45.63	49.74	51.82	51.75	50.10		Interaction NS	
Mean	52.09	50.11	51.99	51.78	52.41				

There was a significant effect of stalk and yellowness on the polar diameter. The highest polar diameter (56 mm) was measured in T9 ie 50% yellow fruits with stalk and treated with 0.5% sodium hypochlorite solution. The smallest figure was observed in T14 (49.01 mm) ie 100% yellow fruits with stalk and surface treatment with garlic extract @ 1% solution by dipping fruits for 10 minutes.

Table 4. Effect of treatments on total soluble solid (TSS °B) at 120 days after storage

Treatment Factor	Acid fumigation	Acid fumigation+ dip in parafin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV, %	P value	LSD
Stalk + 50% yellow	11.48	10.73	11.81	11.67	10.92	11.32		Yellowness*	0.339
Stalk +100% yellow	10.81	11.94	12.21	11.25	12.06	11.65		YellownessxChemical **	0.758
No stalk +50 % yellow	10.36	12.01	10.56	12.09	10.82	11.16	5.7	StxYexChemical **	1.072
No stalk+100 % yellow	12.37	11.24	11.26	11.26	12.65	11.75		Interaction ^{Ns}	
Mean	11.25	11.48	11.21	11.56	11.61				

Results revealed that the yellowness, interaction between yellowness and chemical and stalk, yellowness and chemical were significant on the total soluble solid content in the mandarin fruits. There was a significant difference on TSS due to the effect of yellowness and it was highly significant due to the interaction. The maximum TSS (12.65°B) was found in T20 ie 100% yellow fruits without stalk and without chemical treatments

which was found at par with T13 (11.67⁰B) ie 50% yellow fruits with stalk and dipped in garlic extract solution for 10 minutes. The minimumTSS was recorded in T5 (10.36⁰B) ie fruit without stalk + 50% yellow fruit + surface treatment of acetic or propionic acid fumigation @ 2.5µl/litre of water.

Table 5. Effect of treatments on total titratable acidity (TTA%) at 120 days after storage

Treatment Factor	Acid fumigation	Acid fumigation + dip in paraffin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV, %	P value	LSD
Stalk + 50% yellow	0.55	0.54	0.41	0.61	0.51	0.52			
Stalk +100% yellow	0.46	0.53	0.66	0.56	0.54	0.55		YellownessXC hemical *	0.058
No stalk +50 % yellow	0.44	0.58	0.42	0.63	0.52	0.57	21.3		
No stalk+100 % yellow	0.58	0.36	0.42	0.47	0.61	0.49		Others NS	
Mean	0.50	0.50	0.47	0.56	0.54				

There was a significant effect of the interaction of yellowness and chemicals on the TA percentage. Other interactions and factors were found non-significant. However, it was found lower than that of the initial TA percentage of mandarin fruits titrated at the time of harvesting. The minimum TA percentage which is desirable was observed in T10 (0.36%) ie fruits without stalk + 100% yellow fruit + surface treatment of acetic or propionic acid fumigation @ 2.5µl/litre of water and dipping in 6% paraffin wax for half an hour. The maximum TA% was found in T15 (0.63%) ie fruit without stalk + 50% yellow fruit + Surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes.

Table 6. Effect of treatments on juice content (g) at 120 days after storage

Treatment Factor	Acid fumigation	Acid fumigation+ dip in paraffin wax	Sodium hypochlorite	Garlic extract	Control	Mean	CV %	p value	LSD
Stalk + 50% yellow	20.63	26.78	22.59	25.41	16.23	22.32		Stalk**	2.333
Stalk +100% yellow	17.46	21.86	27.99	20.60	17.19	21.02		Stalk x chemical *	5.217
No stalk +50 % yellow	17.16	17.03	16.84	20.32	16.36	17.54	22.7	Others ^{NS}	
No stalk+100 % yellow	18.45	14.79	14.99	20.76	20.68	17.93			
Mean	18.42	20.11	20.60	21.77	17.61				

There was a significant difference on the juice content in mandarin fruits due to stalk and the interaction of stalk and chemical treatment. The highest juice content (27.99 g/fruit) was weighed in T10 ie fruits with stalk + 100% yellow fruit + surface treatment with sodium hypochlorite @ 0.5% which was at par with T13 (25.41 g/fruit) ie 50% yellow fruits with stalk and dipped in garlic extract for 10 minutes. The lowest amount of juice (14.79 g/fruit) was extracted from T8 (14.79 g/fruit) ie fruits without stalk + 100% yellow fruit + surface treatment of acetic or propionic acid fumigation @ 2.5µl/litre of water and dipping in 6% paraffin wax for half an hour (Table 6).

Table 7. Mean result of organoleptic taste by panels

Treatment	Sourness (1-3)	Sweetness (1-3)	Juice content (1-3)	Marketability (1-3)	Comparison with Indian orange (1-2)	Overall performance (1-3)
1	0.64	2.5	2.5	2.5	1.8	2.6
2	2.0	2.5	2.0	1.5	1.0	2.0
3	2.5	2.0	1.5	1.5	1.0	1.5
4	2.5	2.5	2.5	1.0	1.5	2.5
5	2.0	2.0	2.5	2.5	1.5	2.5
6	3.0	2.0	2.0	1.5	1.0	2.5
7	2.0	2.0	2.0	2.5	1.5	2.0
8	2.0	2.5	1.0	1.0	1.0	2.0
9	1.5	1.5	1.5	1.5	1.0	1.5

Treatment	Sourness (1-3)	Sweetness (1-3)	Juice content (1-3)	Marketability (1-3)	Comparison with Indian orange (1-2)	Overall performance (1-3)
10	2.5	1.5	1.5	2.0	1.0	1.5
11	2.0	1.8	2.0	1.5	1.0	1.6
12	2.0	1.5	2.0	1.5	1.5	2.0
13	1.6	1.8	2.2	2.0	1.6	2.5
14	0.9	2.6	3.0	2.7	2.0	2.8
15	2.2	1.8	2.2	1.8	1.2	1.8
16	1.5	2.0	1.5	1.5	1.0	1.5
17	2.1	1.9	2.1	2.1	1.2	2.1
18	1.5	2.0	1.5	2.0	1.5	2.0
19	1.0	2.5	2.5	2.0	1.0	2.0
20	2.0	1.5	1.8	1.8	1.4	1.8

The result indicated that, the treatment T1 ie fruit with stalk + 50% yellow fruit + surface treatment with acetic acid fumigation @ 2.5µl/litre of water and T14 ie fruit with stalk + 100% yellow fruit + surface treatment with garlic extract @ 1% solution by dipping the fruits for 10 minutes were found encouraging and superior to the Indian mandarin fruits for all parameters (Table 7).

TSS and TTA of mandarin fruits at the start and end of storage period

The TSS of the fruits increased from 11.16 to 11.76 °B where as the TTA decreased from 0.89 to 0.54 % in 100 percent yellow fruits. The trend of the TSS and TTA in 50% yellow fruits was found similar to the 100% yellow fruits. The details of the TSS and TTA ratio are presented in Table 8.

Table 8. TSS and TTA of mandarin fruits at the start and end of storage period

Before storage			After storage (120 days)	
100% yellow fruits			100% yellow fruits	
Fruit no	TSS (°B)	TTA %	TSS (°B)	TTA %
1	11.0	0.99	12.37	0.58
2	10.6	0.85	11.24	0.36
3	11.6	0.94	11.26	0.42
4	11.2	0.81	11.26	0.47
5	11.4	0.86	12.65	0.61
Average	11.16	0.89	11.76	0.54
TSS:TTA	12.5:1		21.7:1	
50% yellow fruits			50% yellow fruits	
1	9.6	0.79	10.36	0.44
2	9.6	0.70	12.01	0.58
3	8.8	0.82	10.56	0.42
4	10.2	0.97	12.09	0.63
5	9.2	0.84	10.82	0.52
Average	9.48	0.82	11.17	0.52
TSS:TTA	11.6:1		21.5:1	

DISCUSSION

Mandarin can be stored in alternate layers of rice straw under ambient temperatures up to 60 days with only about 15% loss due to rotting (Gurung 1991, cited in Subedi et al 1994). A simple cellar type design was studied to prolong the fruit quality under which the fruits were fresh for 105 days and wastage of fruits found to be 9-17% (Subedi et al 1994).

The appropriate harvesting stage for storing mandarin fruits has been found to be 25-50% yellow colored fruits (Subedi, 1998) which is somehow similar to the results of this experiment. He also reported that the dipping of fruits in concentration of paraffin wax (6%) was found effective for controlling weight loss due to the transpiration from the fruits in the store. However, this chemical was not found effective in controlling the blue mould fungus and other fungi in the cellar store. Results of this experiment are on the same line of the former results. Total titratable acidity is a very important parameter for quality fruits. It is inversely proportional to the TSS means it decreases, as the TSS increases. At the end of storage period, the ratio of TSS: TA increased.

The overall results showed that the interactions of stalk, yellowness and chemicals were found non-significant for all observation periods. The fruits without surface treatment had high recovery percentage during the study period. It could be due to the selection of healthy, compact peeled, disinfected medium sized fruits from the bulk at the time of storage. It was experienced that the fruits of other combinations without surface treatment had high loss in the cellar store. High recovery was observed on the stalked fruits having 50% yellowness without surface treatment. The recovery percentage of the fruits without stalk having 100% yellowness and no surface treatment was only 55%. It indicates that the internal health of the fruits as well as orchard sanitation can play a major role in shelf life of the fruits and blue mould disease management in the cellar store.

CONCLUSION

- 50% yellow colored mandarin fruits with stalk can be stored successfully for 30 days after harvesting without any surface treatment of the fruits.
- Garlic extract and acetic acid fumigation can be applied on stalked and 50% yellow fruits to store the fruits for medium and long-term storage (90-120 days). The fruits were found marketable and superior to the Indian fruits in quality parameters.
- Orchard sanitation, safe picking, peels tightness and medium fruit size are the prime factors for controlling blue mould.
- Optimum temperature (12-15°C) and relative humidity (85-90%) should be maintained in the cellar store.

ACKNOWLEDGEMENT

Authors are thankful to the Hill Agriculture Research Project (HARP) for funding HARP-PP-22/98 Project. We would also like to thank Dr DN Sah, for his support and encouragement in carrying out the experiment. We sincerely thank all the member of Horticulture Unit, RARS, Lumle, especially Mr R Paudel and Mr KP Devkota for their tedious and hard work in trial implementation and data recording. Our gratitude and thanks are due to Dr RP Sah, ARS, Lumle, Mr YR Pandey and Dr SR Ghimire for their valuable comments and suggestions for this paper. Our special thanks go to members of organoleptic taste committee for their critical evaluation and Mr RR Adhikari for word processing.

REFERENCES

- APP. 1995. *Agriculture perspective plan*. APROSC and Associates Inc. Agriculture Projects Service Centre, Kathmandu And John Mellor Associates Inc. Washington D.C.
- FVWM. 2001. *Year round wholesale price of vegetables and fruits*. Fruits And Vegetable Wholesale Market, Pokhara, Nepal.
- Rajput CBS and RS Haribabu. 1990. *Citriculture*. Kalyani Publishers, New Delhi, Ludhiana.
- Shrestha PP. 2001. Citrus orchard establishment and management technology (*Suntala Jat Phalpghool bargaicha Sthapana Tatha Byabasthapan Prabidhi*). *Booklet in Nepali*. Agriculture Information and Communication Centre, Ministry Of Agriculture And Cooperative, HMG/N.
- Subedi PP, GB Gurung and DP Lohar. 1994. Nursery methods, production constraints and storage of mandarin and variety screening of peach and chestnut. *LARC Working Paper No. 94/19*.
- Subedi PP. 1998. Effect of maturity stages and anti fungal treatment on post harvest life and quality of mandarin oranges in a cellar store. *LARC Working Paper No: 98/27*.

Integrated Disease Management of Potato through Farmer Field School: A new Approach in Participatory Technology Transfer in Nepal

Tara L Lama

Potato Development Section, Khumaltar, Kathmandu

ABSTRACT

Potato is one of the important tuber crops in Nepalese agriculture and due to its production potential of dry matter per hectare per day potato is taken as one of the priority crop in food security program. To take advantage of its potentials as vegetable, staple and cash crop various methods and approaches has been implemented to evaluate and transfer the technology generated by the research communities in the past as main stream of technology dissemination. The conventional demarcated approaches/methods are mainly bio-agriculture science based and commodity focused with lesser attention on social perspectives in production system. Thus, Farmer Field School (FFS) was initiated for Integrated Disease Management (IDM) of potato for both clean seed as well as ware potatoes production in healthy environment with judicious use of available production inputs for higher economic return. The approach was implemented initially at nine districts and completed with 63 sites in eleven districts. Total 1340 farmers participated of which 48% were women farmers. Through this approach average of 48.8% farmers adopted improved varieties. Participants practiced moderate number of 2-6 sprays compared to less than two or more than eight spray for managing late blight (*Phytophthora infestance* L.) disease of potato by non-participant farmers. Farmers were able to minimize the crop loss after attending the IDM through FFS on potato. Moreover, area under potato per household increased from 0.19 to 0.27 ha. FFS participants were able to increase crop productivity by 65.5% with net profit of 59% of the gross profit per hectare. Average productivity of IDM plots was higher (38%) than farmers' practice in FFS plots.

Key words: Farmer field school, integrated disease management, learning plots

POTATO IN NEPALESE AGRICULTURE

Potato is one of the important tuber crops in Nepalese agriculture in spite of its late introduction (late seventeenth century) among the exotic crops in Nepal. Area under potato in Nepal in 2002 was 135,095 ha (MA/ASD 2002) which is 5th after major cereals with national average productivity of 10.9 mt/ha. The crop is grown across the country from the southern Sub-Himalayan region (Duars piedmont, below 1000 m altitude) to the northern Himalayan region (up to 4000 m). Based on area coverage, Far west Development Region occupies lowest of 6 percent and highest of 33 percent in Central Development Region and mid-hills occupies 45 percent of total area under potato. Potato is identified as one of the priority crop in food security program (NPC 1988) due to its production potential and wider adaptability (Hawkes 1992), nutritional value (CIP 1984), wide variety of taste and culinary practices; area coverage and scale of production (Woolfe 1987). It is because the fact that it provides more nutritious food from less land in less time - and often under adverse condition- than other crops such as wheat, maize and rice (CIP 1984). It ranks second in higher net return per hectare after cauliflower as vegetable crop (Thapa and Paudyal 2002) in Nepal, with per capita consumption of 30 kg/caput/year, one of the highest national rates in Southwest Asia (Hidalgo et al 2000). To take advantage of its potential as vegetable, staple and cash crop various methods and approaches has been widely implemented in agriculture development to evaluate and transfer the technology generated by the research communities. These conventional models and approaches are based mainly on contingent value or production output (Rhodes 1997) of agriculture commodities. It is well accepted that on-farm technology evaluation and adoption by the farmers is not only influenced by interaction of biological entities and agro-ecology of the test site but also by the social blending, cultural bindings of the specific community and prevailing economic opportunities. Although, through farming systems' research, for the first time, social scientists were formally integrated into international and national agricultural institutes and attention was focused specifically on integrating small farmers into the research and

technology transfer process (Neupane and Sharma 1994). However, the conventional approaches are mainly bio-agriculture science based and commodity focused with lesser attention on social perspectives in production system. These demarcated approaches gave rise to new generations of problems in both the production system as well as social aspects. Now, it opened a new horizon in the field of agricultural research and development to assimilate non-contingent values for sustainable agriculture system through farmer field school (FFS) towards extension to social learning. It mainly focuses on non-negotiable principles as: empowerment, group discovery learning and system approach (Lubis 2003). This approach enhanced social mobilization and inter-personal communication (Adhikari 2002) for technology evaluation and adoption process by the group for particular set of community issues. Therefore, the objectives of the program were to facilitate farmer learning on integrated disease management (IDM) in potato crop, to grow healthy potato crop profitably applying sustainable and environmentally safe technologies and to scale up the FFS approach on a wider scale in Nepal.

MATERIALS AND METHODS

In 1999/2000 crop seasons, Potato Development Section (PDS) in collaboration with International Potato Center (CIP) and Users' Perspective with Agricultural Research and Development (UPWARD) implemented IDM practice on potato through FFS approach in nine districts representing high hills, mid hills and Tarai agro-ecology and 253 farmer participated. To facilitate the program in the district level, agricultural technicians of the respective districts were involved. Of the 32 facilitators for potato IDM/FFS, one-third had prior experience in facilitating a similar activity on rice IPM.

A special training was organized to orient the facilitators of respective districts/sites in implementing IDM through FFS approach in their respective sites.

Two review and planning workshops were organized after completion of the field activities and refined the FFS approach to be applied to potato crop (Table 1). It was also recommended that a holistic approach of integrated crop management (ICM) be conducted with specified learning plots in the potato FFS and learning plots also be used for seed multiplication. Most strikingly, agro-ecosystem analysis (AeSA) was redesigned to best fit according to the nature of potato diseases, growing seasons and crop physiology.

Table 1. Initiation of potato IDM/FFS from original rice IPM/FFS approach in Nepal

Feature	Rice IPM/FFS	Potato IDM/FFS	Remarks
Duration	Season-long	Multi-season	Since effect of practice can only be determined replanting the seed tuber in next season.
Sessions	Weekly	Weekly with more, frequent inspection during favouring environment of disease incidence.	Weekly sessions in early part of FFS and more frequent (2-3/week) when disease symptoms develop in the area.
Learning plots	More experimentation	Experimentation, seed multiplication and maintenance.	Seed is one of the important components of IDM. Learning plot is used to multiply healthy seed.
Agro-ecosystem Analysis (AeSA) Evaluation	Basic method for learning by "discovery" Impact after FFS season	AeSA complemented by other "discovery" methods Impact after several season	To be used selectively to interpret the AeSA data for learning and future use. Disease specially virus management takes more than one season to assess the impact of practices implemented.
Extent	Single constraints - crop	Multiple constraints-cropping system	Disease dynamics is closely associated with seed tuber and soil environment. It needs to deal with the interaction in cropping pattern.

Source: Adopted from Hidalgo et al 2000.

Learning components

- Available best alternatives in managing disease in the area,
- Existing farmers' practice for controlling diseases, and
- Package of practice for TPS and PBS utilization for seed production.

FFS process

FFS process was the driving force of the whole learning activities through participation of various stakeholders and its major activities are presented in Table 2.

Table 2. Summary of FFS process for IDM on potato

Activities	
(I) Preparatory phase	
	1. Site identification
	2. Site selection
	3. Program orientation
	4. Collection of socio-economic information
	5. Participant selection
	6. FFS Planning
	7. Pre-test
(II) Implementation phase	
	1. Weekly meeting
	2. PM & E
	3. Group dynamic
	4. Post-test
	4. FFS closing
(III) Post phase	
	1. Follow-up planning
	2. Follow-up plan implementation

Curriculum of IDM/FFS

There were differences in the cultivation season and constraints in the selected nine IDM/FFS sites. Based on local production system and constraints, each group of facilitators and farmers developed its own location specific curriculum. However, all the sites have common curriculum on general management of the crop production and disease management.

Area of trail field varied from location to location depending on number of technology to be dealt with but main learning plot size was of 250-300 m².

Main plot was divided into two equal parts where one half was assigned to IDM practice and second half to farmers' practice. One-fourth to one-third area of the each plots were further allocated as ply ground to perform learning activities during the FFS sessions. These learning sub-plots were further sub-divided according to the number of sub-groups in the FFS. Besides main learning fields other components technologies were designed (Table 3) depending on the site-specific curriculum.

Table 3. Curriculum and major focus of subject on different sites

FFS sites	Package of practices				Component technology				
	LB	BW	Seed	TPS	Plant	Fungicides/ Crop	Varieties	Source	
			Health		nutrients	additives	mgmt.	seed	
Sunsari	√		√		√				√
Dhanusha	√		√		√				√
Mahotai	√		√		√		√	√	√
Sarlahi	√		√		√	√		√	√
Kavrepalanchowk	√		√		√	√	√		√
S. Palchowk	√	√	√		√	√	√		√
Bhaktapur	√		√			√	√	√	√
Kathmandu	√	√	√			√	√	√	√
Syangja	√		√						√
Rupandehi	√		√		√				√
Kapilbastu	√		√		√				√
Surkhet	√		√		√				√

Data gathering

General field data were gathered from all the sites but specific data were gathered from sample four sites each two from hill and Tarai sites. Similarly, household data were gathered from IDM/FFS participants (FFS-1), non-FFS participants in contact with FFS participants (FFS-2) and non-FFS participants with no contact with FFS participants (FFS-3).

ACHIEVEMENTS

Number of IDM/FFS and farmer participation

During four years, 59 FFS were conducted in eleven districts and 1240 farmers participated in the program. Of the total participants, 73% were literate and 48% were women farmers. Women participation was higher than 50% in Sindhupalchok, Mahotari, Kapilbastu and Surkhet, whereas, lowest participation was observed in Dhanusha, Rupandehi and Kavrepalanchowk districts (Table 4).

Changes in farmers' knowledge and practices

Farmers knowledge: Average knowledge gained through IDM/FFS on potato crop management by the participants was 127% based on pre-test (39%) and post-test (82%) score as shown in Table 4.

Improved variety amplified

There was radical change in varieties used by the FFS participants (Figure 2) in Sunsari and Kavrepalanchok before and after the conduction of FFS. Not much change was observed in Sarlahi and certain change was observed in Sindhupalchok. The average occupancy rates of improved and local varieties by the FFS –1 house holds in the four districts before the program were 18.1% and 81.9% respectively, which changed to 66.9% and 33.1% after the program. It shows that in an average, use of improved variety increased by 48.8% with FFS-1 households. At the same time, the varieties used by the FFS-2 households were 41.3% and 58.7% for improved and local varieties. Similarly, for FFS-3, the occupancy rate was 45.3% and 54.7% for local and improved varieties respectively.

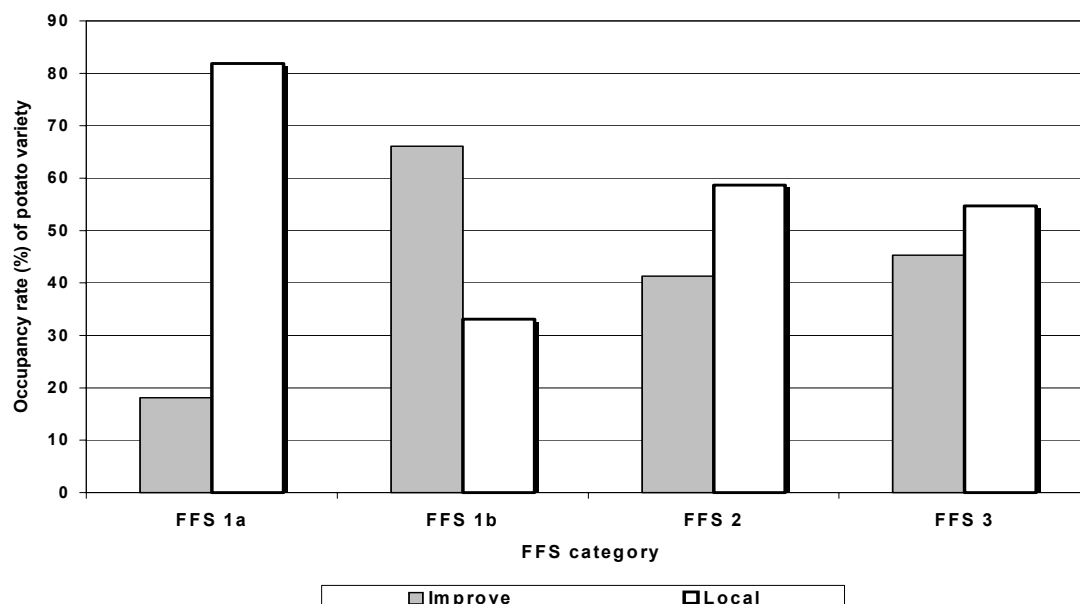


Figure 2. Changes in varieties of potato grown by the farmers in the four FFS sites (FFS 1a = Before FFS, FFS 1b = After FFS).

Table 4. Summary of participants and IDM/FFS sites

FFS site	Participants gender		Literacy, %	Change in knowledge, %				Number of FFS
	Total	M/F		Pre-test score	Post-test score	Net increase	Difference	
1. Sunsari	87	(45/42)	76	42	88	46	109.5	5
2. Dhanusa	119	(67/52)	56	23	77	54	234.8	5
3. Mahotari	41	(12/29)	92	32	86	54	168.8	2
4. Sarlahi	117	(75/42)	78	35	76	41	117.1	7
5. K. Palanchok	114	(77/37)	91	56	83	27	48.2	6
6. S. Palchowk	100	(14/86)	54	32	76	44	137.5	6
7. Kathmandu	129	(73/53)	100	55	73	18	32.7	7
8. Bhaktapur	100	(63/37)	100	35	90	55	157	4
9. Syangja	90	(45/45)	51	-	-	-	-	3
10. Rupendehi	76	(63/13)	42	29	86	57	196.6	5
11. Kapilvastu	136 (24/112)		100	55	78	23	41.8	7
12. Surkhet	103	(14/89)	63	33	95	62	187.9	6
Total /average	1340	(608/637)	75.0	42.0	90.0	48.0	142.0	63

Disease status

After the second season of implementation of IDM/FFS, farmers were able to manage the late blight diseases of potato effectively and efficiently. Pre program situation revealed that the disease incidence was very high as reported by 65.8 % FFS-1 participants. However, after the program this figure was only 10.5 %. The 55.3 % FFS participant were able to reduce the incidence of late blight disease from very high to low. Similar trend was also observed with FFS-2 (Table 5). It was reduced from very high and high to medium and low level. There was slight change in status of other diseases too and it was occurred owing to use of disease management practices.

Table 5. Farmers' response (%) on disease status in their crop

Disease		FFS category		Disease status							
		Pre FFS				Post FFS					
		Very high	High	Medium	Low	Not at all	Very high	High	Medium	Low	Not at all
Late blight	1	65.8	26.3	5.3	2.6	-	10.5	15.8	18.4	55.3	-
	2	71.8	25.6	2.6	-	-	-	-	60.0	40.0	-
	3	-	-	-	-	-	44.4	41.7	11.1	1.8	-
Black Scurf	1	2.9	8.8	8.8	20.6	58.8	-	-	3.0	36.4	60.6
	2	-	-	-	-	-	-	3.7	-	7.4	88.9
	3	-	-	-	-	-	-	-	4.0	8.0	88.0
Common Scab	1	3.1	-	3.1	12.5	81.3	-	3.2	-	16.1	80.6
	2	-	-	-	-	-	-	-	-	7.4	92.6
	3	-	-	-	-	-	-	-	4.0	-	96.0
Bacterial wilt	1	5.4	13.5	-	8.1	2.7	-	2.7	10.8	21.6	64.9
	2	23.7	5.3	7.9	2.6	60.5	16.7	16.7	-	-	66.7
	3	-	-	-	-	-	17.6	11.8	-	2.9	67.6
Wart	1	5.6	5.6	5.6	2.8	80.6	-	2.7	8.1	10.8	78.4
	2	-	-	-	-	-	15.2	6.1	-	-	78.8
	3	-	-	-	-	-	15.2	12.1	-	-	72.7
Other Diseases	1	28.6	35.7	35.7	-	-	-	7.1	21.4	71.4	-
	2	-	-	-	-	-	71.4	-	28.6	-	-
	3	-	-	-	-	-	-	-	-	-	-

Fungicide application

The frequencies of spray varied from site to site. The average number of fungicide sprayed in FFS sites were 2 to 3 for 22.6 %, 3-4 for 25.8 %, 4 to 6 for 38.7 % and 6 to 8 for 12.9 % respondents (Table 6). In non-FFS sites, the frequency of spray varied from 2-3 times to more than 8 times. In FFS-3, the 32 % respondents used to spray fungicide more than 8 times.

Table 6. Frequency of fungicide application in potato crop by farmer category (%)

Farmer category	Frequencies of spray					
	0	2-3	3-4	4-6	6-8	>8 times
FFS-1	0.0	22.6	25.8	38.7	12.9	0.0
FFS-2	3.6	3.6	21.4	28.6	21.4	21.4
FFS-3	0.0	28.0	16.0	8.0	16.0	32.0

Area and productivity of major crops

The average area per household under major crops (Rice, Wheat, Maize and potato) and productivity of these crops is presented in Table 7. Post FFS data revealed that the average area under potato per household in four sample districts increased from 0.19 ha to 0.27 ha. Similarly, the productivity of potato also increased by 65.5 % from 10.7 t/ha to 17.7 t/ha. This clearly indicates the effectiveness of the IDM/FFS approach in increasing the yield through group learning by the participants. However, sizable changes were not observed in other crops.

Table 7. Area (ha) and productivity (t/ha) of major crops within the existing cropping

Crop	Before		After		% change	
	Area/HH	Productivity	Area/HH	Productivity	Area	Productivity
Potato	0.19	10.7	0.27	17.72	41.12	65.4
Rice	0.62	2.05	0.64	2.18	3.39	6.16
Wheat	0.13	0.76	0.16	0.76	20.86	0.39
Maize	0.01	0.50	0.01	0.50	0.00	0.00
W. maize	0.34	1.43	0.35	1.45	2.83	1.75

Potato yield in learning plots

At all the FFS sites crop yield were higher in the IDM practice (25.0 mt/ha) compared to existing farmer's practice (18 mt/ha) of crop management. Average yield difference of IDM practice was 35% higher than the yield of Farmer's practice (Table 8).

Table 8. Average potato yield (t/ha) in learning plots

FFS Sites	Farmers' practice	IDM practice	% difference
1. Sarlahi	17	22	29.4
2. Rupandelhi	17	24	41.2
3. Sunsari	18	26	44.4
4. Sindhu Palchowk	21	35	66.7
5. Danushi	14	20	42.9
6. Surkhet	20	22	10.0
7. Kathmandu	21	25	19.0
8. Bhaktapur	19	21	10.0
9. Kavre Palanchowk	25	35	40.0
10. Kapilbastu	12	18	50.0
Average	18.0	25.0	35.0

Economic gain at household level

An average of net profit obtained were Rs74,200.00/ha, Rs.68, 890.00/ha and Rs61, 505.00/ha by the different farmers categories of FFS 1, FFS –2 and FFS-3 respectively (Table 9). However, there was not difference in percent net profit over gross profit obtained by FFS-1 (59%) and FFS-2 (60%) households but it was less (53%) in FFS-3 households. It indicates that the technology, acquired knowledge and skills gained through IDM/FFS were effectively disseminated from participant to other farmer in contact with them.

Table 9. Comparison of house hold gross income and net profits from potato cultivation across the FFS and non-FFS house holds in the selected sites

House hold	District Category	Sample size (HH)	Gross profit Rs/ha	Net profit Rs/ha	% of Gross profit
(FFS-1)	Sunsari	10	107,940.00	55,200.00	51
	Sarlahi	10	132,000.00	88,200.00	67
	K. Palanchowk	10	173,160.00	100,000.00	58
	S. Palchowk	10	85,800.00	53,400.00	62
	Category average		124,725.00	74,200.00	59
(FFS-2)	Sunsari	8	85,500.00	59,400.00	69
	Sarlahi	9	94,200.00	63,900.00	68
	K. Palanchowk	10	187,960.00	103,860.00	55
	S. Palchowk	10	90,500.00	48,400.00	53
	Category average		114,540.00	68,890.00	60
(FFS-3)	Sunsari	8	90,000.00	56,100.00	62
	Sarlahi	10	84,540.00	47,520.00	56
	K. Palanchowk	10	192,000.00	99,000.00	52
	S. Palchowk	10	96,000.00	43,400.00	45
	Category average		115,635.00	61,505.00	53

Farmers' assessment of the approach

Participatory assessment for the benefit of the program was collected from the participants as presented in Table 10 shows that 95% of the respondents felt that the level of family income had improved and similarly the level of living condition also improved as reported by 90 % respondents.

In the FFS sites 65 % respondents had increased area under potato cultivation and 35% had the same area as before due to small land holding. Majority of the farmers (92.5%) assessed that the quantity of potato production was increased in the community. Most of the respondents (97.4%) had increased knowledge and skills on potato crop management. Besides this, the 76.5 % FFS-1 participants had the feeling that the number of farmers interested to FFS/IDM has been increased in their areas.

Table 10. Farmers' assessment of overall benefits from participating in FFS

Benefits	Farmers' perception, %		
	Increased	Decreased	No change
Level of family income	95.0	-	5.0
Area under potato production	65.0	-	35.0
Knowledge and skills on potato farming	97.4	-	2.6
Quantity of potato production	92.5	2.5	5.0
No. of farmers interested to FFS	76.5	-	23.5
	Excellent	Good	Poor
FFS/IDM approach	76.9	-	23.1
Status of functioning of group	63.2	36.8	-
Quality of extension services	32.5	65.0	2.5
Quality of potato produced	42.5	50.0	2.5

Table 11 shows that farmers had gained better benefits from TPS and introduced modern technology of potato cultivation. Disease management technology had very good impact in disease control like late blight and in

production of better quality seed potato. In comparison to the local seed, the improved seed had given more benefits to the farmers to increase yield, control diseases and improve quality of potato.

Table 11. Farmers' perceptions on benefits achieved from FFS/IDM (average of Sunsari, Sarlahi and Sindupalchok)

FFS/IDM activities	Benefits*			
	Yield increased	Disease controlled	Farming practice improved	Quality of product improved
Use of TPS technology	3.3	3.7	3.0	3.7
IDM practice	2.7	3.7	2.7	3.7
Use of improved technology	3.7	3.7	3.5	2.7
HIV variety	3.2	3.0	2.3	2.3
Use of quality seed	2.7	3.0	2.0	2.7
Use of local seed	1.0	1.0	0.3	0.3

* Rating measures: 4 = Very good; 3 = Good; 2 = Normal; 1 = Poor.

Adopted from Ojha and Lama 2000.

Main lesson learned

In general, compared to conventional methods/approaches for transfer of technology, this approach has following limitations

- More time is required (one day per week).
- Needs regular presence of facilitator during the season.
- Facilitators must bear adequate technical knowledge in the subject and facilitation skill.
- Weak marketing environment for both inputs and products is not favorable in scaling up the approach.
- Human resource was limiting for monitoring and evaluation.

REFERENCES

- Adhikari S. 2002. Study report on integrated pest management: Farmer field school. *CARE Nepal*.
- CIP. 1984. Potatoes for the developing world. *International Potato Center*, Lima, Peru. 150pp.
- Hawkes J. 1992. The potato evolution, biodiversity and genetic resources. *CBS publishers and distributors* (Pvt) Ltd. New Delhi-110002, India.
- Hidalgo OA, DM Campilan and TL Lama. 2000. A report on strengthening farmer capacity for growing healthy potato crop in Nepal. *Scientist and farmer: Partners in research for the 21st Century*. Program report 1999-2000. International potato Center, Lima, Peru.
- Lubis M. 2003. Overview of farmer field schools. Farmer field school: From IPM to platforms for learning and empowerment. *International Potato Center – Users' Perspectives With Agricultural Research and Development*, Los Banos, Laguna, Philippines. 87pp.
- Neupane FP and RC Sharma. 1994. *Farming system research and extension in Nepal*. Tribhuvan University Press. Kathmandu.
- NPC, 1998. Ninth five-year plan (1997-2002). National Planning Commission, Kathmandu.
- Rhoades RE. 1997. *Pathway towards a sustainable agriculture for the 21st century, the Hindu Kush-Himalayan experience*. International Center for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal.
- Thapa GB and D Paudyal. 2000. Nepal. Dynamics of vegetable production, distribution and consumption. In: *Asia* (M Ali, ed). Asian Vegetable research and Development Center. AVRDC publication no. 00-498. 470pp.
- Woolfe J. 1987. *The potato in the human diet*. Cambridge, UK. Cambridge University Press and International Potato Center (CIP).

Literature Review on Stalk Rot Disease of Cauliflower in Nepal

Dol P Dhakal

Plant Pathology Division, NARC, Khumaltar, Lalitpur

ABSTRACT

Vegetables are an integral part of hill farming systems of Nepal, which has been given high priority in the APP. Among vegetables, cauliflower (*Brassica oleracea* L. var *botrytis*) is one of the most widely cultivated commercial crops in Nepal. Cauliflower was mostly imported from India in late 1990s, but with the establishment of the NGOs and the formation of community- based farmer co-operatives, the off-season production of cauliflower is actually exported to Indian market during recent years. The area under cauliflower production in Nepal is 19,267 ha (ie 13% of the total area under vegetables) with average productivity of 7.8 tones per hectars. Cauliflower production can be threatened by the numbers of production constrains. Among them sclerotinia stalk rot is reported to be the most important disease of cauliflower in Nepal. This disease has been reported from all the important commercial cauliflower growing areas of Nepal. This is the most destructive disease of cauliflower attacking almost all growth stages of the crop starting from nursery stage to seed production stage. Stalk rot disease is caused by the two species of *Sclerotinia* on cole crops, *Sclerotinia minor* (up to 0.25 inch) and *Sclerotinia sclerotiorum*. *S. minor* only infects stems or leaves in close contact with the soil where as *S. sclerotiorum* can caused in all stages forming sclerotia that are larger (0.25- 0.5 inch) on average than those of *S. minor*. It has been reported that this disease reduced the yield from the expected 150 kg to 45 kg only in Khumaltar in 1982. In 1983, this disease had caused almost total failure of seed production making 83% losses in Dhankuta farm, only 53 kg/ha seed yield was obtained instead of expected 300-400 kg/ha due to this disease. Similarly, 30-40% and 15-50% of the disease intensity were recorded in Palpa Horticulture Farm and Farmers fields of Palpa respectively in 1982. An average of 30-40% seed yield of cauliflower is estimated to be lost by the infection of this disease every year in Nepal. Disease could be reduced through the addition of organic matter such as composted sewage, sunflower inflorescence residues and pine needles into soil. Crop rotation, flooding, resistance varieties and biological control can be done for disease management.

INTRODUCTION

Nepal is an agricultural country with complex and diversified farming system. The agricultural sector has dominated the Nepalese economy for a long time and will continue to be a major source of livelihood for the majority of the farmers. Agriculture is the main occupation in the rural economy. However, agricultural productivity is decreasing each year due to a number of factors. Among them insect pests and diseases are considered to be the main crop yield depletion factor. It has been reported that significant proportion (20-25%) of agricultural produce in Nepal is lost each year as result of insect pest (APP 1990).

Vegetables are an integral part of hill farming systems of Nepal (Shrestha and Grimire 1996), being one of the high value commodities and given high priority in the APP (APP 1995). Among vegetables, cauliflower (*Brassica oleracea* L. var *botrytis*) is one of the most widely cultivated commercial crops. Cauliflower was mostly imported from India (Koirala et al 1995), but during recent years, with the establishment of the NGOs and the formation of community- based farmer co-operatives, the off-season production of cauliflower is actually exported to India. In Nepal, the area under cauliflower production is 19,267 ha (ie 13% of the total area under vegetables) with average productivity of 7.8 tones per ha (APSA 1995).

Cauliflower cultivation in the hills is a highly labour demanding enterprise, helping to generate employment opportunities and improving living standards of the hill society. Secondly, it may reduce the migration of farmers of the hills to densely populated areas (Tarai). Finally, sufficient production of cauliflower in the hills

may help to alleviate nutritional deficiencies of farmers living in the areas because it is a good source of minerals, vitamins and fiber.

Despite of these remarkable advantages, cauliflower is not free from attacks of various diseases/insects pests' in Nepal. Among the diseases, the most prevailing diseases in the hills of Nepal are listed below followed (Table 1).

Table 1. Diseases of cauliflower in hills of Nepal

Name of disease	Causal pathogen
Stalk rot	<i>Sclerotinia sclerotiorum</i> (Lib) de bary
Damping off	<i>Pythium aphanidermatum</i> <i>Rhizoctonia</i> spp. <i>S. sclerotirum</i> <i>Phytophthora</i> spp. <i>Fusarium</i> spp
Downey mildew	<i>Peronospora parasitica</i>
Alternaria leaf spot	<i>Alternaria brassicicola</i> (Schw) Wiltshire <i>Alternaria brassicae</i> (Berk) Sacc
Black rot	<i>Xanthomonas campestris</i> pv. <i>Campestris</i> (Pammel) Dowson
Soft rot	<i>Erwinia carotovora</i> sub sp. <i>carotovora</i>

Among the diseases of cauliflower, sclerotinia stalk rot is reported to be of the most important (Thapa et al 1995). In Nepal, this disease has been reported from all the important commercial cauliflower growing areas including Rukum, Palpa, Dhankuta and Kathmandu (Bhurtayal 1985). According to Shrestha and Timila (1990) this disease was first reported from Dhankuta district in 1979, 1981, and 1982 respectively (Shrestha 1985b, Shrestha et al 1989). This is the most destructive disease of cauliflower attacking almost all growth stages of the crop starting from nursery stage to seed production stage.

SCLEROTINIA DISEASE

Two species of *Sclerotinia* cause disease on cole crops. *Sclerotinia minor* only infects stems or leaves in close contact with the soil. Once infection takes place, water-soaked, brown necrotic areas develop on these structures. The necrotic areas rapidly turn into soft, watery rots. Plants then wilt and collapse. Profuse amounts white mycelial growth and numerous small (up to 0.25 inch), black, hard resting bodies called sclerotia, form on the outside and inside of the stems. *Sclerotinia sclerotiorum* can also infect lower leaves and stems, causing the same type of systems as *S. minor*. In addition, *S. sclerotiorum* also has an aerial spore that can infect any of the upper leaves and flowers. If conditions are favourable, these spores cause a watery, soft rot of these tissues as well. *Sclerotinia sclerotiorum* form *sclerotiorum* forms sclerotia that are larger (0.25-0.5 inch) on average than those of *S. minor*.

Sclerotia of both species enable the pathogen to survive in soil for a number of years without susceptible hosts. Wet soil conditions favour disease development. For *S. sclerotiorum*, cool and moist conditions are necessary for development of and infection by the spores. The aerial spores usually only infect injured or senescing leaves and flowers.

NATURE OF PATHOGEN

The *Sclerotinia* genus is notorious for causing various types of rot of field, garden and orchard crops affecting seedling, leaves, fruits, etc. Bulter and Bisby (1931) have reported 24 plant species as the hosts of *Sclerotinia sclerotiorum* alone. The fungus is air borne, soil borne and seed borne in nature. Approximately 90 per cent of the life cycle of *S. species* are spent in soil as sclerotia (Adam and Ayers 1979). Survival of sclerotia in soils is very variable and depends on environmental conditions, soil moisture, soil temperature, nutrient status of soil, particularly its organic matter content, and presence of soil micro-organisms population such as hyper-parasite (Moore 1949, Huang and Hoes 1975, Turner and Tribe 1976, Coley-Smith and Cooke 1971). Soil moisture plays a vital role in survival of Sclerotia in soil. A total of 100% sclerotia were killed when soil was flooded with water for 26-31 days (Moore 1949). Soil temperature is another important factor for the survival of sclerotia. According to Adams (1975) soil temperature 10-30°C did not adversely affect on survival. A 35°C constant soil

temperature for 3 weeks or more reduce the survival of sclerotia. Most important factor of survival of sclerotia in soil is soil microorganism such as *Trichoderma* spp, *C. minitans* (Jones and Watson 1969, Tribe 1957, Champbel 1947). Sclerotia under cool temperature and high moisture condition may germinate to form long stalked apothecia. These release/produce airborne ascospores, which are the main source of inoculum for plant (Jones and Watson 1969 Huang 1980).

Mycelium of the Sclerotinia is hyaline, much branched, consisting of large, closely septate hyphae, which are both intra and inter cellular and invade all the tissues of the affected portion. The hyphae are 9 to 18 microns broad and filled with dense protoplasm. No true conidia produced. When the food supply is exhausted and the vegetative growth has ceased the hyphae with thick granular protoplasm collect in small dense masses. These dense masses of closely septate hyphae gradually become the sclerotia. At first these are pink but later turn black and become smooth. The smaller sclerotinia are usually round and the bigger ones are flatter and leaf-shaped or irregular. Their size depends upon the substrate and temperature. They measure 2 to 12 mm, mostly 2.5 to 6 mm in diameter. When the sclerotinia is transversally section cut it show that are composed of thin-walled rectangular cells in the center and thick-walled cells at the periphery. The walls of peripheral cells are impregnated with a gelatinous material, which gives these sclerotia their black appearance. When the sclerotinia buried in the soil, two to five dichotomously branched stripes are produced by each sclerotium and they are fertile. The length of the stipes varies from 25 to 88 mm and the breadth is maximum at the base of apical apothecium, being about one millimeter. The exposed part of the stipe is fawn coloured but within the soil the colour is brown or dark brown.

The apothecial fundaments are borne at the tips of the stipes as minute brownish or fawn coloured, funnel-shaped structures, just above the soil surface. The fundaments, usually one millimeter in diameter, expand into shallow, flat or convex apothecia. The asci are cylindrical and measure 108- 153 x 4.5 – 10 microns, the average being 122.9 x 5.9 microns (Mehta and Bose 1946). The ascospores are discharged in abundance. They are elliptical, minutely guttulate (with tiny drops), and measure 7.2- 11.7 x 3.6- 5.4 microns. Generally mycelium and ascospores are grown in 25°C and are short lived. They have-not growth at 33°C the mycelium of the fungus is incapable of infecting the host. The infection actually occurs through the ascospores formed after the sclerotinia have germinated to produce apothecia. The latter develop when the sclerotinia have been exposed to low temperature and then placed in strong light.

LIFE CYCLE OF *S. SCLEROTIUM*

The fungus forms rounded, resting structures termed "sclerotia" Sclerotia consist of compact masses of intertwined hyaline hyphae (pseudoparenchymatous tissue) enveloped by a layer of black pigmented cells (Jones and Watson 1969). The tuberoid sclerotium is characteristic of *S. sclerotium*. Sclerotia of *S. sclerotium* are nutrient rich, the main cytoplasmic reserves present in sclerotia being glycogen, protein, polyphosphate and lipids (Willettts and Bullock 1992). Sclerotia can remain dormant or quiescent when the environment is unfavourable and germinate to perpetuate the fungus life cycle when conditions become favourable.

Infection of susceptible host plants can occur from mycelium either through the eruptive germination of sclerotia in soil or from germinating ascospores (Purdy 1979, Kapoor 1986). Mycelium from either origin can cause infection of healthy plants. After infection a white mycelium develops when the environmental conditions are favourable, this mycelium kills the affected parts of the host plant. The life cycle is completed as sclerotia are produced externally and internally in the stem, pith of fruit cavity of between and xylem.

Under cool temperature and high moisture conditions, sclerotia may germinate to form long-stalked apothecia. These produce air-borne ascospore which, when released, are the main source of inoculum for plant infection (Jones and Watson 1969, Hauang 1980). Ascospores may be produced over range of temperatures (0-25°C), but are produced optimally at 15-20°C (Smith et al 1988). Carpogenic germination of sclerotia has been obtained experimentally by placing the sclerotia on a substrate low in nutrients such as moist sand, cotton or polyurethane, water agar, or water (Tourneau 1979, Mylchreest and Wheeler 1987, Kapoor et al 1987, Singh et al 1995).

Sclerotia are of paramount importance in survival and epidemiology of the pathogen (Hoes and Huang 1975), serving as the main over-wintering propagules (Huang 1980). The optimum temperature for sclerotial formation in axenic culture is 22-25° C. In more complex media eg PDA this may be higher 25-27°C (Marukawa et al 1974). Approximately 90% of the life cycle of Sclerotinia species is spent in soil as sclerotia (Adam and Ayers

1979). After three months in the soil, sclerotia are "conditioned" and produce apothecia (Purdy 1979, Kapoor 1986). There are a number of reports of sclerotia surviving for long periods, for example Kapoor (1986) quoted Brown and Butler (1936) reported that sclerotia under favourable dry conditions can remain viable for at least 10 years. Sclerotia held under dry storage for seven year, germinated readily and produced viable ascospores (Hungerford and Pitts 1953). Similarly, Coley-Smith et al (1990) reported that sclerotia of *S. cepivorum* persisted 20 years in the absence of host plants. However, under certain conditions sclerotia may survive for 30 weeks (Merriman 1976).

The survival of sclerotia in soils is very variable and depends on environmental conditions, soil temperature, nutrient status of the soil (particularly is organic content) and the presence of soil microorganisms such as hyperparasites (Moore 1949, Coley-Smith and Cooke 1971, Hoes and Huang 1975, Turner and Tribe 1976). Soil moisture plays a vital role in the survival of sclerotia. All sclerotia were killed when soil was flooded with water for 26 to 31 days (Moore 1949). Similarly, soil temperature is another important factor in the survival of sclerotia. According to Adams (1975) soil temperature from 10°C to 30°C did not adversely affect the survival of sclerotia, but a constant 35°C soil temperature for three weeks of more reduced their survival. Biotic factors are also important for survival of sclerotia in soil, especially antagonistic microorganisms such as *Trichoderma spp.* and *Coniothyrium minitans* (Campbell 1947, Tribe 1957, Jones and Watson 1969).

MODE OF INFECTION

The infection process of *S. sclerotiorum* was investigated by de Bary (1887). The sclerotia germinate by production of mycelia or apothecia. Mycelial infections are initiated at the soil line resulting in damping- off or basal stem rot, or by root contact with mycelium germinating from sclerotia (Huang and Dueck 1980, Purdy 1979). Buried seeds infected with mycelium may not germinate and those that do often fail to reach the soil surface (Hungerford and Pitts 1953). *S.sclerotiorum* over wintering on the soil surface or in the seed, as mycelium in may not appear initially. Transmission is usually indirect. Sclerotia in the soil (which may originate from the debris of previous crops or as contaminants associated with the seed) germinate to produce ascocarps from ascospores are discharge and subsequently infect growing crops (Maude 1996). Where sclerotia are in contact with the stem bases of plants, mycelial transmission may occur (Scott and Evans 1984). Once in the soil, *S. sclerotiorum* mycelium will colonise seed and seedlings resulting ultimately in the production of more sclerotia (Blodgett 1946).

S. sclerotiorum ascospores normally infect susceptible plants only if a saprophytic food base is available in the infection court, typically during flowering by fallen petals lodged in the leaf axis (Morrall and Dueck 1982). Previous studies had indicated that a suitable nutrient- rich medium such as dead petal was necessary for ascospore germination and subsequent penetration into host tissues. If conditions are not suitable for germination, the ascospores may remain viable for a short time germinate when conditions again become favourable (Purdy 1979)

Inglis and Boland (1992) reported that viable inoculum of *S. sclerotiorum* could be isolated from field-collected petals of rapeseed (*Brassica napus*) and faba beans (*Vicia faba*). This findings was supported by an experiment carried out by Jamaux et al (1995), in which ascospores were inoculated in leaf discs of rapeseed, rape seed petals and petals placed on leaf discs. The results indicated that ascospores failed to germinate after three hours on the leaf surface, but ascospores on petals germinated, giving rise to one short germ tube each. Similarly, ascospores that had landed naturally on the petal surface germinated and penetrated (Purdy 1979)

DISSEMINATION MECHANISM

The fungus is air and seed-borne. Ascospres of *Sclerotinia spp.* are spread from, field to field and from one geographical area to another by soil adhering to seedlings, farm equipment, animals or humans, or as mycelium in infected host tissue (Adams and Ayers 1979, Shrestha 1985a). Adams and Ayers (1979) quoted Dillon-Weston et al (1946) as showing that on farms where diseased plant tissue is used as cattle feed or bedding, the spreading of manure onto fields may be a source of infection. However, less than 2% of sclerotia of *S. sclerotiorum* passing through the digestive tract of sheep remained in a viable condition (Brown 1937). Irrigation water is also a source of sclerotial dissemination (Steadman et al 1975). However, the greatest potential for long-

distance dissemination of *S. sclerotiorum* in cauliflower appears to be as seed-borne inoculum, either by seed infected with mycelium or by seed contaminated with sclerotia (Neergaard 1958).

HOST RANGE

S. sclerotiorum has been reported on a remarkable 75 plant families, 278 genera and 408 species. Except for *Rumohra adiantiformis* in the Pteridophyta, all hosts of *S. sclerotiorum* occurred within the division Spermatophyta. Within the Spermatophyta hosts are recorded from the classes Gymnospermae and Angiospermae. Families that contain large number of hosts are reported to include Asteraceae, Fabaceae, Solanaceae, Apiaceae and Ranunculaceae, in decreasing order of host number (Boland and Hall 1994). On the other hand, Willetts and Wong (1980) reported the main hosts occur in the families Solanaceae, Cruciferae, Umbelliferae, Compositae, Chenopodiaceae and Leguminosae. Amongst crops, the fungus attacks mostly vegetables and oilseed crops. Partka and Mai (1962) referring to a thesis by Dickson (1930), indicated that 172 species from 188 genera in 37 plant families were known to be susceptible hosts, while in a review by Purdy (1979) *S. sclerotiorum* occurred on 225 genera, 361 species and 22 other taxa (cultivars) for a total of 383 species and other categories distributed in 64 plant families. Farr et al (1989) listed 148 genera of plants that are susceptible to *S. sclerotiorum*. Whatever the exact numbers of hosts, it is clear that *S. sclerotiorum* is a most successful pathogen in terms of host range. Equally *S. sclerotiorum* is found in a wide range of climatic conditions.

CROP LOSSES

In Nepal, a preliminary study was performed at ARS, Pakhribas in 1991/92 in a micro plot seed multiplication block to find out the extent of losses. The result indicated that stalk rot disease of cauliflower caused 17.2% seed yield loss of cauliflower under natural epiphytic condition (Duwadi et al 1993). In cauliflower, the damage of this disease was recorded only in the seed crops attacking the stalks at pod formation stage and it was not counted as disease for curd. But fungus has reported its attack on curds in Bara and Kathmandu as well as in the eastern hills of Nepal. (Shrestha and Bhurtayal, Undated, Duwadi 1998). Furthermore, they have reported that the danger of disease is increasing and it may also attack seedling as damping off. In ARS Pakhribas and its command areas the disease was observed on nursery seedling, 111 days after transplanting the cauliflower seedlings and the curd (Duwadi 1998). Similarly percentage of seedling infestation also reported (Duwadi 1998). In 1983, this disease had caused almost total failure of seed production making 83 % losses in Dhankuta farm, only 53 kg/ha seed yield could be obtained instead of 300-400 kg/ha due to stalk rot disease alone (Rekhi 1983). Similarly, 30-40% and 15-50% of the disease intensity were recorded in Palpa Horticulture Farm and Farmers fields of Palpa respectively (Shrestha, 1982). An average of 30-40% seed yield of cauliflower is estimated to be lost by the infection of the *Sclerotinia* stalk rot disease every year (Bhurtayal 1985). It has been reported that this disease reduced the yield from the expected 150 kg to 45 kg only in Khumaltar in 1982.

MANAGEMENT PRACTICE

Cultural practices

Research findings indicated that *Sclerotinia* disease of cauliflower could be reduced through the addition of organic matter such as composted sewage, sunflower inflorescence residues and pine needles into soil (Milner et al 1982, Lumsden et al 1983, Lumsden et al 1986, Sharma et al 1986). Crop rotation is a disease management option that has often been recommended for control of *S. Sclerotiorum* (Shrestha, 1990). However, crop rotation may not be a practical option for many farmers because *Sclerotinia* has a wide range of hosts and the pathogen can survive years in the soil in the absence of host plants. Flooding a field continuously for 23-45 days or a cycle of alternate flooding and drying led to destruction of Sclerotia of *S. Sclerotiorum* (Moore 1949) in south Florida of the United States. But flooding in Bari- land (rain fed upland where most cauliflower is grown) in Nepal is impracticable. Field sanitation with proper weeding and drainage management is the essential factor for disease management.

Breeding for resistance

Use of resistant crop varieties is potentially one of the most effective and economic methods of disease control particularly in areas where pathogens are soil borne. It has been reported that screening for partial resistance

against *S. sclerotiorum* in cauliflower has been successfully achieved. Sharma et al (1984) studied the reaction of eight genotypes of cauliflower and found two genotypes, which showed least infection. Similarly, Kapoor (1986) reported that out of 79 exotic and indigenous lines, four lines showed a high degree of resistance in two consecutive generations of screening. However, screening successive generations requires long periods of time. The screening technology explored by Kapoor et al (1985) and Kapoor (1986), namely artificial inoculation of seedling using ascospores on partially colonized mustard petals, helped to reduce screening time.

There are numerous examples where resistant varieties have contributed significantly to increased productivity. However, farmers in the hills of Nepal continue to grow genotypes, which are susceptible to stalk rot disease such as Kibogaint, Terai-3, and Kathmandu local. Probably, this is because resistant genotypes are unavailable or the chosen variety has other popular or suitable characteristics such as marketable size, taste or more leaves for animal feed. In India, Singh and Kalda (1995) studied the varietal reaction of sixty-nine genotypes of cauliflower at the seedling stage and found four with low infection (less than 50% of the leaf surface infected.)

POTENTIAL FOR BIOLOGICAL CONTROL

Biological control may be defined as the use of predators, parasites or pathogens to maintain an organism's population density at a lower than would otherwise occur. The degree of population reduction achieved through use of a biological control agent (BCA) may often be enhanced through manipulation of the environment by various means to favour the BCA. Such strategies may be a part of the package of measures eg solarization, drought and flooding, crop rotation and possibly genetic manipulation of the crop.

Biological control of *S. sclerotiorum* using micro-organisms has explored by various researchers. The antagonist *Coniothyrium minitans* applied to soils as spore suspensions killed 85% to 99% sclerotia of *S. trifoliorum* within 11 weeks in a pot experiment in UK (Tribe 1957). Promising biological control of *S. sclerotiorum* in some crop including cauliflower has obtained by incorporating the mycoparasitic fungi *C. minitans*, *Gliocladium roseum*, *G. virens*, *Sporidesmium sclerotivorum* and *Trichoderma viride* in Sclerotinia infected soil (Agrios 1988).

The fungal antagonist *C. minitans* is well documented as a mycoparasite of *S. sclerotiorum* (Turner and Tribe 1976, Huang 1980, Budge and Whipps 1995, Elnaggar and Vajna 1995). *C. minitans* has the capacity to kill a large proportion of the population of field sclerotia of *S. sclerotiorum* within one month provided that moist conditions and moderate temperatures prevail (Trutmann et al 1980). *C. minitans* also has ability to kill hyphae of *S. sclerotiorum*. It produces cell wall degrading enzymes which ultimately cause the disintegration of the cell wall, death of hyphae and sclerotial (Huang and Hoes 1976).

Biological control of Sclerotinia stem rot (*S. minor*) in sunflower by treatment with *G. virens* has been explored by Burgess and Hepworth (1996). Seeds were soaked in a conidial suspension of *G. virens* for two hours before planting. Results were effective in the field soil as well as in pasteurized potting medium. Increasing concern with soil conditions in the Nepalese hills means that biological control of soil – borne fungi by the use of indigenous micro organisms is highly desirable.

REFERENCES

- Adam PB. 1975. Factors affecting survival of *Sclerotinia sclerotiorum* in soil. *Plant Disease Report*. 59: 599-603.
- Adam PB and WA Ayers. 1979. Ecology of *Sclerotinia* species. Symposium on *Sclerotinia* (=whetzelinia): *Taxonomy, Biology and Pathology*. 69(8): 896-899.
- Agrios GN. 1988. *Plant pathology*. 4th ed. Academic Press Inc. London.
- APP. 1995. *Nepal agriculture prospective plan*. Agricultural Project Services Centre and John Mellor Associates, Inc. National Planning Commission, HMG/N and ADB.
- APSA. 1995. *Asian seed'95. Volume 2*. Technical report. The Asia and Pacific Seed association, New Delhi, India. Pp.1-15.
- Bhurtyal PR. 1985. Report on trial conducted on radish and cauliflower disease control for seed production. In: *Proceeding of 4th national seminar on vegetables and vegetable seed production*. Vegetable Development Division, Department of Agriculture, GMG/Nepal.
- Blodgett EC. 1946. The *Sclerotinia* rot disease of beans in Idaho. *Plant Disease Report* 30:137-144.
- Boland GJ and R Hall. 1994. Index of plant hosts of *Sclerotinia sclerotiorum*. *Canadian Journal of Plant Pathology* 9:218-224.
- Brown JG and KD Butler. 1936. Sclerotinosis of lettuce in Arizona. *Ariz Agri. Exp. Stn. Tech. Bull.* 63:475-506.

- Burgess DR and G Hepworth. 1996. Biocontrol of *Sclerotinia* stem rot (*Sclerotinia minor*) in sunflower by seed treatment with *Gliocladium virens*. *Plant Pathology* 45(3):583-592.
- Butler EJ. 1931. Fungi and diseases in plants. Cited from RS Singh. 1996. *Plant disease: Disease caused by Ascomycotina*.
- Campbell WA. 1947. A new species of *Coniothyrium* parasitic on sclerotia. *Mycologia* 39:190-195.
- Coley-Smith JR and RC Cooke. 1971. Survival and germination of fungal sclerotia. *Annual Review of Phytopathology* 9:65-92.
- Dickson F. 1930. Studies on *Sclerotinia sclerotiorum* (Lib) de Bary. *PhD Thesis*. Cornell University, Ithaca, New York. 136pp.
- Dillon-Weston WAR, RA Loveless and ER Taylor. 1946. Clover rot. *Journal of Agricultural Sciences* 36:18-28.
- Duwadi VR. 1999. Integrated management of stalk rot disease (*Sclerotinia sclerotiorum*) of cauliflower in the eastern hills of Nepal. *PhD Thesis*. University of Greenwich, UK.
- Duwadi VR, RB Paneru and MR Bhattarai. 1993. An estimate of yield loss of cauliflower (cv Kibogaint) seed caused by *Sclerotinia sclerotiorum*. *PAC Working Paper no.52*, Pakhribas Agricultural Centre, C/o BAPSO, PO Box 106, Kathmandu, Nepal.
- Farr DF, GF Bills, GP Chammuris and AY Rossman. 1989. *Fungi on plants and plant products in the United States*. APS Press, St. Paul, Minn. 1252pp.
- Hoes JA and HC Huang. 1975. *Sclerotinia sclerotiorum*: Viability and separation of sclerotia from soil. *Phytopathology* 65:1431-1432.
- Huang HC and JA Hoes. 1976. Penetration and infection of *Sclerotinia sclerotiorum* by *Coniothyrium minitans*. *Canadian Journal of Botany* 54:406-410.
- Huang HC and J Dueck. 1980. Wilt of sunflower from infection by mycelial germinating sclerotia of *Sclerotinia sclerotiorum*. *Canadian Journal of Plant Pathology* 2:26-32.
- Hungerford CW and R Pitts. 1953. The sclerotinia disease of beans in Idaho. *Phytopathology* 43:519-521.
- Inglis GD and GJ Boland. 1992. Evaluation of filamentous fungi isolated from petals of beans and rape seed for suppression of white mould. *Canadian Journal of Microbiology* 38:124-129.
- Jamaux I, B Gelie and C Lamarque. 1995. Early stages of infection of rape seed petals and leaves by *Sclerotinia sclerotiorum* revealed by scanning electron microscopy. *Plant Pathology* 44(1):22-23.
- Jones D and D Watson. 1969. Parasitism and lysis by fungi of *Sclerotinia sclerotiorum* (Lib) de Bary, a phytopathogenic fungus. *Nature* 224:287-288.
- Kapoor KS. 1985. A technique for artificial inoculation of cauliflower seedlings with *Sclerotinia sclerotiorum* (Lib) de Bary. *Phytopathologische Zeitschrift* 122(2):191-192.
- Kapoor KS. 1986. Disease resistance in cauliflower (*Brassica oleracea* L. var *botrytis*) against *Sclerotinia sclerotiorum* (lib) de bary. **In:** *Proceedings of National Symposium on New Horizons in Resistant Breeding of Vegetable Crops*. Vegetable Science. 13(2): 285-288.
- Kapoor KS, HS Gill and SR Sharma. 1987. Survival and carpogenic germination of sclerotia of *Sclerotinia sclerotiorum*. *Indian Phytopathology* 40:500-502.
- Koirala GP, GB Thapa and GR Joshi. 1995. Can Nepalese compete in domestic market? A comparison of the relative setting and performance in agriculture of Nepal and India. *Research Report Series no. 34*. Winrock International, Policy Analysis of agriculture and related resources Management. Kathmandu, Nepal.
- Lumsden RD and JA Lewis. 1989. Biological control of soil borne plant pathogen, problems and progress. **In:** *Biotechnology of Fungi for improving plant growth* (JM Whipps and RD Lumsden, eds). Cambridge University Press, Cambridge.
- Marukawa S, S Funakawa and Y Satomura. 1974. Some physical and chemical factors on formation of Sclerotia in *Sclerotinia libertinia* Fukel. *Agr. Biol. Chem.* 39(2):463-468.
- Mehta PR and SK Bose. 1946. Some new hosts of *Sclerotinia sclerotiorum*. Cited from RH Singh. 1996. *Plant disease: Diseases caused by Ascomycotina*.
- Merriman PR. 1976. Survival of *Sclerotinia sclerotiorum* in soil. *Soil Biology and Biochemistry* 8:385-389.
- Millner PD, RD Lumsden and JA Lewis. 1982. Controlling plant disease with sludge compost. *Biocycle*. 23:50-52.
- Moore WD. 1949. Flooding as a means of destroying sclerotia of *Sclerotinia sclerotiorum*. *Phytopathology* 39:920-927.
- Morrall RAA and J Dueck. 1982. Epidemiology of *Sclerotinia* stem rot of rape seed in Saskatchewan. *Canadian Journal of Plant Pathology* 4:161-168.
- Mylchreest SJ and BEJ Wheeler. 1987. A method for inducing apothecia from sclerotia of *Sclerotinia sclerotiorum*. *Plant Pathology* 36:16-20.
- Neergaard P. 1958. Mycelial seed infection of certain crucifers by *Sclerotinia sclerotiorum* (Lib) de Bary. *Plant Disease Reporter* 42:1105-106.
- Purdy LH. 1979. *Sclerotinia sclerotiorum*: History, diseases and symptomatology, host range, geographic distribution and impact. Symposium on *Sclerotinia* (=whetzelinia): Taxonomy, Biology and Pathology. *Phytopathology* 69:675-880.
- Rekhi SS. 1983. Seed production status and future scope in Nepal. *Seed Production Development Strategy*, Ministry of Agriculture, HMG, Nepal.
- Scott SW and DR Evans. 1984. *Sclerotinia trifolium* in red clover seed. *Transactions of the British Mycology Society* 82:567-569.
- Sharma RC, SL Sharma, I Sharma. 1984. Verietal reaction of cauliflower against stalk rot by *Sclerotinia sclerotiorum* (lib) de Bary. *Crop improvement* 9(2):167-168.
- Shrestha K and RD Timila. 1990. Case history of some diseases of cauliflower in Nepal. **In:** *Proceedings review and programme discussion on vegetable and vegetable seed production*. VDD, DOH, HMG/FAO, Nepal.

- Shrestha K, K Singh, SB Mathur. 1989. *Major seed borne disease of selected vegetable crops of Nepal*. DGISPDC AND NARCS, HMG, Nepal.
- Shrestha SK. 1985a. Stalk rot major problem for cauliflower seed production. *Journal of Natural History Museum* 9(1-4):59-64.
- Shrestha SK. 1985b. Some important diseases of vegetables and their control measures. **In:** *Proceedings of 4th national Seminar on vegetables and vegetable seed production*. Vegetable Development Division, Department of Agriculture, GMG/Nepal.
- Shrestha TN and NP Ghimire. 1996. Fresh vegetable production in Nepal. **In:** *Proceedings of 4th national seminar on vegetables and vegetable seed production*. Vegetable Development Division, Department of Agriculture, GMG/Nepal.
- Shrestha KK. 1990. *Important diseases of vegetables in Nepal*.
- Singh H, TS Kalda. 1995. Screening of cauliflower germplasm against *Sclerotinia* rot. *Indian Journal of Genetics* 55(1):98-102.
- Tourneau DL. 1979. Morphology, cytology and physiology of *Sclerotinia sclerotiorum* in culture. *Phytopathology* 69:887-890.
- Tribe HT. 1957. On the parasitism of *Sclerotinia trifoliorum* by *Coniothyrium minitans*. *Transactions of the British Mycology Society* 40:489-499.
- Turner GJ and HT Tribe. 1976. On *Coniothyrium minitans* and its parasitism of *Sclerotinia sclerotiorum*. *Transactions of the British Mycology Society* 66:97-105.
- Willettts H and JA Wong. 1980. The biology of *Sclerotinia sclerotiorum*, *S. trifoliorum* and *S. minor* with emphasis on specific nomenclature. *The Botanical Review* 46:102-155.
- Willettts HJ and S Bullock. 1992. Review developmental biology of sclerotia. *Mycological Research* 96(10):801-816.

Phyllosticta Leaf Spot Disease of Ginger: Management and its Economic Analysis under Mid Hill Conditions of Nepal

Buddhi P Sharma¹ and Jib R Acharya²

¹ National Potato Research Programme, Khumaltar

² National Ginger Research Programme, Salyan

ABSTRACT

Phyllosticta leaf spot caused by *Phyllosticta zingiberi* Ramkr. is one of the widely spread diseases of ginger (*Zingiber officinale* Rosc.) occurring through out the ginger growing areas of the country. An experiment was conducted during three consecutive years 1997-1999 to estimate the yield losses and select cost effective fungicide against the disease under south faced hills located at 1450 masl at Kapurkot, Salyan. Five fungicides i.e. Mancozeb, Copperoxychloride, Carbendazim, Chlorothalonil and Bordeaux mixture were tested against leaf spot and compared with non-treated water sprayed plot. Highest efficacy was observed in Chlorothalonil with disease control 54.0%. No significant yield losses had been observed in control plot, during the experimental period. Obtained results revealed that spraying of any fungicide up to the leaf spot severity of 47 % was not found to be economical for a released ginger variety Kapurkot Aduwa-1 (ZI-9721) under mid hill conditions.

Key words: Fungicides, ginger, *Phyllosticta* leaf spot, yield loss

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is one of the commercial horticultural export commodities of Nepal being grown basically in the mid hills in a wider geographic region from Mechi to Mahakali. Area under ginger in Nepal has been estimated to be 9189 hectares and production 87909 mt with the national average productivity of 9.57 t/ha (APSD 2002). Lack of high yielding varieties, poor soil fertility and poor knowledge of plant protection measures have been considered as bottlenecks for higher yield.

Regarding with the economically important diseases concern Phyllosticta leaf spot (*Phyllosticta zingiberi* Ramkr.) is the second important disease after rhizome rot. It is wide spread through out the ginger growing areas of the country but the severity of the disease was found to be quite variable 5 to 40 % depending on the cultivars grown, size of the rhizome bits planted, cropping pattern and inter cropping and light intensity due to sloping direction of the land (Sharma 2000). Since this disease is epidemic, ginger farmers of many locations have been found to be worried on this disease with the assumptions of high yield loss. Leaf spot and rhizome rot may occur on the same plant under such conditions farmers get confused for identifying primary causal factor of yield loss.

Phyllosticta leaf spot is observed on leaves especially when the crop is grown under exposed conditions. The disease starts as water soaked, oval to elongated spots and later turns as whitish spot surrounded by dark brown margin with a yellowish halo. Pycnidia appear on mature lesions and remain viable for about 14 months in leaf debris. Spores ooze out into water drops on the leaves and get dispersed through rain splashes (Brahma and Nambiar 1982, 1984).

The pathogen is seed and soil borne. *Phyllosticta* leaf spot is noticed at any stage of crop growth, but more often when the crop is around 3 months old specially during July-September which coincides with onset of monsoon. The disease spread is slow or absent when ginger is grown in shaded area.

Regarding with the resistant varieties to leaf spot Dohroo et al (1986) reported that none of the ginger clones screened was found resistant to *P. zingiberi*. However, cultivars Maran, Karakkal were reported to be field tolerant to *P. zingiberi* by Premnathan et al 1982). The disease can be managed by one or two spray of 1 % Bordeaux mixture (Sharma and Anandraj 1973).

However, majority of the farmers realized the extent of yield loss is lower than the rhizome rot. The yield loss caused by leaf spot was estimated to be ranging 5 to 10 % under Kerala and Himachal Pradesh hill conditions (Dake 1995). Under Nepalese mid hills conditions detail investigation on yield loss was not done in the past. However, Sharma *et al* (1998) reported that leaf spot severity ranged up to 40 % and yield loss roughly estimated 10 percent. Farmers are intended to spray fungicides to control leaf spot without knowing its economic threshold levels.

On the other hand, European and American Countries, which are the major consumers of ginger, have their own trade Associations ie European Spice Association (ESA) and American Spice Trade Association (ASTA). These Associations strictly follow their minimum quality standard (George 2000). When farmers are exposed to International quality standards and cleanliness specifications, farmers of Palpa have started growing "Organic ginger". Now they need to have disease resistant ginger varieties and economic threshold levels of frequently occurring diseases like rhizome rot and *Phyllosticta* leaf spot.

Keeping these points in view, an experiment was conducted with the objectives of measuring extent of damage due to *Phyllosticta* leaf spot and yield loss on promising ginger variety, selection of cost effective fungicides to manage the disease and minimize the cost of production.

MATERIALS AND METHODS

A field experiment was conducted under natural epiphytotic condition at Kapurkot, Salyan in the consecutive years 1997-1999 to evaluate the efficacy of fungicides and estimate the yield losses due to *Phyllosticta* leaf spot of ginger. There were six treatments including check with three replications arranged in a Randomized Complete Block Design. Fungicides were Mancozeb (Indofil M-45 0.25%), Copperoxychloride (Blitox- 50: 0.25%), Carbendazim (Bavistin 0.1%), Chlorothallonil (Kavach 0.15%), Bordeaux Mixture (4:4:50) and Check (Water spray). Plot size was 4.5 m² providing spacing between plot to plot and block to block, 0.5 m 1.0 m respectively. Experiment was planted on second week of April in all the three years.

Planting was done at 30- x 30-cm spacing with the seed rhizome bits of around 50 g weight having strong healthy sprout. Farmyard manure 30 t/ha was applied 5 days prior to planting during final land preparation. Chemical fertilizers were also applied 100:50:50 kg NPK/ha. Half dose of N, K₂O and full of P₂O₅ were used as basal during planting where as remaining half of N and K₂O were applied as top dressed during first and second intercultural operations. Dry leaves mulch 10 t/ha was applied just after planting to suppress the weeds and conserve the soil moisture since ginger was grown under rain fed conditions. *Phyllosticta* leaf spot disease usually occurs every year in almost all the ginger growing areas of the country but the severity of disease was found always higher on sole crops grown on field facing towards south. Even then, to build up the strong disease pressure, naturally infected leaves were incubated for 24 hours at 25°C under humid chamber to initiate the Pycniospore production. After incubation, infected leaves were macerated with the help of mortar and pestle, filtered and sprayed over the experimental plots at 90 days after planting (after first disease scoring) at 4-5 pm. This practice was followed in the first experimental years. Disease severity was recorded based on the leaf area damaged by leaf spot. Randomly thirty leaves were selected from three leaf positions lower, middle and top considering the similar leaf size from each plot. Depending on the level of disease severity, leaves were divided into 5 groups. Necrotic area on leaf surface was estimated on individual leaf and computed as follows.

$$\text{Leaf area damage (LAD), \%} = \frac{\text{Sum of all area damaged (\%) on leaves}}{\text{Total no of sample leaves}}$$

Fresh rhizome yield was also recorded at harvest after removing dirt, roots and pseudo stems. Spraying of fungicides was done at intervals of 15 days. Water was sprayed in each spraying on check plot instead of fungicide. Finally cost of disease control was also analyzed based on price of 1999.

RESULTS AND DISCUSSION

Etiology of fungus

Microscopic studies conducted at laboratory showed that, infected leaves with mature lesions when incubated into a humid chamber for 24 hours were found to be ready for Pycniospore release from pycnidium as volcanic explosion. Pinpoint brown or black dot like pycnidia could be seen on older lesions with the help of hand lens. Pycniospore get released from ostiole when pycnidium was submersed into water droplets. Pycniospores were hyaline, round or oblong.

Incidence and severity

During the early crop growth, some dwarf plants developed from shriveled rhizome bits were found to be more prone to *Phyllosticta* leaf spot infection as compared to tall plants of normal growth. In other hand, when secondary infection starts from onset of monsoon top tender leaves get severely infected than the lower and centrally located leaves. Disease incidence was 100% in all the plots irrespective of treatment but the severity was found to be variable between the treatments. Mean leaf spot severity of three years in the check plot was 47% and lowest on Chlorothallonil sprayed plot (21%). Disease severity was highest in 1997 (52.5%) followed by 1998 (49.7%) and 1999 (38.8%). Data are presented in Table 1. The reason behind it could be the amount of primary inoculum density of pathogen, rainfall and size of rhizome planted. Rainfall data of three years showed that in 1997 there was 14 rainy days prior to 85 days of crop whereas in 2nd and 3rd year rainy days were 7 and 12 respectively (Figure 6).

Table 1. Efficacy of fungicides to control *Phyllosticta* leaf spot under field conditions at Kapurkot, 1997 to 1999

SN	Treatment	Leaf spot severity, %				Disease control, %			
		1997	1998	1999	Mean	1997	1998	1999	Mean
1	Mancozeb (Indofil M-45)	48.60	43.47	33.30	41.79	15.1	20.6	14.1	16.6
2	Copperoxychloride (Blitox- 50)	35.10	25.80	28.07	29.66	33.1	58.2	48.2	46.5
3	Carbendazim (Bavistin)	38.00	28.02	23.77	29.93	27.6	43.6	38.7	36.6
4	Chlorothallonil (Kavach)	29.40	17.20	16.33	20.98	44.0	65.4	52.7	54.0
5	Bordeaux mixture (4:4:50)	36.80	26.32	24.70	29.27	35.6	55.1	36.3	42.3
6	Check (Water spray)	52.50	49.72	38.77	47.00	0.0	0.0	0	0.0
F test		**	**	**					
CV, %		7.37	13.78	12.43					
LSD (0.05)		4.9	7.2	5.7					

Efficacy of fungicides

Among the fungicides tested, Chlorothallonil 0.15 % was found to be significantly superior to control leaf spot (54%) than Mancozeb (16.6 %). However, Chlorothallonil, Blitox-50, Bavistin and Bordeaux mixture were found comparable (Figure 1). Among them cheapest one could be used for leaf spot control, if necessary.

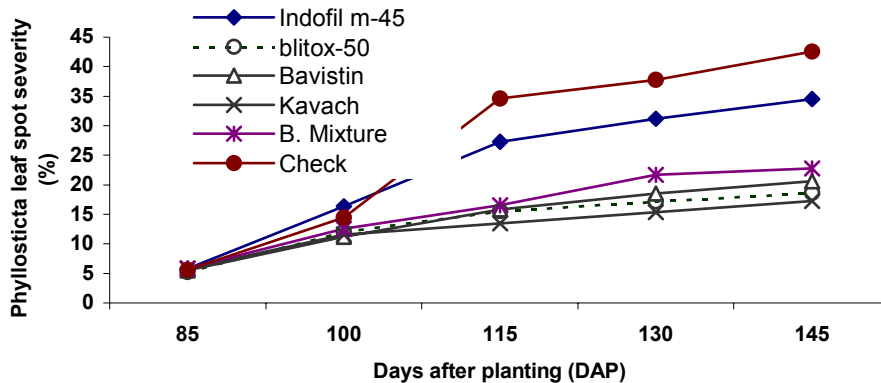


Figure 1. *Phyllosticta* leaf spot development after fungicides spray in different time intervals, mean of three years (1997-1999) at Kapurkot Salyan.

Effects on rhizome yield

There were no significant yield differences between the treatments in all the experimental years. Number of tillers per clump is one of the yield attributing characters of ginger was also found to be non significant (Table 2). There was no correlation observed between disease severity and rhizome yield.

Table 2. Effects of fungicides to control *Phyllosticta* leaf spot and its effect on tillers and rhizome yield under field condition at Kapurkot, during 1997 to 1999

SN	Treatment	Tillers /clump				Yield, t/ha				Yield loss, %
		1997	1998	1999	Mean	1997	1998	1999	Mean	
1	Mancozeb (Indofil M-45 @ 0.25%)	8.20	7.90	6.40	7.5	42.38	43.23	54.33	46.65	4.42
2	Copperoxychloride (Blitox- 50 @ 0.25%)	7.70	6.00	5.90	6.5	41.57	49.52	54.03	48.37	0.88
3	Carbendazim (Bavistin @ 0.1%)	8.30	7.30	5.70	7.1	40.53	41.80	57.20	46.51	4.69
4	Chlorthalonil (Kavach @0.15%)	6.75	7.70	6.80	7.1	42.43	45.20	58.77	48.80	0.00
5	Bordeaux Mixture (4:4:50)	9.50	8.10	6.20	7.9	37.63	47.13	54.33	46.36	5.00
6	Check (Water spray)	7.90	6.80	6.10	6.9	37.13	41.20	51.13	43.15	11.57
	F test	NS	NS	NS		NS	NS	NS		
	CV, %	15.8	16.7	29.3		7.60	10.24	6.98		

Conducive environment

Micro weather conditions favor for leaf spot disease development. At 70 days after planting infection was just started on tender leaves of dwarf plants. With the onset of monsoon due to secondary infections disease progressed rapidly from 80 to 145 DAP (Figure 1). Precipitation and sunshine hours were found to be responsible for disease development. Amount of precipitation and leaf spot severity was found positively correlated ($r=0.95$) where as, duration of sunshine was found to be negatively correlated ($r= -0.98$) with leaf spot severity (Figure 2, 3 and 4). There was no significant variation in minimum (19.8-20.6°C) and maximum (25.2-26.3°C) temperatures during the disease progress period (Figure 5).

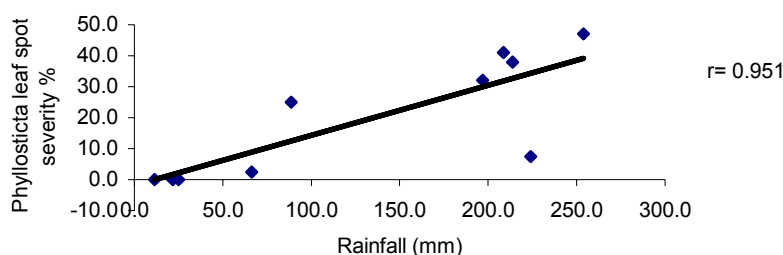


Figure 2. Correlation between amount of rainfall and *Phyllosticta* leaf spot disease severity at Kapurkot Salyan 1500 masl during 1998-99.

It has been reported that when crop is exposed to Sun, severity of disease was found to be high as compared to crops of shaded areas. This experiment showed that with the presence of sufficient water droplets, even two hours of sunlight exposure enhance the severity of *Phyllosticta* leaf spot (Figure 3).

Yield loss assessment

There were no significant yield differences observed between the treatments in all the three years 1997 to 1999. When yields of check plot and 54% disease control plots were compared losses appears 11.57% in untreated plots (Table 2). This difference was not found significant since yields of treatments were at par. It clearly shows that leaf spot severity up to 47% on ginger variety ZI-9721 (Kapurkot Aduwa-1) does not need any fungicide spray to control *Phyllosticta* leaf spot. This statement may not hold true for all the ginger cultivars which are of short plant and grown under poor soil fertility conditions.

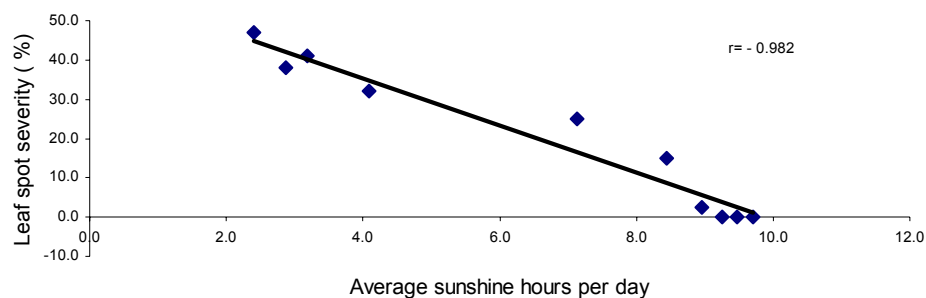


Figure 3. Correlation of sunshine hours and leaf spot severity during the observational period at Kapurkot, Salyan during 1997-1999.

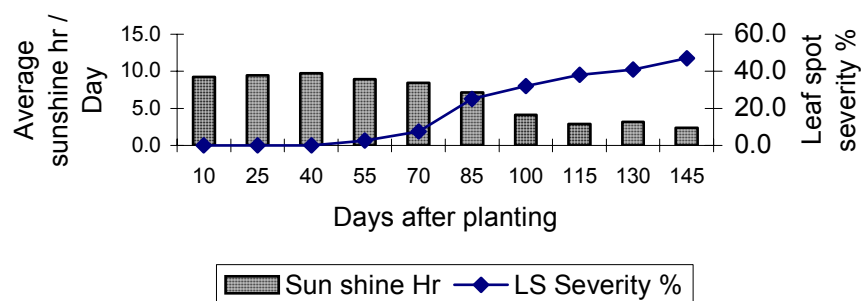


Figure 4. Effects of sun shine hours on *Phyllosticta* leaf spot severity under south faced mid hills (1450 masl) at Kapurkot, Salyan.

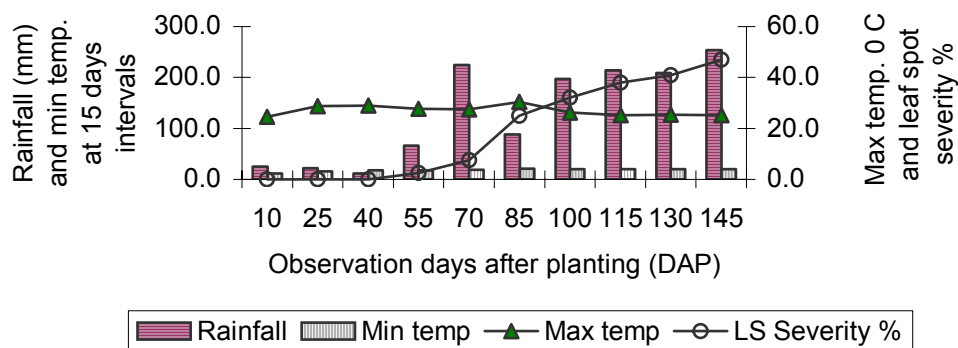


Figure 5. Effects of rainfall and temperatures on *Phyllosticta* leaf spot severity.

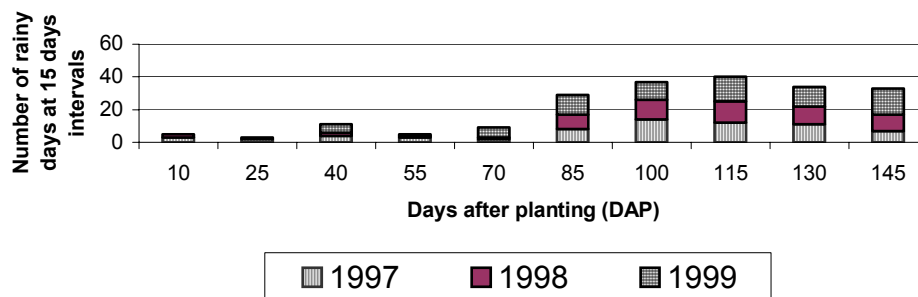


Figure 6. Number of rainy days during crop period up to 145 DAP in three consecutive years 1997-1999 at Kapurkot, Salyan.

Economic analysis of disease control

Out of four effective fungicides, cost of Chlorothallonil application per hectare was found higher (Rs8631) followed by Carbendazim (Rs8069) and Bordeaux mixture (Rs8631) and Copperoxychloride (Rs6250) as shown in Table 3. Bordeaux mixture preparation should be cheaper but due to high price of Copper sulphate in the local market it became expensive than the Blitox-50. Results of this study certainly would guide for fungicide selection on other leaf spot susceptible cultivars under disease conducive environments. Results clearly showed that use of fungicides increasing cost of production and simultaneously environmental pollutions as well.

Table 3. Economic analysis of fungicides spray to control *Phyllosticta* leaf spot at Kapurkot, Salyan in 1999

SN	Treatment	Rhizome yield, t/ha	Yield increase over check, t/ha	Additional cost of treatment, Rs/ha
1	Mancozeb (Indofil M-45)	46.65	3.49	4694
2	Copperoxychloride (Blitox- 50)	48.37	5.22	5116
3	Carbendazim (Bavistin)	46.51	3.36	8069
4	Chlorothallonil (Kavach)	48.80	5.65	8631
5	Bordeaux Mixture (4:4:50)	46.36	3.21	6250
6	Check (Water spray)	43.15	0.00	0

Price rate of spray inputs: Indofil M-45 Rs165/500 g. Blitox-50 Rs175/500 g. Copper sulphate Rs130 /kg. Llime (CaO) Rs25/kg. Bavistin Rs115/100 g. Kavach Rs125 /100 g. Labour Rs80/labour/ day.

CONCLUSION

Phyllosticta leaf spot is one of the wide spread diseases of ginger (*Zingiber officinale* Rosc.) occurring through the ginger growing areas of the country. Phyllosticta leaf spot could be effectively controlled with any one of the four fungicides ie Chlorothallonil, Copperoxychloride, Carbendazim, and Bordeaux mixture. The mean severity of disease over the three years in the check plot reached up to 47 %. There was no significant yield increase even with the disease control of 54% by chlorothallonil spray. Since yield was not significantly increased, means there was no yield losses due to Phyllosticta leaf spot. Experimental results showed that spraying of any fungicide up to the leaf spot severity of 47 % was not found to be economical for a released ginger variety Kapurkot Aduwa-1 (ZI-9721) under mid hill conditions. Sufficient amount of precipitation (>1000 mm) and minimum sunshine (2 hrs) during mid growth period enhance the disease development. Bold rhizome bits with strong sprout of "Kapurkot Aduwa-1" variety when planted in a fertile soil preferably in humus soil does not need fungicide spray to control Phyllosticta leaf spot under mid hill conditions.

REFERENCES

- APSD. 2002. His Majesty's Government, Ministry of Agriculture and Cooperatives. *Agri-Business Promotion and statistics Division*, Singh Darbar Kathmandu, Nepal.
- Brahma RN and KRN Nambiar. 1982. Survival of *Phyllosticta zingiberi* Ramakr., causal agent of leaf spot disease of ginger. **In:** *Proc. National Seminar on Ginger and Turmeric*. 8-9 April Calicut.
- Brahma RN and KRN Nambiar. 1984. Spore release and dispersal in ginger leaf spot pathogen *Phyllosticta zingiberi*. **In:** *Proc. PLACROSYM Indian Society for Plantation Crops*, Kasaragod, India. Pp.541-554.
- Dake GN.1995. Diseases of ginger (*Zingiber officinale* Rosc.) and their management. *Journal of Spices and Aeromatic Crops* 4(1):40-48.
- Dohroo NP, KR Shyam, SS Bhardwaj and BN Korla.1986. Reaction of ginger germplasms to *Phyllosticta* leaf spot. *Indian Phytopath.* 39:605-606.
- George CK. 2000. Quality assurance of spices and herbs. *Paper presented at the National Workshop on Spice Quality and Export Possibility*. FNCCI, Kathmandu.
- Premanathan T, CK Peethambaran and A Chiran. 1982. Screening of ginger cultivars against *Phyllosticta* leaf spot. **In:** *Proc. National Seminar on Ginger and Turmeric*. 8-9 April Calicut.
- Sharma YR and M Anandraj. 2000. Diseases of spices crops and their management. *Indian Journal of Areca nut, Spices and Medicinal Plants* 12(1):13-19.
- Sharma BP, SK Shrestha and YP Giri.1998. Present status of disease and insect pest of ginger in Nepal. **In:** *Proc. Second National Horticulture Workshop*. Pakhribas. Pp.173-178.
- Sharma BP. 2000. Ginger an exportable commodity: Scenario of research, production and export. **In:** *Proceedings of Third National Horticultural Workshop*. 7-8 June 200.

Status of Disease of Large Cardamom in Nepal

Dol P Dhakal and Sundar K Shrestha

Plant Pathology Division, NARC, Kathmandu

ABSTRACT

This study is concerned with the major diseases affecting plantation decline and production losses of large cardamom in the eastern hills of Nepal. Rapid rural appraisal (RRA) and participatory rural appraisal (PRA) along with scientific field survey were carried out in the five cardamom growing sites that were selected on the basis of key informants for the study. Based on the farmers perceptions, large cardamom cultivation has been threatened by numbers of factors such as diseases (eg rhizome rot, viral diseases like Foorkey and Chhirkey and other leaf diseases), insect pests (eg stem borer, leaf eating caterpillars), vertebrate pest (eg *Kala*, rodent, monkey and squirrel) and natural calamities (eg drought and frost) in the study area of the eastern hills of Nepal. Disease incidence in the field was also studied through scientific field survey for crosschecking of information generated through participatory approaches. Rhizome rot was ranked as the first priority problem faced by the farmers in terms of immediate production effect whereas Foorkey was ranked as the first priority disease for long-term plantation declined. Chhirkey was ranked as the third priority disease both for production and plantation of large cardamom. The disease incidence was found to decrease with the increase in plantation altitude and vice versa. The incidences of rhizome rot at the lower altitudes at Fikkal and Panchakanya VDCs of Ilam district were ca. 17% and 23% respectively. At the higher altitudes of Panchakanya VDC, Ilam and Madhimulkharka VDC, Sankhuwasawa the incidence of rhizome rot were ca. 9% and 14%. The incidence of Foorkey disease was found to decrease with altitude. It was recorded ca. 15%, 12% and 11% in three-study site of Panchkanya VDC. Foorkey disease incidence in Fikkal and Madhimulkharka VDCs was ca. 7% and 10%. The Chhirkey disease was only recorded in Sankhuwasawa District among the five studied sites. Disease incidence was ca. 4%.

INTRODUCTION

Diseases are major problem for the production of large cardamom both in Nepal and in cardamom growing areas of India. The Indian Council for Agricultural Research (ICAR), Research complex for North East Hills (NEH) region has recorded 15 diseases of large cardamom. Of these all diseases, two diseases were of viral origin (Chhirkey-Mosaic streaks and Foorkey, 11 diseases were of fungal origin, one nematode and one algae disease (Srivastava 2000).

Two unidentified diseases, angular purple leaf spot and Kanchanjungha leaf blight were also reported from India. However, scientists of Spices Board and Govinda Baldav Pant University, India prioritised Foorkey and Chhirkey as the major diseases of the crop.

Shrestha (1998) reported Foorkey and Chhirkey (viral diseases), rhizome rots caused by *Fusarium* sp, *Pythium* sp.; Leaf blight caused by *Coniothirum* sp. and *Alternaria* sp. He further highlighted that rhizome rot is the major disease with high to medium severity that has spread to almost all the cardamom growing areas in Nepal. It alone reduces the yield up to 50% (Duwadi, unpublished). Chhirkey and Foorkey are viral diseases and Chhirkey is reported as mosaic streak virus from India (Raychaudhari 1964).

The main objectives of this study were to investigate the status of large cardamom diseases perceived by the farmers involved in the study and to cross check them in the field by quantifying disease incidence through scientific field survey in the eastern hills of Nepal.

MATERIALS AND METHODS

Madhimulkharka Village Development Committee (VDC) of Sankhuwasawa district and Fikkal and Panchakanya (VDCs) of Ilam district were selected for the study. The five representative sites were surveyed from three VDCs of these two districts. These two districts are the main pockets for large cardamom production in Nepal covering about 50% of the area and production (Anon, 2000). Among the VDCs, Panchakanya and Fikkal are the potential VDCs in Ilam and Madhimulkharka is the main pocket within Sankhuwasawa district. Moreover, these VDCs cover the wide range of representative climate (warm sub-tropical to cool temperate), topography, soil types and altitudes zones (1200-2000 masl) for large cardamom cultivation in Nepal. Therefore, the representative five sites from three VDCs of the two districts were surveyed. Three sites, namely high altitude (ca. 1700 masl), mid altitude (around 1600 masl) and low altitude (ca. 1400 masl) from Panchakanya VDC, one site (ca. 1700 masl) from Fikkal VDC of Ilam district and another one site (ca. 1800 masl) from Madhimulkharka VDC of Sankhuwasawa district were taken for this study. Participatory Rural Appraisal (PRA), rapid rural appraisal (RRA) follow by group discussions, problem ranking, field observations, problem cause analysis and semi-structural questionnaire techniques were used for the field survey. Five groups of farmers, each consisting of 16 farmers were formed at each site.

For cross checking the results obtained from survey, fifty orchards, 30 from Panchakanya VDC (1200-17500 masl), Ilam and 10 each from Fikkal VDC (1300-1700 masl), Ilam District and Madhimulkharka VDC (1800-1950 masl) (Sankhuwasawa district) were randomly selected for direct observations from five different growing sites. These fifty farmer's fields, in the above mentioned two districts, from a range of different altitudes, were studied to evaluate disease incidence and its relationship with altitude. From each selected orchard, 100 m² areas from the central part of the orchard were marked using plastic ropes and wooden sticks. From these selected 100 m² areas, the total number of clumps and tillers were counted and recorded. Disease incidence was recorded for rhizome rot, Foorkey, Chhikey and total number of diseased clumps. Average numbers of tillers were obtained from a random selection of 10 clumps to determine the typical numbers of tillers per clumps.

RESULTS AND DISCUSSION

Main problems of large cardamom cultivation

There are a series of problems faced by the growers of large cardamom. The majority of the respondents (66%) reported that they are facing many simultaneous problems. Table 1 gives the distribution of problems faced by the growers from each of the participating villages. Four percent of the total respondents were facing abiotic problems eg drought and frost and 30% of them are facing biotic problems caused by insect pests, diseases and vertebrate pests (eg monkeys, rodents, *Kala*, squirrel). Among these problems, ca. 24% of the respondents reported disease and insect pest problems and the rest are facing problems from vertebrate pests. More than 66% of the respondents are facing a range of problems like diseases, insects and vertebrate pests, drought, frost and marketing.

Table 1. Main problems for cultivation of large cardamom in Ilam and Shankhuwasawa districts

Types of problems	Number of farmers					Percent	
	Panchakanya VDC, Ilam, m			Fikal VDC, Ilam, m	Mulkharka VDC, Sankhuwasawa, m		
	1400	1600	1700	1700	1800-1950	Total	
A-biotic Problems	1	0	0	1	1	3	4
Biotic Problems	5	3	6	7	3	24	30
Diseases and Pests	4	3	4	5	3	19	24
Vertebrate Pests	1	0	2	2	0	5	6
Multi-faced problems	10	13	10	8	12	53	66
Total	16	16	16	16	16	80	100

Multi-faced problems: -Two or more than two problems simultaneously. Abiotic problems, Drought, frost, etc.

Disease prioritization by the farmers

Rhizome rot disease was ranked as the first most important disease followed by foorkey at 1400 masl altitude, whereas equal scores were obtained for rhizome rot and Foorkey at 1600 masl in Panchakanya VDC. Foorkey was the second most important disease at this altitude. Foorkey ranked first followed by rizome rot at 1700 masl in the same VDC. Foorkey was ranked as the first priority disease followed by rhizome rot at Fikkal VDC, Ilam. Almost all the respondents from Ilam ranked Chhirkey disease as the third priority disease. In Madhimulkharka VDC, Sankhuwasava district with altitudes ranging from 1800-1950 masl, foorkey was ranked first and rhizome rot as second priority disease followed by Chhirkey as third (Table 2).

Table 2. Farmers' prioritisation of diseases

Name of disease	Rankings											
	Panchakanya VDC, Ilam						Fikkal VDC, Ilam			Mulkharkha VDC, Sankhuwasawa		
	1400 masl			1600 masl			1700 masl			1700 masl		
	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd
Rhizomerot	9 ¹ (56) ²	7 (44)	-	8 (50)	8 (50)	-	7 (44)	9 (56)	-	6 (37)	10 (63)	-
Oorkey	7 (44)	9 (56)	-	8 (50)	8 (50)	-	9 (56)	7 (44)	-	10 (63)	6 (37)	-
Chhirkey	-	-	16 (100)	-	-	16 (100)	-	-	16 (100)	-	-	16 (100)
Other Diseases	-	-	-	-	-	-	-	-	-	-	-	-

Figure within the parenthesis indicate percentage. Although this survey was carried out during the dry period when rhizome rot disease symptoms were not clearly visible in the field, farmers were giving their views following their experiences

Farmer perception of production losses due to diseases

The Table 3 indicates the trends of total production losses due to diseases at two districts. Of the 80 respondents, 9 have experienced more than 60% losses and 13 have found less than 20% losses due to diseases. Similarly, twenty-two respondents reported that they were loosing 21-40% and 36 respondents reported loosing 41-60% of their production as a result of disease attack.

Table 3. Production losses due to diseases

Total losses due to all diseases	Number of farmer					Total	Percent
	Panchakanya VDC, Ilam		Fikal VDC, Ilam		Mulkharka VDC, Sankhuwasawa		
	1400 masl	1600 masl	1700 masl	1700 masl	1800-1950 masl		
0- 20%	0	4	1	2	6	13	16.25
21-40%	5	2	8	2	5	22	27.50
41-60%	9	8	5	9	5	36	45.00
> 60%	2	2	2	3	0	9	11.25
Total	16	16	16	16	16	80	100.00

Regarding the losses due to rhizome rot, 9% (7) farmers were found facing less than 10% and only 1% of them reported that they were facing more than 50% of their production losses due to rhizome rot disease. Majorities (55%) of these respondents reported that a range of 10-20% of their production was lost due to rhizome rot disease lone (Figure 1).

Farmers perception of the possible causes of large cardamom diseases in the study area

When farmers were asked what they would consider could be the possible causes for the diseases they observed in their large cardamom crops, the majority (74%) opinionated that they were unknown. Some suggested that disease symptoms were a consequence of growing on unsuitable land (10%), and a few farmers suggested that they were cultivating unsuitable varieties (1%). Water logged and poor nutrition was each cited by 3% of participating farmers. Importantly, only 10% of farmers suspected that poor crop health was caused by pests and / or diseases (4% cited disease and 6% pests as the cause of unhealthy crops).

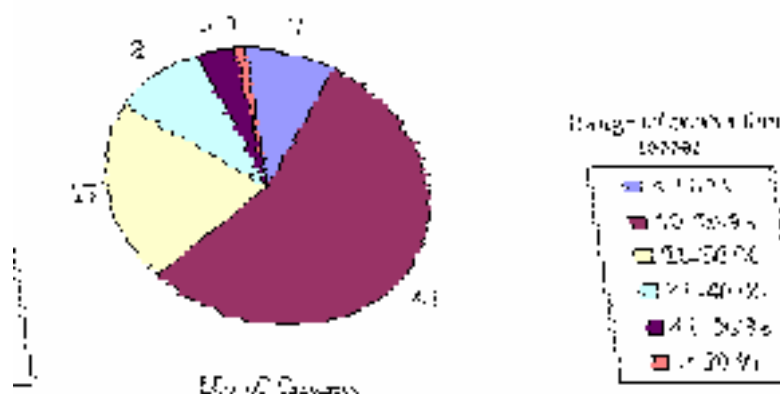


Figure 1. Production losses due to rhizome rot disease in the study area.

Disease incidence

The survey revealed that disease incidence was high at low altitude (1200-1375 masl and 1400-1550 masl) and it was quite low at high altitude (1600-1750 masl) in Panchakanya VDC of Ilam district. The incidence of diseases in Fikkal VDC at 1300-1400 masl was 26%, whereas at the same altitude range, the disease incidence was recorded 45% at Panchakanya VDC. The incidence of rhizome rot and Foorkey disease were found to be highly affected by altitudes. Lower disease incidence was recorded at increased altitude. The incidences of rhizome rot at the lower altitudes from Fikkal and Panchakanya VDCs of Ilam district were ca. 17% and 23% respectively. The total disease incidence was 21% in the higher altitude (1600-1750 masl) in Panchakanya VDCs of Ilam district. In Madhimulkharka VDC of Sankhuwasawa District, total disease incidence was 31%. At the higher altitudes of Panchakanya VDC, Ilam and Madhimulkharka VDC, Sankhuwasawa the incidence of rhizome rot were ca. 9% and 14% respectively. The incidence of Foorkey disease was found to decrease with altitude and was recorded ca. 15%, 12% and 11% in three study site of Panchakanya VDC. Foorkey disease incidence in Fikkal and Madhimulkharka VDCs was ca. 7% and 10%. The lower percentage of Foorkey disease in Fikkal may be due to rouging practice adopted by the farmers when it appeared on their farm. The Chhirkey disease was only recorded in Sankhuwasawa district among the five studied sites and its incidence was found ca. 4 %.

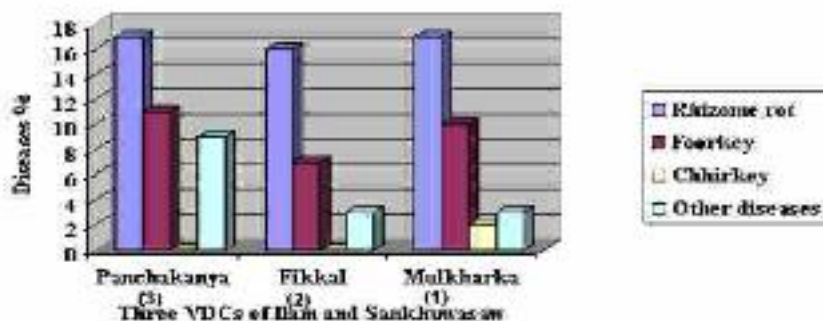


Figure 2. Disease situation in the study villages of Ilam and Sankhuwasawa.

The average percentage of diseases at two VDCs of Ilam and one VDC of Sankhuwasawa district is presented in Figure 2. Chhirkey disease was only observed in Sankhuwasawa district whereas rhizome rots, Foorkey and other diseases (foliar diseases) were observed at all sites. The average percentage of rhizome rot disease was ca 16% at all VDCs whereas that of Foorkey was ca. 10% in Panchakanya VDC, Ilam and Madhimulkharka VDC, Sankhuwasawa but about 7% at Fikkal VDC of Ilam district (Figure 2). The farmers in Fikkal areas are more aware and they immediately destroy the diseased clump when it appears in their fields. This could be the reason for lower percentage of Foorkey disease in Fikkal area. In early days, some orchards were already wiped out by this disease in this area.

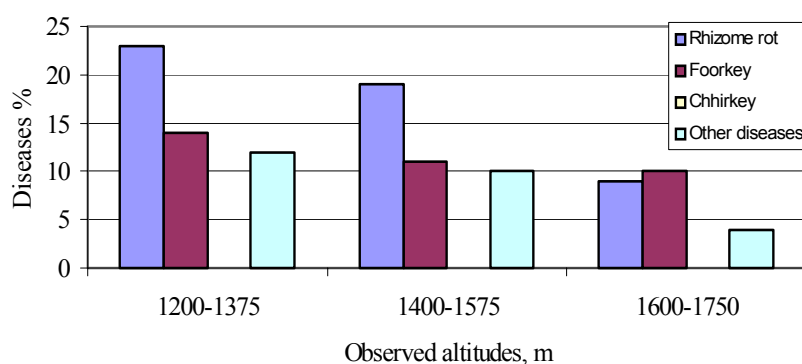


Figure 3. Disease situations in three altitudes at Panchakanya VDC, Ilam.

Although there was no Chhirkey disease at all observed altitudes, rhizome rot, Foorkey and other diseases were related to altitude. It has been found that the higher the altitudes the lower the diseases occurrence and vice versa. The lower percentage of all diseases was observed at the higher altitudes and vice versa (Figure 3).

Table 4. Summary of field observations in two districts of Nepal

Parameter	Sites altitudes, m				
	Panchakanya, Ilam			Fikkal, Ilam	Madhimulkhark, Sankhuwasawa
	1200-1375	1400-1575	1600-1750	1300-1400	1800-1950
Large cardamom clumps per 100 m ²	21.2	26.8	21.1	24.7	19.9
Diseased clumps, %	45.3	40	22	25.9	31.1
Rhizome rot infected clumps, %	22.8	18.9	8.6	16.4	13.4
Foorkey disease infected clumps, %	14.3	11.2	10.4	6.9	9.5
Chhirkey disease infected clumps, %	0	0	0	0	3.5
Other disease infected clumps, %	12.2	10.1	4.4	2.6	4.6
Tillers per clump, %	40.6	39	39.9	57.6	43.2
<i>Average per 100 m².</i>					

CONCLUSION

The study showed that rhizome rot was ranked by farmers as the most important disease problem in terms of production losses, but the Foorkey was the most serious problem in terms of its long-term effect on large cardamom plantations. Plantations have decline and production losses are the most serious problem for large cardamom cultivation in Nepal. Although there are many factors responsible for these problems, diseases are becoming most serious constraint for large cardamom production (1996-2000). The average losses were 44%, caused by all the diseases on large cardamom. Rhizome rot alone can causes up to 75% losses. The study showed that the majority of the farmers are not aware about the causes of these diseases. A number of the farmers considered that diseases may be caused either by unsuitable planting environments (drought, water logged soil, high or low temperature), unsuitable planting materials or by poor orchard management, whereas others feel this may be due to biotic factors such as pathogens or insects.

The average number of clumps/100 m² is 23, which has no relationship to altitude. The average number of tillers/clump is 45. The number of tillers/clump was not related to altitude or disease incidence. There is however, a relationship between disease incidence and altitudes. If the altitude is lower, the diseases occur more frequently. The incidence of total diseases in Fikkal VDC at 1305-1400 masl was 26%, which was lower than 45% recorded in the same range of altitude in Panchkanya VDC. In Madhimulkharka VDC of Sankhuwasawa district, total disease incidence was 31%. The total disease incidence was 21% in the higher altitude (1600-1750 masl) in Panchakanya VDC of Ilam district.

The incidence of rhizome rot and Foorkey disease was found to be highly affected by altitudes. Decrease disease incidence was recorded at increased altitude. The incidences of rhizome rot at the lower altitudes from Fikkal and Panchakanya VDCs of Ilam district were ca. 17% and 23% respectively. At the higher altitudes of Panchakanya VDC, Ilam and Madhimulkharka VDC, Sankhuwasawa the incidence of rhizome rot were ca. 9% and 14%. The incidence of Foorkey disease was found to decrease with altitude it was recorded ca. 15%, 12% and 11% in three-study site of Panchkanya VDC. Foorkey disease incidence in Fikkal and Madhimulkharka VDCs was ca. 7% and 10%. The lower percentage of Foorkey disease in Fikkal was may be due to rouging practice adopted by the farmers when it appeared on their farm. The Chhirkey disease was only recorded in Sankhuwasawa district among the five studied sites. Disease incidence was ca. 4%.

REFERENCES

- Dhakal DP. 2001. Study of the significance and causes of rhizome rot disease of large cardamom in the mid hills of Nepal. *MSc Thesis*. NRI, University of Greenwich, United Kingdom.
- Manandhar HK and DP Dhakal. 1996. *Tour report on cardamom of Ilam and Panchthar districts*. Plant Pathology Division, Khumaltar, Lalitpur, Nepal.
- Raychaudhari SP and S Chatterjee. 1964. Aphid transmission of a new a mosaic streak disease of large cardamom. *Phytopathology* 54: 904.
- Shrestha SK. 1998. Diseases and pest of cardamom: Its magnitude and distribution in Nepal. *Proceedings of the Seminar/Workshop on Cardamom Production, Research and Marketing*. Cardamom Development Centre, Fikkal, Ilam, 9-10 March 1998. Pp.49-53.
- Srivastava. 2000. *Diseases of large cardamom and their management in North Eastern hills region*. ICAR Research Complex for NEH Region Sikkim Centre, Tadong-737 102, Sikkim.

Estimation of Plant Nutrients Content in Biogas Slurry and Losses during Handling

Krishna B Karki

Soil Science Division, NARC, Khumaltar

ABSTRACT

Biogas plants in Nepal have been installed with the objectives of substituting firewood and dung cakes that are used as kitchen fuel, improving health of rural women by reducing obnoxious smoke in the kitchen and increasing crop production by the use of biogas slurry. With the establishment of over 100,000 biogas plants in the rural areas of Nepal there has been substantial improvement in the reduction of forest clearance and in women health. Biogas slurry is an excellent organic fertilizer, if properly used note worthy reduction in the importation of expensive mineral fertilizer and sustainable crop production could be achieved. Therefore, Ministry of Agriculture and Cooperatives should pay proper attention in the use of biogas slurry that helps to sustain crop production.

Key words: Biogas, environment, slurry, sustainability

INTRODUCTION

Biogas plants are installed in Nepal with the main objectives of reducing deforestation and improving the environmental condition, including health and hygiene of rural population, especially women and increasing crop production by the use of biogas effluent. Because of ignorance, manure produced from over 100,000 biogas installed to date has been neglected. It has been calculated that from the envisaged 1.3 million potential family-sized biogas plants (6-8 m³) in Nepal, 1.90 million MT of compost would be produced (Gajurel et al 1994). From this amount of compost, 23,385 MT of N (on dry weight basis) could be supplied. Additionally it could provide 14,259 MT P₂O₅ and 28,518 MT and K₂O. This amount of N, P₂O₅ and K₂O would be equal to 36.32%, 58.68% and 1807% of the fertilizing nutrients consumed during 1994/95 from the mineral source (Karki 2002). The same amount would be equal to 58.95%, 37.24% and 1,862% N, P₂O₅ and K₂O of the projected demand for the year 1996/97. These estimates show that biogas slurry can play an important role in substituting the mineral nutrient required by Nepalese soils (Karki and Gurung 1996, Karki 1995, Joshi 1997).

Biogas slurry is liquid. Application of liquid fertilizer is not practical in Nepalese condition. Applying directly to the field may be harmful (Sathianathan 1975, Maskey 1978, FAO 1996). Farmers dry it in the sun to make it lighter before it is transported to the field and leave it on the field for some time. Farmers plough it under the soil only when they get time to do so. While doing so, more than 50% of the total nitrogen is lost in the air (Demont et al 1991). During the process of methane generation all the plant nutrients are converted into the available form. Therefore, most of the available nitrogen escapes into the atmosphere when exposed to sun. This necessitates a study on the loss of plant nutrients at various stages of application and handling.

METHODOLOGY

Sites for sample collection

Three biogas villages representing two ecological regions were selected for this study. Bharatpur of Chitwan was selected from the Tarai Region, whereas Benighat of Dhading and Mahadevsthan of Kavre from hill region. Farmers participating in the slurry extension programme and non-participating farmers were selected for fresh

dung, fresh slurry and compost collection. The samples were analyzed for moisture, organic carbon (OC), total nitrogen (N), pH, total phosphorus (P) and total potash (K).

Samples collection

Samples from different farmers following various practices were collected for the laboratory analysis. The conditions of samples were as follows:

1. Fresh slurry
2. Slurry/compost from pits
 - Slurry from collection tank
 - Slurry compost from compost pit at three different layers that is from surface, mid-depth of the pit and bottom of pit
 - Composted slurry with dry matter
 - Slurry/compost from shaded pits
 - Slurry / compost from open pit
 - Slurry/compost from the pit covered with straw and grasses
3. Slurry dried outside the pit and applied to the field

All the samples were collected in duplicates representing the Tarai and hill regions. In all, 34 farmers were selected for the study. One half of them were from Dhading and Kavre and the rest were from Chitwan. Slurry was collected from the outlets of the biogas digester. From a well functioning biogas plant that was from a farmer of Chitawan, about 40 liters of fresh slurry was collected in a container. From this, a liter of slurry was poured in 18 plastic basins and dried in sun for 1, 2, 3, 7, 15 and 30 days. On the day mentioned earlier, samples in triplets were collected for analysis. Plant nutrients loss was analyzed from the dried slurry. Slurry samples were dried in oven for complete evaporation and analysis was carried out.

Chemical analysis

The samples were analysed in the Soil Science Division, NARC at Khumaltar. Nitrogen was analysed by Micro-Kjeldahl methods by following wet digestion methods. Organic carbon was determined following the Wakley-Black method as described by PCARR (1980). Detection of P_2O_5 and K_2O from the samples was done by following the dry ashing procedure as outlined by Lundel et al (1955). After dry ashing and dissolving the ash in the acid, a part of the aliquot was fed to the flame photometer directly to detect potassium and the other part was taken for phosphorus detection as chlorostannous-molybdophosphoric acid. Moisture content of the samples was detected on oven dry basis at $105^{\circ}C$. pH of the samples were measured using Cornig combined electrode pH meter. The pH of the slurry was taken by dipping the electrode in the slurry and that of compost was taken after drying the sample at $40^{\circ}C$ in a hot air oven in 1:5 ratio (manure and water).

Limitation of study

The study was started from 15 Nov 1997 and ended in the 3rd week of Jan 1998. For these types of study, the period of two months was not sufficient. In addition, these months were the coldest period of the year. During these cold months, gas formation as well as the decomposition of organic wastes was slow. Moreover, unusual rain during the month of Dec had hampered the study and moisture content of the samples was increased especially in periodical drying of the samples in the field. During this period, sunshine intensity was low. Therefore, evaporation was less as compared to summer.

RESULTS AND DISCUSSION

Nutrient content of fresh dung

The mean value of the nutrient present in fresh dung, fresh slurry and general compost is presented in Table 1. Naturally biogas slurry contained higher amount of moisture (98.84%) following fresh dung (88.37) and compost (80.62). At this stage of moisture transport the compost in Nepalese condition would be difficult (Karki and Gurug 1996, DevPart 1996). The pH of all the samples is in alkaline side (7.5 to 7.9). It is alkaline, although it does not have any negative effects since it is in organic manures and it would act as buffering materials in soil especially in acidic soils. Comparing the nutrient content of the fresh dung and compost the former having higher amount of organic carbon could be due to mineralization of the feeding stuffs by the livestock as during cold period mineralisation of the materials is low (Acharya 1961, Takenaka et al 1990). With the nitrogen it was similar. Higher amount of P present in the fresh dung (1.34%) could be results of the feeds fed to the livestock

since this time of the year green fodders are limited and farmers fed their animals with the industrial feeds which was widely available in the markets. Higher amount of K (1.61%) in the compost might be due to thick layer of bedding materials added to absorb the liquid in the slurry and the dry materials especially straw contained higher amount of K. These results were similar to the findings of ATC (1997).

Table 1. Plant nutrient contents in dung, biogas slurry and biogas compost

Content	Biogas slurry	Fresh dung	Biogas compost
Moisture	98.84	88.37	80.62
PH	7.5	7.9	7.7
OC, %	43.5	32.5	27.02
Total N, %	0.28	1.4	1.5
Total P, %	0.02	1.34	0.8
Total K, %	.017	1.25	1.61

The data in Table 2 shows the results of the slurry and compost, which was covered every day after the slurry flowed into the pit. Different environments seriously affect the nutrient content of the samples. Everyday the flow of effluent over the composting material was covered with dry materials. The compost samples taken for this study had almost the same quantity of moisture (Table 2). The measured pH also was similar. Although the compost was prepared out of the biogas slurry with different types of composting materials, especially straw and grasses, it could not strongly support idea of the quality of compost was based on the quality of slurry (Acharya 1961, ATC 1997). Slurry with higher amounts of nitrogen content would have produced better quality compost. But it did not show any definite trend although, systematized compost contained slightly higher nitrogen (0.01 unit higher). Factors controlling nitrogen content in the slurry should be further investigated. Phosphorus content did not differ much but there was note worthy difference in the K content of the compost prepared systematically (1.61%). These results were similar to the value obtained by Gupta (1991).

Table 2. Plant nutrient content in the biogas slurry, farmers' compost and systematic prepared compost

Content	Biogas slurry	Farmers' compost	Systematized compost
Moisture, %	91.95	78.43	76.88
PH	7.4	7.74	7.4
Total N, %	0.15	1.4	1.8
Total P, %	0.01	0.85	0.77
Total K, %	0.17	1.48	2.27

The compost pits were filled with the slurry and other composting materials. The samples were collected as a composite sample from the surface, half way of the pits that was about 50 cm from the surface. The same procedure was applied when collecting samples from the bottom of the pit (80-100 cm). The samples were brought to the laboratory and analyzed. The results were compared with the slurry falling into the pits.

Slurry fell into the pit over the thick layer of dry composting materials spread at the bottom of the pit. The slurry falling every day in the pit gradually filled it up. The slurry with less than 7.6% total solid remains on the surface of the dry matter whereas the liquid, which is over 92%, moves down to the bottom (Table 3). During the downward movement of the liquid into the pit, nutrient elements that are present slurry were carried away along with soluble nitrogen, and deposited at the bottom. This erratic result could be due to the sealing of the pore space in the composting materials by the finer particles of the slurry. The leaching and deposition process would have accumulated more nitrogen at the mid-depth. At the bottom of the pit farmers put thick layers of dry materials to absorb nutrients. Sample collected from the bottom shows lesser amounts of total nitrogen than the surface and middle depth. The other elements like phosphorus and potassium were not affected. In this case lower amount of total nitrogen present in the sample from the bottom of the pits could also be due to the thick layers of dry materials with higher C:N ratio added at the bottom of the pit to absorb moisture falling at in the pit which ultimately deposited at the bottom.

Table 3. Plant nutrient content in biogas compost from different depth

Content	Slurry from outlet	Materials from surface	Mixed materials from 40-50 cm	Compost from 80-100 cm
Moisture, %	95.77	91.95	84.98	42.49
pH	6.95	7.43	7.16	7.58
OC, %	40.65	30.73	29.51	24.76
Total N, %	0.12	1.56	1.42	0.71
Total P, %	0.11	0.64	0.76	0.84
Total K, %	0.21	0.79	1.22	1.31

Comparing the nitrogen content of the samples from different depths there was a small variation on the nitrogen content at the mid-depth of the pit compared to the compost from the surface of the pit and the bottom. The amount of nitrogen in the half way from the surface to bottom was lower by 7% and the difference from the second layer and the bottom was only 12%. It shows that there was an accumulation of small amounts of total nitrogen at the bottom of the compost pit (Table 3). In a short study like this, it is difficult to draw any conclusion but it provides a basis for further study.

Providing a shade over the compost pit protects manure from direct sunrays falling into the pit that reduces the evaporation. It also helped conserving the volatilization loss of ammonia form of nitrogen that was present in the slurry. For this study, manure from several farmers with shade and without shade pits were collected, analyzed and pooled together and mean value is presented here (Table 4). Among the nutrient content there was 43% lower nitrogen in the compost from open pit.

Table 4. Nutrient difference in shaded and non-shaded compost pit

Nutrient	Shaded		Non shaded	
	Slurry	Compost	Slurry	Compost
Total N, %	0.29	1.41	0.23	0.79
Total P, %	0.017	0.87	0.02	0.59
Total K, %	0.12	1.8	0.42	1.4

Organic manure, if exposed to direct sunrays, lost most of its moisture. Along with the moisture, more than 50% of total nitrogen and over 96 % of ammonia form of nitrogen escapes into the air (Acharya 1961). A small observation was made in the farmers' field to note the percentage of nitrogen escaping under the given condition. Based on a simple observation, the original compost was dried on the field as well as in the cemented slab for one week each. It could be said that there is a loss of 25.98% of total nitrogen in one week when the compost was dried on a cemented slab (Table 5).

Table 5. Effect of drying on slab on nitrogen content of the slurry

Material	Total N, %	Difference
Original compost	1.77	
Dried one week in slab	1.31	25.98%

From the above discussion it was clear that there was a loss of nitrogen during different ways of handling. In order to confirm the obtained results another observation was made in the laboratory by drying the slurry for one month. The experiment was started simultaneously and the slurry was sampled in the first, second, third, seventh, fifteenth day and thirty days intervals. They were analyzed and presented in Table 6. There was a high loss of moisture (about 87%) from the first day to the 30 days. Regarding the pH, there was a gain of 7.24% but the nitrogen loss was 58.76%. Loss of phosphorus was also observed (32.14%) but the amount of potassium remained almost the same. There is a gradual decrease in the amount of nitrogen from the second day itself. The loss was greater after the seventh day of drying. From the third to the seventh day, the loss was 63%. Then after, the loss was not severe. Data indicates the loss of nitrogen on the different days of drying. Loss was greater after the second day till the seventh day. Then the rate decreases. After 15 days of drying there was a very little difference until the 30 days

Table 6. Effect of drying in laboratory condition on nitrogen content of slurry

Days of drying	Total N, %	Difference, %
1	1.77	
2	1.64	7.34
3	1.18	28.05
7	0.91	31.36
15	0.81	10.99
30	0.73	9.88
Total difference from first to last day		58.76

ACKNOWLEDGEMENTS

Support received from Biogas Support Program to conduct this study is thankfully acknowledged. Due appreciation goes to the staffs of Soil Science Division Khumaltar for samples analysis.

REFERENCES

- Acharya C. N 1961. *Preparation of fuel, gas and manure by anaerobic fermentation of organic materials*. New Delhi, Indian Agriculture Research Institute.
- ATC 1997. *A report of analysis of manure from biogas plant*. Report Submitted to Biogas Support Programme (BSP) / SNV-Nepal.
- Britt C. 1994. *The effect of biogas on women workload in Nepal*. An overview of studies conducted for the Biogas Support Programme, BSP. Kathmandu.
- Demont D, A Skeyde and A Ulrich. 1991. *Possible application of bioslurry for the purpose of fertilisation in Changing Village*. Volume 10 (1), Jan-March 1991.
- DevPart Nepal. 1996. *Final report of impact of biogas uses*. Kathmandu, BSP.
- FAO. 1996. *Biogas technology: A training manual for extension*. Support for Development of National Biogas Programme (FAO/TCP/NEP/4451-T) Nepal.
- Gupta DR. 1991. *Biofertilizers from biogas plant in Changing Village*. Volume 10(1), Jan 1991.
- Joshi D. 1997. *Soil fertility and fertiliser use in Nepal*. Soil Science Division, Nepal Agriculture Research Council, Khumaltar, Lalitpur, Nepal.
- Karki KB and B Gurung. 1996. *Evaluation of slurry extension pilot programme*. Kathmandu, BSP/SNV Nepal.
- Karki KB. 1995. Influence of organic and inorganic fertilisers in sustaining crop productivity in the central hills of Nepal. *PhD Dissertation*, BOKU, Vienna, Austria..
- Karki KB. 2002. Response of biogas effluent to maize and cabbage in Lalitpur District. **In:** *Abstract*. Proc. International Seminar on Mountain, Royal Nepal Academy of Science and Technology (RONAST), Kathmandu
- Lundel GEF, HA Bright and JT Hoffman. 1955. *Applied inorganic analysis with reference to the analysis of metals, minerals and rocks*. John Wiley and Sons Inc. New York.
- Maskey SL. 1978. Manurial value of bioslurry: Some observation. *Paper Presented in International Workshop on Microbial Aspect of Gas Production*, 31 May – 1 June 1978, Kathmandu.
- PCARR 1980. *Standard methods of analysis for soil, plant tissues, water and fertilizers*. Philippines Council for Agriculture and Resource Research, Los Banos, The Philippines.
- Sathianathan MA. 1975. *Achievement and challenges*. New Delhi Association of Voluntary Association. India.
- Takenaka M, T Miyoshi, K Hori and T Matsuguchi. 1990. Effect of temperature on nitrogen mineralisation of different types of winter wheat field. *Transaction XIV International Congress of Soil Science IV*:587-588.

Blending and Evaluation of Angora Wool to Produce High Quality Products

Damodar Neupane and Tribubaneshwor Dhaubhadel

Swine and Avian Research Programme, NARC, Khumaltar

ABSTRACT

A study was conducted at Swine and Avian Research Programme, Khumaltar to evaluate the quality of products by mixing the Angora wool with other fibers in different proportion. Angora wool was blended with cotton, silk, Pashmina, yak wool and Allo in 50% combination. The fabric was also blended with 33% Angora wool, 33% cotton, 33% Pashmina and 33% yak wool. The carding of fiber was done by machine. Spinning was done manually with the help of foot operated wooden spindles and weaving was done with the help of handlooms. The products were evaluated on the basis of number of fiber sheds in one strong touch. It was found that the shedding effects of shawls made from 50% Allo and 50% Angora rabbit wool was significantly lower as compared to shawls made from 100% Angora wool and other four different combinations. Similarly, shedding effects of shawls on cotton system (100% cotton clothes) was found significantly lower as compared to woolen system (100% woolen cloths).

Key words: Angora wool, blending, quality products

INTRODUCTION

Angora wool is considered to be a luxury fiber and takes its place along with Silk and Pashmina. Angora wool is desirable for its feel, appearance and warmth. But, pure Angora wool is more difficult to spin, and therefore quality of yarn is uneven. Poor quality yarn diminishes the quality of the finished product, which are mostly hand-loomed or hand-knitted. Poor quality products therefore cannot fetch a high price hence cannot compete in both appeal and price (Neopane and Diana 1993). This research was conducted to evaluate the quality of products by mixing the Angora wool with other fiber in different proportion (yak wool, cotton, Allo, Pashmina and silk) in order to increase the resiliency of the yarn and decrease the natural shedding property of the products. The results of these and subsequent action may help to alleviate the bottleneck caused by the current practice and make Angora yarn more attractive with low cost to the local manufactures. The supply of good quality yarn will increase the quality of the finished products, which may give it, at the retail level, a slight competitive edge. An increased competitive edge combined with a product push approach may translate into increase in demand for the Angora Rabbit Wool, produced through out the Country. The objective of this study was to develop and evaluate the line of products mixing Angora wool with cotton, silk, Pashmina, yak wool and Allo.

METHODOLOGIES

The Research includes the mixing of angora wool with other fibers, in order to increase the resiliency of the yarn and decrease the natural shedding property of angora woolen products. In this research blending of angora wool with, cotton, silk, Pashmina, yak wool and Allo was done in different combination. The mixing of different fibers was done on weight basis volume. Carding was done by machine and spinning of the yarn was done by hand operated wooden spindles. The Yarns of different types were made available to five different manufacturers to make the final products. The products made by different manufacturer were collected and analyzed differently. The products were evaluated on the basis of number of fiber sheds in one strong touch. The shedding effects were analyzed in different types of cloths (100% cotton and 100% woolen). After the

experiment all the available information was introduced in to the analysis of variance table to find out the final result.

Five replication of each treatment were applied and these five treatments are given below.

T ₀	100% Angora wool- control
T ₁	50% silk and 50% Angora wool
T ₂	50% cotton and 50%Angora wool
T ₃	50% Allo and 50% Angora wool
T ₀₄	33.33% cotton, 33.33% Pashmina and 33.33%Angora wool
T ₅	33.33% cotton, 33.33% yak wool and 33.33% Angora wool

The name of the manufacturers involved

Angora Rabbit Breeding Farm Koteshwor
Rural Community Development Society, Dhulikhel, Kavre
Hari Krishna Shrestha, Kalopool
Yam Bahadur Magar, Lazipat
Woman Awareness Group, Illam

RESULTS AND DISCUSSION

The shedding effects of the products made from blended angora wool with different combination are presented in Table 1 and 2. The angora wool is necessary to blend with other fiber like, cotton, Pashmina, Yak wool and Allo. It was found that such blended products posses special virtues like less shedding effects, softer feel, and cheaper as compared to pure angora woolen products. The processing loss and migration/ shedding effects of the Angora products can also be controlled with suitable engineering of yarn structure i.e. through blending of angora wool with other fibers (Gupta 1997).

The experiment included the mixing of angora wool with silk, cotton, Allo, Pashmina and yak wool in order to increase the resiliency of the yarn and decrease the natural shedding property of the products. The shedding effects of the products made from blended angora wool with different combination are presented in Table 1, 2.

Table 1. Shedding effects in cotton system

SN	Types of fiber combination	Name of article	No of article	Straight of fiber shed	No of touch	Fiber shed Mean±SD	Remark
1	100% Angora wool	Shawl	5	156	25	6.24±93	VI
2	50% silk and 50% Angora wool	Shawl	5	125	25	5±0.82	IV
3	50% cotton and 50% Angora wool	Shawl	5	152	25	6.08±1.15	V
4	50% Allo and 50% Angora wool	Shawl	5	21	25	0.84±0.80	I
5	33.33% cotton, 33.33% Pahmina and 33.33% Angora wool	Shawl	5	58	25	2.32±1.14	III
6	33.33% cotton, 33.33% yak wool and 33.33% Angora wool	Shawl	5	49	25	1.96±1.24	II

Table 2. Shedding effects in woolen system

SN	Types of fiber combination	Name of articles	No of articles	Strength of fiber sheds	No of touch	Mean ±SE	Remark
1.	100% Angora wool	Shawls	5	324	25	12.96±1.39	VI
2.	50% silk and Angora wool	Shawls	5	248	25	9.92±1.82	IV
3.	50% cotton and Angora wool	Shawls	5	309	25	0.84±1.19	V
4.	50% Allo and Angora wool	Shawls	5	46	25	12.36±1.44	I
5.	1/3 part cotton Pahmina and Angora wool	Shawls	5	131	25	1.84±1.18	III
6.	1/3 part cotton yak wool and Angora wool	Shawls	5	104	25	4.16±0.80	II

The result shows that the shedding effects of shawls made from 50% Allo and 50% Angora Rabbit wool found significantly lower as compared to shawls made from 100% Angora wool and other four different combinations.

Similarly, shedding effects of shawls on cotton system (100% cotton clothes) was found significantly lower as compared to woolen system. (100% woolen clothe). The mean shedding effects in cotton system was 6.24, 6.08, 5.23, 1.96 and 0.84 in the shawls made from 100% angora wool, 50% cotton and Angora wool, 50% silk and Angora wool, 1/3 part cottons, Pashmina and Angora wool, 1/3 part cotton yak wool and Angora wool and 50% Allo and 50% Angora wool respectively. The mean shedding effects in woolen system found was 12.96, 12.36, 9.92, 5.24, 4.16 and 1.84 in the shawls made from 100% Angora wool, 50% cotton and Angora wool, 50% Silk and Angora wool, 1/3 part cotton, Pashmina and Angora wool, 1/3 part cotton yak wool and Angora wool and 50% Allow and Angora wool respectively.

CONCLUSION

The shedding effect of shawls made from 50% Allo and 50% Angora rabbit wool was lower than that of the shawls made with 100% angora wool and other our different combination. The shedding effects of shawls on cotton system were found lower as compared to woolen system. It is recommended that further research to confirm this finding is necessary.

REFERENCES

- Gupta NP. 1997. Utilization of Angora fiber in organized and decentralized sector. *A Workshop Report*, April 18-19, 1997. CSWRI, India. Pp. 42-50.
- Nuepane D and M Diana. 1993. Angora wool commodity survey report. *A study Report*. CECI Asia, Kathmandu.

Effect of Space Density on White Leghorn

Shambhu B Shrestha

RARS, Tarahara

ABSTRACT

The present study was undertaken in white Leghorn breed maintained at Poultry Research Centre, GB Pant University of Agriculture and Technology, Pantnagar. At 20 week of age 256 birds were randomly transferred in three different space density groups as 0.20, 0.25 and 0.30 sq m/bird. The traits measured in each space density were egg production, mortality and egg weight up to 100 day egg production. The overall average mortality was 0.1533 ± 0.21 with a cv of 6.79%. The mortality under three different floor space density were 0.210 ± 0.032 , 0.13 ± 0.032 and 0.12 ± 0.037 (21, 13) and 12% respectively. Results showed that the space density had no significant influence on mortality. The overall average number of egg laid by bird up to 100 day was 20.62 ± 0.36 with c v. of 31.34 percent. In three different floor space density group number of eggs laid were 27 ± 0.646 , 19 ± 0.646 and 15 ± 0.640 respectively. The statistical analysis revealed highly significant effect on egg production due to floor space density. The overall average egg weight was 49.43 ± 0.195 , the average egg weight under three different floor space density groups as 0.20, 0.25 and 0.30 sq m/bird were 49.62 ± 0.342 , 49.05 ± 0.342 and 49.64 ± 0.342 respectively. The results revealed that the density had non-significant effect on egg weight. Based on egg production at 70-80 days, egg quality traits in white leghorn birds studied. It may be concluded that shape index and albumin volume had no significant difference under three different floor space density groups whereas albumin index, yolk index, yolk weight, shell thickness, shell weight, albumin weight and egg weight had significant difference in these space density groups 0.20, 0.25 and 0.30 sq m/bird.

INTRODUCTION

Poultry farming has been identified as a subsidiary occupation and the contribution of a growing poultry sub sector to the national economy is significant. Poultry rearing created employment opportunities in rural and urban areas. It is important as a means of self-employment, supplementary income, production of animal protein food, therefore is an important part of integrated rural development programme.

The stocking density and system of management are the two important factors, which affect egg production/quality parameters. Poultry housing is required to protect it from vagaries of nature including predators. It has to provide space for feeding, watering and normal movement of the birds for their optimum growth and production. The adequate floor space is generally plays an important role in influencing, rate of lay and quality of eggs. The main quality attributes of egg are freshness, size, soundness and cleanness of egg shell, albumin firmness, yolk colour, nutritive value, functional and sensory quality, yolk index, albumin index, shape index etc. This study was undertaken with the objectives of to study the egg quality traits under different space density and to find out the effect of space density on production and the egg quality traits.

MATERIALS AND METHODS

The present study was conducted on white leghorn breed maintained at poultry Research Center, GB Pant University of Agriculture and Technology, Pantnagar. At 20 weeks of age 256 birds were randomly transferred in three different space density groups, which are as follows.

Group I	0.20 sq m/bird
Group II	0.25 sq m/bird
Group III	0.30 sq m/bird

The traits measured in each group were average egg production (n), mortality (%) and average egg weight (g) upto 100 days of laying and egg quality.

Egg production

The number of eggs laid by a bird from the date of sexual maturity to 100 days of laying was obtained from each group.

Average egg weight

Egg weight was expressed as the average weight of egg of each group in g. All the eggs laid in 100 days were weighed.

Mortality

Mortality was expressed as the rate of number of hen died to number of hen housed.

$$\text{Mortality} = \frac{\text{Number of hen died}}{\text{Number of hen housed initially}} \times 100$$

After 70-80 days of egg production 40 eggs were collected from each group and following observation were recorded.

1. Weight of egg, g	8. Width of yolk, mm
2. Length of egg, cm	9. Height of yolk, mm
3. Width of egg, cm	10. Thickness of egg shell, mm
4. Length of thick albumin, cm	11. Weight of egg shell, g
5. Width of thick albumin, cm	12. Weight of albumin, g
6. Height of thick albumin, cm	13. Weight of yolk, g
7. Length of yolk, mm	14. Volume of albumin, ml

By taking above observation following egg quality traits were calculated for intact egg.

1. Egg weight: The egg weight was measured in grams with the help of an electronic balance.
2. Shape index: The length and width of the egg was measured by Vernier Calliper and shape index expressed as ratio width /length of eggs.
3. Shell weight: The shell weight was recorded in grams on an electronic balance.
4. Shell thickness: Shell thickness was measured by screw gauge and the average expressed in millimeters.
5. Yolk index: It was measured by Spherometer and Vernier Calliper at two places and expressed as ratio of height and width of the yolk.

$$\text{Yolk index} = \frac{\text{Height of the yolk}}{\text{Width of the yolk}}$$

6. Albumin index: Height and width of albumin were measured by Spherometer and Vernier Calliper and expressed as ratio of height and width of albumin.

$$\text{Albumin index} = \frac{\text{Height of the albumin}}{\text{Width of the albumin}}$$

7. Albumin volume: It was measured in ml in a measuring cylinder.
8. Albumin weight: The albumin weight was measured in grams on an electronic balance.
9. Yolk weight: It was measured in gram on an electronic balance.
10. Albumin length: The length of thick albumin was measured by Vernier Calliper in cm.
11. Yolk width: The width of yolk were measured at two places by Vernier Calliper in cm.

Statistical analysis

Data were analyzed for statistical significant of differences by the analysis of variance technique, means and effect of space density on various traits were tested by Completely Randomized Design according to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Production traits

The average values of production traits along with standard error and coefficient of variation for mortality, egg production (no.) and egg weight (g) under three different floor space density and analysis of variance are given Table 7 and 8, respectively.

Mortality

The overall average mortality was 0.1533 ± 0.21 with the coefficient of variation 6.79 per cent upto 100 days of laying. The mortality under three different floor space density was 21, 13 and 12% respectively (Table 7). The average mortality observed in this study was lower than those reported by Tripathi et al (1977) but higher than in three floor space 2.5, 2.0 and 1.5 sq ft / bird reported by Sharma et al (1985), Parajuli (1989) and Lee (1989). Mortality percent was higher in 0.20 sq. meter floor space than others floor space groups but the results revealed that the space density had no significant influence on mortality. This is in accordance with the findings of Amutha et al (2001).

Egg production

The overall average number of egg laid by bird upto 100 days was 20.62 ± 0.36 , with CV of 31.34%. In three different floor space density group number of eggs laid were 27 ± 0.646 , 19 ± 0.646 and 15 ± 0.640 , respectively (Table 7). The averages of egg production higher than Mishra et al (1988) but lower than reported by Bagha (1970), Reddy et al (1972), Tripathi et al (1977). Statistical analysis revealed significant ($p < 0.01$) effect on egg production Ramos et al. (1986) stated that the egg production was significantly higher in birds provided with 0.5 sq ft than those housed at 0.4 sq ft/bird.

Egg weight

The overall average egg weight was 49.43 ± 0.195 g, the average egg weight under three different floor space densities groups under 0.20, 0.25 and 0.30 sq m/bird were 49.62 ± 0.342 and 49.64 ± 0.342 , respectively (Table 1). The average egg weight was higher than the reports of Ready et al (1972), Mishra et al (1984), Lee (1989) and Amutha et al (2001). The results revealed that the density had non-significant effect on egg weight.

Table 1. Means of mortality, egg production and egg weight in White Leghorn under different floor space densities

Treatment	Floor space/bird, m ²	Mortality	Egg production	Average egg weight, g
1.	0.20	0.21 ± 0.037 (21%)	27 ± 0.646^a	49.62 ± 0.342
2.	0.25	0.13 ± 0.037 (13%)	19 ± 0.037^b	49.05 ± 0.342
3.	0.30	0.12 ± 0.037 (12%)	15 ± 0.640^c	49.63 ± 0.342
CV, %		6.79	31.34	6.94

Different super scripts indicate significant differences ($P < 0.05$).

Egg quality traits

Considering the quality consciousness averages of few egg quality traits were determined these included shape index per cent, albumin index, yolk index, shell thickness (mm), shell weight (g), yolk weight (g), albumin weight (g), albumin volume (ml) and egg weight (g) of the eggs (Table 2)

Shape index

The overall averages shape index was observed as 74.65 with a CV of 8.25% (Table 2). The means and standard error of shape index (%) under three different floor space density groups were 76.12 ± 0.974 , 74.40 ± 0.974 and 73.45 ± 0.974 (Table 3). The above findings were higher than the reports of Muller et al (1960), Khare et al (1974), Maan et al (1983) and Laxmi et al (2001). The reports of Hick et al (1961) were similar with 0.25 sq m/bird space density groups. The data revealed that the floor space density groups under study did not have any significant effect on shape index percent (Table 3). Analysis of variance study of quality traits between different floor space density groups has not been reported.

Albumin index

The overall average albumin index was observed as 0.13 with a CV of 19.32% (Table 2). The mean and standard error of albumin index under three different floor space density groups were 0.10 ± 0.003 , 0.12 ± 0.318 and 0.17 ± 0.341 (Table 3). The above findings were higher than the reports of Kumar and Kapri (1996), Johri and Singh (1968) and Jain (1977). The data revealed that the floor space density groups have significant effect on albumin

index (Table 3). Jhori and Singh (1968) and Tayyab (1983) reported similar results in 0.20 sq m/bird floor space group.

Yolk index

The overall average yolk index was 0.546 with a CV of 10.60% (Table 2). The mean and standard error of yolk index under three different floor space density groups were 0.422 ± 0.007 , 0.472 ± 0.007 and 0.473 ± 0.007 (Table 3). The above findings were in agreement with Johri (1973) and Jain (1977) but higher than the reports of Kotaih et al (1975), Rai (1985) and Laxmi et al (2001). The results revealed that the floor space density groups had significant effect on yolk index (Table 3).

Shell thickness

The overall shell thickness was observed as 0.425 mm with a CV of 14.55% (Table 2). The mean and standard error of shell thickness under three different floor space density were 0.495 ± 0.0097 mm, 0.396 ± 0.0097 mm and 0.383 ± 0.0097 mm (Table 3). The above findings were similar with reports of Hick et al (1961) but higher than the reports of Muller et al (1960), Mahapatra et al (1982), Tayyab (1983) and Laxmi et al (2001). The results revealed that the floor space density groups had significant effect on shell thickness (Table 11).

Shell weight

The overall shell weight was observed as 6.436 g with a coefficient of variation 13.57 per cent (Table 2). The mean and standard error of shell weight under three floor space density groups were 6.18 ± 0.138 g, 6.28 ± 0.138 g and 6.83 ± 0.138 g (Table 3). The above findings were higher than the reports of Johri and Singh (1968), Sreedharan and Mukundan (1972), Rahmatullah et al (1978), Rai (1985) and Laxmi et al (2001). Reports given by Mahto et al (1980) were in agreement with the present study. The data reveal that the floor space density group had significant effect on shell weight (Table 3).

Yolk weight

The overall Yolk weight was observed as 15.097 g with a coefficient of variation 16.08% (Table 2). The means and standard error of yolk weight under three different floor space density ranged from 16.61 ± 0.0383 g, 15.07 ± 0.383 g and 13.60 ± 0.383 g (Table 3). The above findings were higher than the reports of Johri and Singh (1968), Aggarwal (1970), Pour-Reza et al (1983). The data reveal that the floor space density groups have significant effect on Yolk weight (Table 3), but the lower than those reported by Mahato et al (1980) and similar reports were given by Johri and Singh (1968) in 0.25 sq m/bird floor space group.

Albumin weight

The overall albumin weight was observed as 29.04 g with a CV of 16.58% (Table 9). The means and standard error of albumin weight under three different floor space density groups were 25.77 ± 0.761 , 30.47 ± 0.761 and 30.87 ± 0.761 (Table 10). The above findings were in agreement with Johri and Singh (1968) in third group and Ahmad et al (1970) with first group and higher than the reports of Aggarwal (1970), Pou-Reza et al (1983) but the lower than those reported by Johri (1973) and Mahato et al (1980). The data reveal that the floor space density groups had significant effect on albumin weight (Table 3).

Albumin volume

The overall volume was observed as 26.991 ml with a CV of 12.27% (Table 2). The means and standard error of albumin volume under three different floor space density groups were 26.25 ± 0.523 , 27.95 ± 0.523 and 26.75 ± 0.523 (Table 3). The above findings were lower than the reports of Rai (1985). The data reveal that the floor space density groups did not had any significant effect on albumin volume (Table 11).

Egg weight

The overall average egg weight was observed as 50.308 g with a CV of 9.74% (Table 2). The means and standard error of egg weight under three different floor space density groups were 48.308 ± 0.774 g, 51.300 ± 0.774 g and 51.42 ± 0.774 g (Table 3). The average egg weight were similar to those reported by Johri and Singh (1968) in 0.25 sq m and 0.30 sq m per bird for space group and the higher than the reports of Ahamad et al (1970), Aggarwal (1970), Mahapatra et al (1982), Pou-Reza et al (1983) and Mohan et al (1992), but the smaller than those reported by Muller (1960) and Laxmi et al (2001). The results revealed that the density had significant effect on egg weight at 72 to 80 days of production (Table 3). Amutha et al (2001) reported that housing system had significant influence on egg weight.

Based on egg production at 70-80 days quality traits in white leghorn birds studied. It may be concluded that shape index and albumin volume had non-significant difference under three different floor space density groups, whereas albumin index, yolk index, yolk weight, shell thickness, shell weight, yolk weight, albumin weight and egg weight had significant difference in these space density groups 0.20 sq m/ birds, 0.25 sq m/birds and 0.30 sq m/birds.

Table 2. Overall mean, standard deviation and CV of egg quality traits

Trait	Mean	SD	CV
Shape index, %	74.65	6.16	8.25
Albumin index	0.130	0.207	19.32
Yolk index	0.456	0.045	10.60
Shell thickness	0.425	0.062	14.55
Shell weight, g	6.436	0.873	13.57
Yolk weight, g	15.097	2.427	16.08
Albumin weight	29.041	4.815	16.58
Albumin volume, ml	26.991	3.512	12.27
Egg weight, g	50.308	4.899	9.74

Table 3. Mean and SE of egg quality traits in White Leghorn under three-space density

Trait	Treatment	Space density, m ²	Mean $\pm$ SE
Shape index, %	1	0.20	76.12 $\pm$ 0.974 ^a
	2	0.25	74.40 $\pm$ 0.974 ^a
	3	0.30	73.45 $\pm$ 0.974 ^a
Albumin index	1	0.20	0.10 $\pm$ 0.003 ^a
	2	0.25	0.12 $\pm$ 0.318 ^a
	3	0.30	0.17 $\pm$ 0.0341 ^b
Yolk index	1	0.20	0.422 $\pm$ 0.007 ^b
	2	0.25	0.472 $\pm$ 0.007 ^b
	3	0.30	0.473 $\pm$ 0.007 ^b
Shell thickness	1	0.20	0.495 $\pm$ 0.009 ^a
	2	0.25	0.396 $\pm$ 0.009 ^b
	3	0.30	0.383 $\pm$ 0.009 ^b
Shell weight, g	1	0.20	6.18 $\pm$ 0.138 ^a
	2	0.25	6.28 $\pm$ 0.318 ^a
	3	0.30	6.83 $\pm$ 0.318 ^b
Yolk weight, g	1	0.20	16.61 $\pm$ 0.383 ^a
	2	0.25	15.07 $\pm$ 0.383 ^b
	3	0.30	13.60 $\pm$ 0.318 ^b
Albumin weight, g	1	0.20	25.77 $\pm$ 0.761 ^a
	2	0.25	30.47 $\pm$ 0.761 ^b
	3	0.30	30.87 $\pm$ 0.318 ^b
Albumin volume, ml	1	0.20	26.25 $\pm$ 0.523 ^a
	2	0.25	27.95 $\pm$ 0.523 ^a
	3	0.30	26.75 $\pm$ 0.523 ^a
Egg weight, g	1	0.20	48.308 $\pm$ 0.774 ^a
	2	0.25	51.300 $\pm$ 0.774 ^b
	3	0.30	51.42 $\pm$ 0.774 ^b

CONCLUSION

At 20 week of age 256 birds were randomly transferred in three different space density groups 0.20, 0.25 and 0.30 sq m/bird. The traits measured in each space density was egg production, mortality and egg weight upto 100 day egg production. The overall average mortality was 15.33 $\pm$ 2.1 with a CV of 6.79%. The mortality under three different floor space densities was 0.210 $\pm$ 0.032, 0.13 $\pm$ 0.032 and 0.12 $\pm$ 0.037 (21, 13 and 12%) respectively. Results showed that the space density had no significant influence on mortality. The overall average number of egg laid by bird upto 100 days was 20.62 $\pm$ 0.36 with CV of 31.34%. In three different floor space density group

number of eggs laid were 27 ± 0.646 , 19 ± 0.646 and 15 ± 0.640 respectively. The statistical analysis revealed highly significant effect on egg production due to floor space density.

The overall average egg weight was 49.43 ± 0.195 g the average egg weight under three different floor space density groups, as 0.20, 0.25 and 0.30 sq m/bird were 49.62 ± 0.342 , 49.05 ± 0.342 and 49.64 ± 0.342 g respectively. The results revealed that the density had non-significant effect on egg weight. Based on egg production at 70-80 days egg quality traits in white leghorn birds studied. It may be concluded that shape index and albumin volume had no significant difference under three different floor space density groups whereas albumin index, yolk index, yolk weight, shell thickness, shell weight, albumin weight and egg weight had significant difference in 0.20, 0.25 and 0.30 sq m/bird space density groups.

REFERENCES

- Aggarwal CK. 1970. Phenotypic correlation of some economic traits in white leghorn pullets. *Indian Vet. J.* 47:34-43.
- Ahmad KN, MR Chaudhary and GH Shah. 1970. Comparative study on the interior quantity of eggs in Khaki Campbell duck and white leghorn chicken. *W. Pakist. J. Agric. Res.* 8:200-204.
- Amutha R, K Sundaresan and K Viswanathan. 2001. Effect of stocking density and system of management on egg production parameters. *Indian J. Poult. Sci.* 36:18-22.
- Bagha GS, J Kumar and RM Acharya. 1970. Floor and feeder space for white leghorn. *Indian J. Poult. Sci.* 5:12-15.
- Harvey WR. 1987. *Mixed model least squares analysis and maximum likelihood computer program*. LSMLMW PC-1 version.
- Hicks AF, EG Buss and AJG Mew. 1961. The heritabilities of seasonally determined egg quality traits. *Poult. Sci.* 40:821-822.
- Jain RS. 1977. Genetic studies on economic traits and transferring polymorphism in white leghorn. *MSc Thesis*. GB Pant University of Agriculture and technology, Pantnagar.
- Johari DC and BP Singh. 1968. Studies on internal egg quality. I. Influence of breed, season and age of the birds on internal egg quality. *Ind. Vet. J. Poult. Sci.* 45:139-144.
- Johari, DC 1973. a note on some parameters of internal egg quality in single comb white leghorn birds. *Ind Poult. Gaz* 57:77-79.
- Johri DC, P Renganathan and RC Garg. 1984. Effect of housing system on the performance of six strain crosses of white leghorn. *Indian J. Poult. Sci.* 9:171-176.
- Khare SP, AG Khan and BS Sathe. 1974. Egg quality studies on six strains of white leghorn breed. *Indian J. Poult. Sci.* 9:47.
- Kotaish T, VBA Iqbaluddin and SC Mohapatra. 1975. Egg quality traits as affected by method of housing. *Indian J. Poult. Sci.* 2:78-84.
- Kumar J and BD Kapri. 1966. Genetic studies on internal egg quality and its relationship with other economic traits in white leghorn birds. I. Heritability and repeatability of egg quality traits. *Ind. Vet. J.* 43:825-829.
- Laxmi PJ, VLK Prasad and SR Murthy. 2001. Inheritance of various egg quality traits in three strains of white leghorn. *Indian Vet. J.* 78:820-823.
- Lee K. 1989. Laying performance and fear response of white leghorn as influenced by floor space allowance and group size. *Poult. Sci.* 68:1332-1336.
- Maan RS, RK Sharma and BS Chhikara. 1983. Studies on some egg quality traits and their relationship with some production traits. *Haryana Agric. Univ. J Res.* 13:191-192.
- Mahapatra CM, NK Pandey and RC Goyal. 1982. Evaluation of egg quality traits in Delhi birds and their crosses with exotic breeds. *Indian J. Poult. Sci.* 15:196-197.
- Mahto B, CSP Singh and HR Mishra. 1980. Studies on weight and measurements of eggs in white leghorn birds during advanced stage of lay. *Indian. J. Poult. Sci.* 15:268-270.
- Mishra PS, KS Johari and A Singh. 1988. Factors affecting egg production and egg weight in white leghorn birds. *Indian Veterinary Medical. J.* 12:262-264.
- Mohan B, M Ramkrishnan and V Mani. 1992. Influence of egg weight on egg quality characteristics of commercial chicken egg. *Indian Vet. J.* 69:41-44.
- Muller WJ, AJE Mow and E Buss. 1960. The influence of season and age weight, shape index, albumin quality and shell thickness. *Poult. Sci.* 39:854-856.
- Parajuli DP. 1989. Comparative study on performance of white leghorn, New Hampshire and Australorop at Pokhara, Nepal. *MSc Thesis*. GB Pant University of Agriculture and Technology, Pantnagar, India.
- Pour-Reza J, MJ Zamiri and A Farid-Naeini. 1983. Egg components of the Native Fars chicken in cages and on deep litter. *Iran Agric. Res.* 2:115-124.
- Rahmatullah MS, RP Singh and SN Shukla. 1978. Breed and strain differences in internal quality of egg. *Indian J. Ploult. Sci.* 13:203-208.
- Rai J. 1985. Genetic studies of plasma protein, cholesterol and glucose and their association with egg quality traits in inbred lines of white leghorn. *MSc Thesis*. GB Pant University of Agriculture and Technology.
- Ramos NC, KE Anderson and AW Adams. 1986. Effects of type cage shape and bird density on productivity and well being of layers. *Poult. Sci.* 65:2023-2028.

- Reddy CV, VLK Prasad and D Subbaraudu. 1972. Studies on phenotypic correlations for some important economic traits in white leghorn pullers. *Indian J Poult. Sci.* 7:21-27.
- Sharma MD, MR Singh and RP Singh. 1985. Growth and production architecture of white leghorn fowl. *Indian Poult. Rev.* 16:27-32.
- Snedecor GW and CWG ochran. 1967. *Statistical methods*. Oxford and I.B.H. Publishing Co. Calcutta.
- Sreedharan AV and G Mukundan. 1972. Studies on the correlation between various egg quality traits in white leghorns. *Kerala J. Vet. Sci.* 3:40-43.
- Tayyab M. 1983. Genetic studies of production and egg quality traits in half sib families of white leghorn. *MSc Thesis*. GB Pant University of Agriculture and Technology, Pantnagar.
- Tripathi DC, BS Sathe and AG Khan. 1977. Studies on Inter-strain variation in the performance of white leghorn pullers housed in deep litter and in individual battery cages. *Indian J Poult. Sci.* 12:57-60.

Hill Goat Selection Programme in the Eastern Nepal

Prakash K Pokharel and Shriram P Neopane

Animal Breeding Division, NARC, Khumaltar

ABSTRACT

An attempt for the first time ever in the livestock species has been made to enrich the production potentiality of hill goat through selective breeding. Two tier open nucleus breeding scheme has been assiduously applied in order to enhance the genetic gain. Response of selection for the first generation kids in nucleus flock at station was found to be 7.9 and 4.7 percent generation for 4 and 6-month weights respectively. Similarly, twinning ability of hill goats for the period was increased by 0.73 percent reaching the level of 68.75. In on-farm condition response of selection for first generation kids per year was 0.22, 7.01 and 7.41 percent for birth, 4 and 6month weights respectively. Likewise, twinning frequency was improved by 27 percent indicating the level of 55. In both low and mid altitudes (up to 1700 masl) of eastern hill the selection programme was found effective for improving the productivity of local hill goats.

Key words: Hill goat, Eastern Nepal, selection

Indigenous Buffaloes of Nepal: Status of their Improvement

Shriram P Neopane and Kalyani Mishra

Animal Breeding Division, NARC, Khumaltar

ABSTRACT

There has been several investigation work done on native buffaloes in the country by several organization and institution. Information available within the country is not documented and this has created a difficulty in developing suitable breeding strategies for their improvement and utilization. This has also lead to a situation for many duplication works. Hence a study on native buffaloes was initiated by the animal Breeding Division, Nepal Agricultural Research Council (NARC) with the objective of making a comprehensive review in order to help develop breeding strategies for native buffaloes. Information available was collected, compiled and analysed. The results in a form of status report of native buffaloes were presented at a workshop in February 2003 in Kathmandu including the participants from different organizations and institutions. The results reveal that there are mainly three native buffalo breeds that have been identified. They are lime, Parkote and Gaddi, Lime buffaloes are located in low to mid hill and that of Parkote in low to high hill. Gaddi, Which is the heaviest breed, are located in hilly areas of far western region. Lime and Parkote represent 64% of the total buffalo population and that of Gaddi represent 0.5% of the total population and 16% of the regional population. All these three native breeds have been characterized both on phenotypic and chromosomal level. Morphological characterization revealed that Gaddi is the heaviest native breed having larger heart girth (195 ± 1.80 cm) and body length (141.0 ± 1.63 cm) followed by Parkote (176.0 ± 0.87 cm and 127.7 ± 0.76 cm) and Lime (174.0 ± 1.92 cm and 125.0 ± 1.47 cm) in terms of adult weight, Gaddi buffaloes have the highest weights (452.2 ± 8.03 kg) and the other two breeds are more or less similar in weights. Chromosomal characterization revealed that all three identified breeds, Lime, Parkote and Gaddi belong to riverine buffalo ($2n=50$). Lime and Parkote buffalo have acrocentric and submetacentric chromosomes while Gaddi has acrocentric, metacentric and submetacentric chromosomes. The results indicated that interbreeding between Lime and Parkote is not problematic.

Kew words: Indigenous buffaloes, Nepal, status

Production Performance of Turkey at Parwanipur

Mukesh Karki¹, Tribhuwaneswar Dhaubhadel² and Netra P Osti³

¹ Regional Agriculture Research Station, Parwanipur

² Swine and Avian Research Program Khumaltar

³ Animal Nutrition Division, Khumaltar

ABSTRACT

Turkey (*Meleagris gallopavo*) is an important poultry species reared mainly for meat production. It was introduced at Parwanipur in January 2001 from CARI, India by importing 200 fertilized eggs. The study was conducted at RARS, Parwanipur during April to December 2002 in one hundred and twelve day old turkey poults with four replications to know the production performance under ordinary management condition. Similar feed and management were provided to all experimental birds. Daily feed intake, mortality and weekly weight gain were recorded from day old to 34 weeks of age. Four male and 3 female at 16 week and one male and one female at 24 weeks of age were slaughtered for carcass yields. Besides farm experimentation, some turkeys distributed to farmers were also monitored and farmer's responses were also collected by contact and field visit. Turkey is to be voracious feeder and good foragers. It gained 1.639 kg of body weight (straight run) at 10 weeks of age by consuming 5.959 kg cumulative feed with feed to gain ratio of 3.7. Male are high feeder and heavier than female. At 16 week of age male and female gained average body weight of 3.728 ± 0.53 kg and 2.635 ± 0.22 by consuming 13.844 kg and 11.849 kg cumulative feed with feed to gain ratio of 3.76 and 4.59. Average mortality was observed 5.35% up to 16 weeks of age at station. At 43 weeks of age Male and female attained 11.34 ± 1.299 kg and 5.988 ± 0.83 kg body weights. Dressing percentage was increased with age ie 73.73% and 73.69% at 16 week and 77.87% and 76.08% at 24 week of male and female respectively. Feed efficiency is found to be adversely affected after 16 week of age under ordinary feed and management. From on-farm result it was found that Turkey is easy to rear and performed very well under scavenging condition Male and female gained 10.916 ± 1.57 kg and 6.466 ± 0.833 kg body weight in 10.5 months. In nutshell, turkey farming offers great scope and potential for higher meat production and income generation. However, emphasis on further research activities should be carried out on breeding, nutrition and management aspects for better-feed efficiency and more return.

Key words: Management, production, turkey

INTRODUCTION

Turkey (*Meleagris gallopavo*) is an important poultry species reared mainly for meat production. It is quite popular in western countries for relish white meat and is also associated with Christmas and Thanksgiving among the Christian population. Turkey production is growing globally with an average annual growth rate of 3%, amounted 5.06 Million Tones of meat production in 2001 and is no longer just a Thanksgiving and Christmas treat. The bulk of Turkey production was concentrated in North and Central America (52%) and Europe (40%), however in order to diversify meat production from different avian species, it is gaining popularity in tropical and subtropical countries including India (Tyagi 2001).

The present per capita meat production of Nepal is very low (7.96 kg) as compared to basic need requirement (14.4 kg) and based on the production projection of APP, the meat production will have to be increased from 0.16 mill mt to 0.46 mill mt by the year 2016/17. However, still we have to go a long way to meet basic need requirement as present production were able to meet 55.3% only of the requirement (Pradhan 2000). The situation even worse if we consider per capita availability of poultry meat in Nepal (0.6 kg/person/year), which is very low, compared to world average (10.5 kg/person/year) and even of Asian average (6.3 kg/person/year). As diversification is the key to success in any enterprise, we need to diversify to other poultry species in order to increase meat production.

It is reported that Turkey is easy to raise with similar management as chicken and can also be reared in free-range system (Khaddakar 2001). It is relatively more resistant to heat and some of the disease compared to chicken. In 24 weeks of age a large variety Turkey tom could weigh 35 lb and both tom and hen attained 17.5 lb in 17 weeks by consuming 3.5 lb feed for one lb of meat and the carcass yield of Turkey is also higher (80.5%) compared to chicken (68.1%) (Austic and Neshein 1990).

Considering these promising attributes, it was imported in Nepal for testing its performance under our circumstances. In this connection, 200 fertile eggs were imported from Central Avian Research Institute, Izatnager, India in January 2001. Hatching was accomplished in 28 days with 51% hatchability in Regional Agriculture Research Station, Parwanipur. All poults were brooded and reared under deep litter system providing more or less similar management as chicken. Mortality was recorded 6.86% up to 6 week, 10.78% up to 12 week of age and 14.7% up to 37 week of age. Female started to lay at 46.4 weeks of age at which average weight of male and female was observed 12.1 kg (maximum 14.5 kg) and 6.7 kg and offspring of which were subjected to feeding trial.

MATERIALS AND METHODS

One hundred and twelve day old turkey chicks were randomly divided in to four groups and were housed in separate cage. Similar feed were fed to all groups and reared under same management condition. Feed was prepared by addition of 6% fish meal + 0.3% lysine + 0.125% Methionine in Layer starter ration manufactured by Animal Feed production and Development Board, Hetaunda, for growing turkey poults up to 8 week of age. From 9 to 16 week, two number layer ration with supplementing 5% fish meal was fed to all groups. Then after, ordinary three number chicken rations were fed. All birds were kept in cage up to 8 week of age without sex separation. Then after, experimental birds were transferred in deep litter housing and sex was separated at 10 weeks of age. Male and female were randomly divided in to groups and kept on separate compartment. Daily feed intake, weekly weight gain, mortality were recorded during entire experimental period and cumulative feed intake, and feed efficiency were calculated. Four male and 3 female at 16 week and one male and one female at 24 week of age were slaughter. Dress weight and cut of part yield were recorded and dressing percentage were calculated.

Besides farm experimentation, some turkeys distributed to farmers were also monitored and farmer's response was collected by contact and field visit. Personal experience of rearing and management of turkey birds at RARS, Parwanipur is also included in this paper.

RESULTS AND DISCUSSION

It has been experienced that same Incubator and Hatcher being used for chicken could be used to hatch turkey eggs providing same temperature and other management as chicken. However better result could be obtained by raising level of RH in hatchers. Turkey egg takes about 28 days to hatch. So, it should be kept in incubator about one week more than chicken before transfer to hatchers. Turkey egg seems very sensitive to hatch than chicken that any deviation of temperature and management could lead huge damage resulting in to very poor hatchability.

Day old Turkey poults weighting 54.57 g are found little slow in learning to eat and drink than chicken and starvation and dehydration may occur leading to death. For this reason, careful attention must be given in first few days to ensure that they begin to eat and drink. To help get the poults eating and drinking quickly; the poults may be placed in the feed troughs immediately after hatching prevented by guards and feed must be kept on paper flats or winning fan under bright light in the brooding areas. Placing of 5-10 numbers of day old Chicken chicks with Turkey poults for a few days is practiced at RARS, Parwanipur to encourage turkey poults to fed and found best way to start feed and drink easily. It was observed that while chicken chicks pecking the feed, the turkey poults attracted to it and started to eat and drink quickly. In this on station experiment, mortality was recorded 1.8% at one week age and 5.35% up to 16 week of age. Though, lameness was observed in 13.6% of poults at 5 weeks but recovered by liquid feed supplementation.

Daily feed intake, average weight gain, cumulative feed intake and feed conversion ratio of straight run turkey up to 10 weeks of age are presented in Table 1. Turkey are found voracious feeder. It can gain 475.5 g body weight by consuming 1.439 kg cumulative feed at 5 week age with feed efficiency of 3.4 and 1.639 kg of body weight at 10 week of age by consuming 5.959 kg cumulative feed with feed to gain ratio of 3.7. Similarly, daily intake, average weight, cumulative feed intake and feed to gain ratio of male and female turkey up to 16-week age are presented in Table 2. Table 2 showed that male are high feeder and heavier than female. Male and female can only be differentiated after 8 weeks of age by physical appearance. Dew bill or snood, a fleshy protuberance near the base of the beak is relatively large, plump and elastic in males where as it is relatively small, thin and non-elastic in females. Males have conspicuous black beards attached to the skin of the upper region and also found to do strutting their feather more often. At 16 weeks of age male and female gained average body weight of 3.728 ± 0.53 kg and 2.635 ± 0.22 by consuming 13.844 kg and 11.849 kg cumulative feed with feed to gain ratio of 3.76 and 4.59 respectively. Female have showed poor feed efficiency compared to male, though male have also poor feed efficiency as reported by Austic and Neshein (1990) ie 3.5.

Table 1. Daily intake, weight, feed efficiency of turkey (straight run) up to 10 weeks

Age, week	Average weight, g	Daily intake, g	Cumulative feed intake, g	Feed conversion ratio
0	54.57 $\pm$ 0.44			
1	80.8 $\pm$ 4.04	9.92 $\pm$ 0.14	69 $\pm$ 0.98	2.6 $\pm$ 0.42
2	146 $\pm$ 11.19	25.16 $\pm$ 1.76	245 $\pm$ 4.36	2.7 $\pm$ 0.36
3	235 $\pm$ 13.65	48.2 $\pm$ 1.98	583 $\pm$ 16.29	3.2 $\pm$ 0.19
4	376 $\pm$ 22.07	60.56 $\pm$ 2.11	1006 $\pm$ 22.45	3.1 $\pm$ 0.2
5	475.5 $\pm$ 33.46	61.75 $\pm$ 4.10	1439 $\pm$ 27.9	3.4 $\pm$ 0.23
6	647 $\pm$ 40.44	86.02 $\pm$ 2.69	2041 $\pm$ 46.17	3.4 $\pm$ 0.18
7	897 $\pm$ 23.39	118.94 $\pm$ 12.3	2874 $\pm$ 77.91	3.4 $\pm$ 0.13
8	1068 $\pm$ 88.41	162.09 $\pm$ 3.62	4008 $\pm$ 59.04	3.9 $\pm$ 0.28
9	1310 $\pm$ 138.8	147.3 $\pm$ 13.09	5039 $\pm$ 97.7	4.0 $\pm$ 0.4
10	1639 $\pm$ 185.5	131.48 $\pm$ 4.3	5959 $\pm$ 127	3.7 $\pm$ 0.33

Table 2. Daily intake, average weight, cumulative feed and feed conversion ratio of male and female turkey up to 16 weeks of age

Age, week	Daily intake, g		Average weight, kg				Cumulative feed intake, kg		Feed conversion ratio	
	M	F	M	N	F	N	M	F	M	F
11	148	98	2.05 $\pm$ 0.211	15	1.532 $\pm$ 0.16	14	6.99	6.648	3.5	4.41
12	164	138	2.33 $\pm$ 0.345	14	1.833 $\pm$ 0.22	13	8.147	7.615	3.57	4.28
13	201	141	2.793 $\pm$ 0.45	14	2.027 $\pm$ 0.19	13	9.556	8.603	3.48	4.36
14	198	157	2.927 $\pm$ 0.33	13	2.2 $\pm$ 0.189	14	10.942	9.701	3.81	4.5
15	209	142	3.188 $\pm$ 0.25	13	2.309 $\pm$ 0.16	14	12.404	10.692	3.95	4.74
16	205	165	3.728 $\pm$ 0.53	21	2.635 $\pm$ 0.22	22	13.844	11.849	3.76	4.59

Average body weights of turkey up to 43 weeks of age are given in Table 3. The Table that average weight increased with advancement of age. At 43 week of age Male and female attained 11.34 ± 1.299 kg and 5.988 ± 0.83 kg body weights. Daily intake, cumulative feed intake and feed to gain ratio are presented in Table 4. It was found that male gained average weight of 5.433 ± 0.516 kg by consuming 30.196 kg of feed at 24 weeks of age with very poor feed to gain ratio of 5.65 and situation of female is almost poor. It was observed that although body weight of both sex increased with advancement of age, feed to gain ratio is adversely affected after 16 week under ordinary management condition. In this on station experiment, very poor 'feed to gain' ratio was observed than cited by Austic and Neshein (1990) ie 3.5. That might be due to poor quality of feed offered to them and lack of proper management because of new species for us. It is reported that ration having 28% crude protein with 2800 kcal ME up to 4 week, 25% CP with 2900 Kcal ME for 5-8 week, 22% CP with 3000 Kcal ME for 9-12 weeks, 19% CP with 3060 Kcal ME for 11-16 week and 16% CP with 3130 Kcal ME after 16 week is necessary to fed for optimal growth of turkey and better feed efficiency could be attained only when ration contained all amino acid and vitamins in properly balanced form (Bhanja et al 2001). Turkeys are able to derive more energy from low energy diets as compared to chicken and turkeys diets need to have a narrower energy to protein ratio (Tyagi 2001) By this experiment it was found that turkey could be raised under similar feeding and management as chicken but it resulted slow growth and poor 'feed to gain' ratio. Under ordinary management condition it is better to sell turkey at 16 weeks of age. It was reported that 4 kg body weight of turkey is most demanded in market, which is generally attained in 10-12 weeks of age providing adequate feed and management. Further, it is realized that Turkey need especial feed and other management than chicken to achieve fast growth and better-feed efficiency.

Some of the turkeys distributed to farmers have shown encouraging result even under scavenging condition with same management as local chicken. Turkeys are found good foragers and efficient kitchen left utilizes. High mortality was reported in poults distributed at day old stage, mostly due to predator attack (crow, eagle and cat) and poor management at farmers' condition. However, poults distribution at the age of 5 weeks (25 poults) has performed very well in Ishwarpur however 12% predation by jackles. A problem Turkey have shown promising results at farmers management condition that Male and female gained 10.916 ± 1.57 kg and 6.466 ± 0.833 kg body weight in 10.5 months. The meat price of turkey sold by farmers was reported to be Rs120-130 per kg of live weight and Rs180-200 per kg of flesh meat. All farmers are very interested to raise turkey and demand is very high. Most of the person who had tested turkey meat responded that test is more or less comparable to goat meat and even testies than goat meat. At farmer's field females brood their eggs and hatched maximum of 8 chicks. Similarly, turkey eggs given to broody local hen for poults production was also successful and is being practiced by farmers. Farmers preferred to rear Turkey because of its higher meat production ability even under scavenging condition. However, limited turkey poults production at station due to several resource limitations has influenced its expansion. Besides, lack of sexing in early stage also resulted uncertainty of either male or female that is distributed to farmers and in most of the cases no further generation would be expected, as some farmers have got only male and some got only female.

Table 3. Average weight (kg) of turkey from 17 to 43 weeks of age

Age	Male	N	Female	N
17	3.913 ± 0.475	13	2.907 ± 0.346	11
18	4.233 ± 0.409	13	3.211 ± 0.322	13
19	4.413 ± 0.407	14	3.083 ± 0.168	13
20	4.525 ± 0.408	11	3.312 ± 0.393	12
21	4.86 ± 0.45	12	3.404 ± 0.451	13
22	5.328 ± 0.415	15	3.931 ± 0.314	14
23	5.333 ± 0.374	13	3.733 ± 0.42	13
24	5.433 ± 0.516	16	3.65 ± 0.38	16
26	6.78 ± 0.466	13	4.55 ± 0.31	11
28	7.08 ± 0.348	10	4.19 ± 0.331	9
30	7.691 ± 0.594	13	4.529 ± 0.243	9
32	8.4 ± 0.429	9	4.7 ± 0.508	9
34	8.88 ± 0.263	9	5.18 ± 0.545	8
43	11.34 ± 1.299	7	5.988 ± 0.83	7

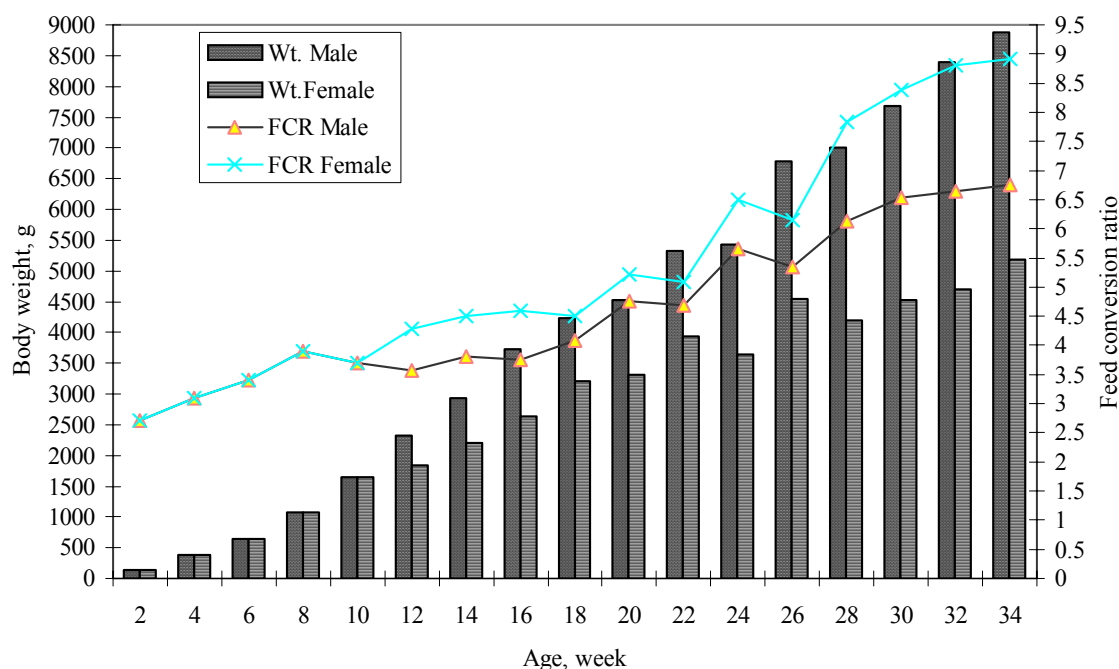


Figure 1. Average body weight and feed conversion ratio of Turkey.

Dress weight, cut of part yield of male and female Turkey at 16 and 24 weeks of age are presented in Table 5. The Table 5 showed that at 16 weeks of age both male and female have similar dress weights ie 73.73 % and 73.69%, respectively with higher yield of valuable part like Breast (20.87 and 21.1 % of live weight), thigh (11.3 and 11 % of live weight) and drumstick (10.84 and 10.3 % of live weight). Similarly, dressing percentage was found to be increased with age and male has slightly higher dressing percentage (77.87%) than female (76.08%) at 24 weeks of age. Singh reports similar findings that of 77% and 79% dressing percentages are obtained at 16 week and 23 weeks, respectively have been reported by Singh (2001).

Table 4. Daily intake, cumulative feed intake and average feed conversion ratio of male and female turkey from 17 to 34 weeks of age

Age, week	Daily intake, g		Cumulative feed intake, kg		Feed conversion ratio	
	Male	Female	Male	Female	Male	Female
17	224± 18.8	180 ± 3.39	15.41	13.11	3.94	4.5
18	267 ± 5.91	193 ± 10.82	17.28	14.46	4.08	4.5
19	302.65± 5.58	193.05 ± 14.49	19.399	15.812	4.39	5.12
20	307.85 ± 17.7	209.15 ± 9.26	21.554	17.276	4.76	5.21
21	262.15 ±3.33	200.18 ± 8.47	23.389	18.677	4.81	5.48
22	231.35 ± 28.7	187.8 ±17.25	25.008	19.992	4.69	5.08
23	347.5±14	238.79 ± 17.84	27.441	21.663	5.14	5.8
24	393.6 ± 19.19	305.35 ± 15.91	30.196	23.801	5.65	6.5
26	434.5 ± 42	320.4 ±5.94	36.30	28.07	5.35	6.15
28	503.4 ± 19	347.5 ±14.38	43.53	32.84	6.14	7.84
30	484.8 ± 8.34	368.57 ± 16	50.32	37.99	6.54	8.38
32	379.65 ± 14	210.26 ± 10.27	55.85	41.65	6.64	8.8
34	422.79 ± 19	221.87 ± 14.41	61.55	44.74	6.76	8.92

Table 5. Dressed weight and cut of parts yield of male and female turkey

Age	16 weeks							
	Male				Female			
	Wt of 4 bird, g	% of live wt	Wt of 3 bird, g	% of live wt	Wt, g	% of live wt	Wt, g	% of live wt
Live weight	4319± 308		2792± 300		6100		4600	
Neck	233 ±34	5.37	129 ± 27	4.6	325	5.33	240	5.21
Back	430 ± 48	9.95	297 ± 56	10.5	800	13.11	700	15.21
Wings	473 ± 62	10.9	300 ± 50	10.7	575	9.42	450	9.78
Breast	900 ± 54	20.87	587 ± 56	21.1	1285	21.06	925	20.11
Thigh	487 ± 25	11.3	308 ± 29	11.0	775	12.7	525	11.4
Drumsticks	469 ± 47	10.84	287 ± 23	10.3	700	11.47	475	10.33
H + L + G	193 ± 13	4.47	150 ± 25	5.36	290	4.75	185	4.02
Dress weight	3184 ± 24	73.73	2058± 246	73.69	4750	77.87	3500	76.08
Head	106 ± 12	2.46	65 ± 8.66	2.34	175	2.86	125	2.7
Feet	165 ± 16	3.82	79 ± 7.5	2.86	200	3.28	100	2.17

CONCLUSION

By conducting this on-station experiment it has been observed that Turkey could be raised under more or less similar feeding and management practices as for chicken. Although body weight and dressing percentage increased with advancement of age, feed efficiency is found to be adversely affected after 16 week of age. So, further research activities should be towards breeding, nutrition and management aspects for better feed efficiency. From on-farm result it was found that Turkeys are easy to rear and performed very well under scavenging condition. Farmers preferred to rear turkey because of its higher meat production ability by utilizing kitchen waste, grasses and cereal by-product. However, generation and dissemination of appropriate technologies towards minimizing poults mortality at early stage under scavenging system is essential. In nutshell, turkey farming offers great scope and potential. It has a special favor with rural farmers especially woman because of its potential to produce supplementary income in shortest possible time with ordinary management. There is no doubt that Turkey could be the alternate choice of farming community for higher meat production and income generation.

ACKNOWLEDGEMENTS

The Authors would like to express sincere thanks to Mr R Mishra and Mr DB Ghatri for valuable comments and suggestion. Authors are thankful to Mr Dilip Saha, Mr PL Adhikari and Mr Khem Pomu, staff of poultry unit RARS, Parwanipur for their active involvements through out the experimentation.

REFERENCES

- Austic RE and MC Neshein. 1990. Brooding and rearing. *Poultry production*. 13th ed.
- Bhanja SK and S Majumdar. 2001. Formulation of turkey feed. *Modern turkey production and management*. Turkey research unit, Central Avian Research Institute, Izatnager.
- Khaddakar N. 2001. Popularization and promotion of Turkey farming in India. *Modern turkey production and management*. Turkey research unit, Central Avian Research Institute, Izatnager.
- Pradhan SL. 2000. Livestock development in Nepal future challenges, development, concepts and approaches. **In:** *Proceedings of 3rd National Animal Science Convention*. Pp.15-16.
- Singh RP. 2001. Processing, carcass yield, nutritive value and processed turkey products. *Modern turkey production and management*. Turkey research unit, Central Avian Research Institute, Izatnager.
- Tyagi PK. 2001. The nutritional requirement of commercial turkeys. *Modern turkey production and management*. Turkey research unit, Central Avian Research Institute, Izatnager.

Selection for Nematode Resistance: An Alternative Approach for Parasite Control in Sheep

Bhola S Shrestha

RARS, NARC Lumle, Kaski

ABSTRACT

Parasitism in sheep is considered as one of the major problems. Control strategy based on anthelmintic treatment has come under threat due to emergence of anthelmintic resistance in wide range of nematode species. Breeding sheep for nematode resistance has emerged as one of the alternatives. Nematode resistance trait is under genetic control and is mediated through immunological response. The common measure of resistance is faecal egg counts (FEC) and FEC is moderately heritable with typical heritability of 0.2-0.4. The heritability estimate in lambs (1-2 months) is not significantly different from zero indicating that resistance is rather acquired than the innate trait. The genetic correlation between resistance and production traits (body weight and wool) is mostly favourable (r , -0.20 to -0.8) though neutral to slightly unfavourable correlation has also been reported. The genetic parameters suggest that the resistance trait can be incorporated as one of the criteria in selection objective.

Key words: Nematode, parasite control, sheep

INTRODUCTION

Parasitism, especially gastrointestinal nematodes is one of the major problems in sheep throughout the world. Of the number of gastrointestinal (GI) nematodes, *Haemonchus contortus* and *Ostertagia circumcincta* are major constraints on sheep production in sub-tropical and temperate areas respectively (Stear et al 1999a). The economic loss to the farmers and industries is substantial in terms of reduced productivity, animal mortality, condemnation of carcasses and cost of anthelmintic treatments. A potential loss in body weight gain of more than 25% has been reported in *Ostertagia circumcincta* infestation in sheep in the UK condition (Coop et al 1985). In monetary terms, millions of dollars are lost each year due to GI nematode infestation problems in the USA (Gasbarre and Miller 2000), New Zealand (Bisset et al 1992) and Australia (Kloosterman et al 1992).

Proper pasture management (rotational grazing, stocking densities) along with the judicious use of anthelmintics are the common parasite control measures. However, the evolution of parasite species resistant to a wide range of currently available anthelmintics (Jackson 1993, Prichard 1994, Swarnkar et al 1999) has been a major concern for the sheep industry. In addition, the growing concern of consumers over chemical residues in meat and environment and possible higher price associated with the development of new anthelmintics (Wendon 1996) necessitates the search for alternatives in parasite control measures. Breeding for nematode resistance (especially selection within breed) might be one of the economically viable and technically feasible options, as many researchers have already shown that there exists considerable variation within breed in resistance against wide range of GI nematodes species. The resistance trait as measured by faecal egg count (FEC) is moderately heritable (Bishop et al 1996, Stear and Murray 1994). The between breed variability of resistance to nematodes also keeps the area open for breed substitution, however, substitution of one breed for another will entirely depend on the economic merits of the concerned breeds.

The success of a selection program (response to selection) depends on the extent of genetic control of the trait (heritability), the selection intensity applied and the generation interval of the population under selection. The extent of genetic control of the trait (heritability) however has been reported to vary considerably across different breeds, at different sets of environment and different parasite species as well as well as method of estimation and

data transformation (Beh and Maddox 1996, Douch et al 1995, Bishop et al 1996, Woolaston and Piper 1996). The incorporation of resistance trait in the multi traits breeding objective also depends on the genetic correlation of this trait with other production traits and its relative economic importance. The published reports on genetic correlation of resistance traits with production traits are also inconsistent (Bishop et al 1996, Bisset et al 1992, Eady et al 1998), which necessitates that genetic parameters (heritability, genetic and phenotypic correlation with economically important traits) need to be estimated in the environment of the population in concerned before embarking any selection program.

There have been three types of selection strategies developed, namely for resistance, for resilience and for reduced number of treatment (Woolaston and Baker 1996). The selection for resistance (based on FEC) is important as the resistant animals essentially pass fewer eggs in their faeces (less pasture contamination) and thus subsequent lesser infestation problem. The other approaches currently under investigation to mitigate the anthelmintics resistance havoc are vaccine against nematodes, genetic modification of parasites, biological control (nematophagous fungi) or combination of some or all of them (Praslicka et al 1999).

In these contexts, the objectives of this review are to understand the extent of genetic control of nematode resistance in sheep in various circumstances, their correlation with the economically important traits, relative importance of indicators of resistance and future prospects of sheep breeding for parasite resistance.

Table 1. Gastrointestinal worms of sheep

SN	Infection site	GI worms
1	Abomasum	Haemonchus, Trichostrongylus, Teladorsagia
2	Duodenum	Trichostrongylus, Nematodirus, Cooperia, Strongyloides
3	Large intestine	Oesophagostomum, Trichuris
4	Small intestine	Ancylostoma, Necator, Bunostomum

Source: www.eap.mcgill.ca/AgroBio/ab370-04e.htm#SUSCEPTIBILITY AND IMMUNITY. Accessed at 08 2000.

Anthelmintic resistance in nematodes: a need for other parasite control measure

The anthelmintic resistance is states of increased number of individuals that can tolerate higher doses of drugs relative to normal population (Prichard et al 1980) resulting form selective destroy of susceptible parasites by repeated use of anthelmintics. The over-dependence on broad-spectrum anthelmintics as a means of parasite control in intensive sheep production systems has resulted in the development of resistance in a wide range of GI nematodes against currently available anthelmintics. Prichard (1994) in his review article, citing various authors, reported world wide occurrence of anthelmintic resistance with a high level of benzimidazole resistance in *Haemonchus contortus*, *Nomatodirus spathiger*, *N. folicollis*, *N. abnormalis*, *Teladorsagia circumcincta*, *Teladorsagia trifurcata*, *T. davtiani*, *Trichostrongylus axei*, *T. colubriformis* and *T.vitrinus* in sheep in south Australia; *Haemonchus contortus* in north Carolina; *Cooperia curtecei* in lambs in southern England and in eastern USA. He also reported levamisole resistance in *H. contortus* and *Trichostrongylus colubriformis* in Australia and Netherland. Recent development of closantel resistance in *H. contortus* has also been reported from Australia (Rolfe et al 1990). However, closantel was found 100% successful in controlling *H. contortus* in crossbred sheep when used for the first time in arid region in India (Swarnakar et al 1999). Swarnakar et al (1999) found complete resistance in *H. contortus* in sheep against fenbendazole while efficacy of tetramisole was found 25% on faecal egg count reduction test (FECRT) and in vitro egg hatch assay (EHA). They also indicated a possible development of resistance in same nematode species against rafoxanide.

Mechanism of host resistance for nematodes

Resistance is defined as the initiation and maintenance of responses provoked in the host to suppress the establishment of parasites and or eliminate the parasite load. A slightly different term, resilience is defined as the ability of the host to survive and be productive in the face of parasite challenge (Baker 1999).

Studies in Scottish Blackface lambs have shown that the genetically resistant hosts reduce nematode egg production by decreasing worm fecundity. The immunological mechanism that regulates worm length and fecundity of *Ostertagia circumcincta* is the quantity and specificity of parasite-specific IgA (Stear et al 1997). They found a significant association with the activity of IgA to fourth-stage larvae in the abomasal mucus, but not with the activity of IgG₁, the number of mast cells, the number of eosinophils or the number of globule leukocytes. Analysis of data revealed a strong relationship between worm length and worm fecundity, substantial genetic variation in faecal egg counts and worm length (h^2 : 0.62±0.20) but not in worm number (Stear et al 1999b). The heritability estimate of the worm burden was also very low and not significantly different from zero

in the lambs, indicating that lambs can't control worm burden. By contrast, in adult sheep infected with *O. circumcincta*, egg counts were substantially lower than in lambs due to acquisition of an immune response that reduced worm number possibly by immediate hypersensitive reaction against incoming third stage larvae indicating a slight different mechanism of nematode control (Stear et al 1999a). However, the low heritability (essentially zero) of the resistance trait by variance analysis in the early life of the lambs (1-2 month) revealed that the nematode resistance is rather acquired, not an innate trait (Bishop et al 1996).

The Scottish Blackface sheep with allele g2 of the MHC DRB1 locus (out of 19 allele identified) have been shown to have high resistance to nematodes as against the presence of most common allele (Schwaiger et al 1995). The faecal egg counts of the lambs carrying the g2 allele is 50 times less than those of lambs carrying the normal I allele. The identification of such genes in other breeds will greatly enhance the response in selection programmes along with possibility of selection without having to challenge the animals with parasites.

Indicators of resistance

The direct measure of resistance is the extent of parasite burden in the host as measured by number of worms established in the host. However, the destructive nature of this measure (animals need to be killed) is of no use in the selection program based on individual performance (but useful in family selection). Faecal egg count is by far the most commonly used parameter to indicate the degree of resistance to nematodes in animals as it is both a heritable and repeatable trait, though it has some limitations viz. FEC is not always closely related with worm burden, is affected by an array of host parasite relationship, level of host immunity, age of host, species of parasites, stage of infection accuracy of count etc (Baker 1999). The strong and consistent association of increased level of IgA specific for fourth stage larva of *O. circumcincta*, with shorter worm length and thus lower egg count with both natural and deliberate infection indicates its (IgA) potential use (more useful than FEC) as a phenotypic marker (Stear et al 1999a). Such a phenotypic marker as the indicator of parasite resistance can be used to compare animals exposed under similar infection. Contradictorily, Baker (1999) states that no immunological (total antibody, specific immunoglobulin, eosinophil) parameters have been identified which are better predictors of resistance than FEC. Douch et al. (1996) estimated the heritability of eosinophil counts in the 13 months old Merino sheep artificially infected with *T. colubriformis* to be only 0.19 as against 0.40 for FEC. They found the genetic correlation of -0.62 between eosinophil counts and FEC indicating that eosinophils would be only 43% as efficient at selecting for lower FEC as was done for FEC itself. Similarly, the relative efficiency (f) of antibody as an indirect selection parameters for FEC can be calculated by $f = h_{Ab}/h_{FEC} \times r_{Ab\ FEC}$ (Dough et al 1996) and found 67% as efficient as that of direct selection based on FEC. A significant ($p < 0.05$) higher mean value of haemoglobin, packed cell volume, total serum protein and peripheral eosinophil counts in respondents (resistant line) than those of non-respondent (susceptible line) sheep after deliberate infection with *H. contortus* (Hooda et al 1999) indicates the use of haematological parameters as indicators of resistance. However, it has been seldom used because of the different modes of parasitism in different species.

Table 2. Phenotypic/Clinical indicators of parasite infection in sheep

Worm burden	Host expression of resistance	Clinical effect
Faecal egg count	Serum antibody	Packed cell volume
	Circulating eosinophils	Plasma pepsinogen
		Albumin leakage
		Dag score
		Faecal consistency score

Source: Beh and Maddox 1996.

GENETIC VARIABILITY IN NEMATODE RESISTANCE

Within and between breed variability

In nature, it can be seen that certain species of livestock are affected by some diseases but not other species or man. Baker (1999) reported that Red Maasai sheep and Small East African goats are more resistant to GI parasites (predominantly *H. contortus*) than Dorper sheep and Galla goats. Stear and Murray (1994) also found that Red Masaai sheep are significantly ($p < 0.001$) more resistant than the Romney sheep following initial infection and pastured in separate paddocks measured in terms of faecal egg count. The Scottish Blackface sheep are more resistant than Fin Dorset sheep to *H. contortus* infection (Altaif and Dargie 1978). The other breeds of sheep reported to be comparatively more resistant to nematode infestations are Djallonka and Sabi of

Africa; St. Crois and Barbados Black-belly of Caribbean; Florida native, Louisiana native and Narajo of north America and Garole of India (Baker 1999). In one comparative study, Gulf Coast Native sheep were more resistant to *H. contortus* infection as compared to Suffolk sheep (Miller et al 1998). One of the plausible hypotheses underlying the nematode resistance has been suspected to strong peripheral eosinophil response, as both Red Massai and Scottish Blackface show such response (Stear and Murray 1994). Among the three native sheep breeds of Nepal, Kage (found in mid hills and valleys) was relatively superior in resistance to *H. contortus* challenged artificially, than the Lampuchhre (found in Terai) and Baruwai (found in high hills) sheep breeds. The superiority was expressed in terms of lower worm establishment, lower faecal egg counts, lower worm recovery and higher eosinophil response (Joshi 2000).

Table 3. Sheep breed comparisons for resistance to internal parasites

Resistant breed	Susceptible breed (compared with)	Parasite species	Reference
Targhee	Rambouillet	Ostertagia (Teladorsagia) spp Nematodirus spp	Scrivner 1964
Scottish Blackface	Finn Dorset	Haemonchus contortus	Altaif and Dargie 1978
Border Leicester x Merino	Merino	Oteladorsagia spp	Donald et al 1982
Florida Native	Rambouillet	Haemonchus contortus	Jilck and Bradley 1969
Florida Native	Dorset x Rambouillet	H. contortus, Trychostrongylus spp	Zajac et al 1988
Florida Native	Barbados	H. contortus	Courtney et al 1985a
Florida Native	Suffolk	H. contortus	Ruvuna and Stephens 1997
Red Maasai	Merino, Corridale, Hampshire	H. contortus	Preston and Allonby 1978
Red Maasai	Dorper	H. contortus	Baker et al 1994

The within breed variation in nematode resistance is shown by the overdispersed distribution patterns of faecal egg counts. Stear and Murray (1994) in their experiment found that only 10% of the Scottish Blackface lambs of 5month old were responsible for about 50% of the total eggs produced. The amount of variation among lambs increased as the lamb grew from 3-5 months of age, possibly because of heterogeneity in the rate of development of protective responses (Stear et al 1995). Various researchers have estimated the heritabilities of resistance measured in terms of FEC for different breeds after deliberate or natural infection of single or mixed species of parasites. However, the usefulness of genetic parameter estimates is influenced by the environment, the plane of nutrition, the age of the animals, the history of the exposure and concurrent infection with other pathogens (Stear and Murray 1994). In Australia, Eady et al (1996) demonstrated the within bloodline variation as a major source (22.2% of total variation) in Merino sheep flock with parental half-sib heritability estimate of cube root transformed FEC as 0.22 (0.07-0.42). Woolaston and Piper (1996) estimated the heritability as 0.23±0.03 and 0.21±0.03 for FEC and PCVD (packed cell volume decline) respectively after deliberate *H. contortus* infection in Merino sheep. However, the estimate of heritability increased to 0.29±0.03 after cube root transformation of FEC data. Similarly, the heritability estimate of FEC was found 0.35±0.18 in Avikalin sheep naturally infected with GI nematodes (predominantly *H. contortus*) in Rajasthan, India indicating a substantial within breed variation in the resistance trait (Singh et al 1999). Between year and between season within year variation in heritability estimates of FEC (Log transformed) in Polish long-wool sheep have been reported where predominant infection were *H. contortus* and *T. circumcincta*. (Bouix, et al 1998). Bisset and Morris (1996) found the heritability of various measures of resilience (number of treatments required, growth rate) to be relatively small (0.10±0.03 to 0.19±0.04) in Romney sheep.

Genetic correlation between nematode resistance and production traits

It is unlikely that the sheep-breeding program will only be based on the resistance trait as the sole selection criteria. However, incorporation of nematode resistance as one of the selection criteria in breeding goal depends on the relative economic importance and its genetic correlation with other production traits under consideration. The favourable the correlation, the more genetic gain could be expected. Bishop et al (1996) found a very high and favourable (r , -0.8) genetic correlation between faecal egg count and body weight traits in the Scottish Blackface lamb after natural and predominantly *T. circumcincta* infection. Bouix et al (1998) also found a strong negative correlation (-0.6) between FEC in September and body weight gain in one grazing season in Polish long-wool sheep. Bisset et al (1992) estimated correlation coefficients of -0.48 for FEC X hogget weight and -0.31 for FEC X clean fleece weight in Romney sheep in New Zealand. They also compared the result with inconsistent reports from various authors (eg Watson et al 1986, Baker et al 1991) showing slightly unfavourable correlation as well. Eady et al (1998) reported genetic correlation of -0.20, -0.18 and -0.26 between cube root

transformed FEC and weaning, 10-month and 16-month weight body weight respectively. Similarly they also reported the genetic correlation between FEC and grease fleece weight at 10-month, 16-month and 21-month as 0.21, -0.06 and 0.21 respectively.

Breeding strategy for nematode resistance

The overall goal of raising livestock is to maximise the profit. To achieve this goal several breeding objectives have to be set up. The strategy for breeding livestock is driven by these objectives, which are influenced by particular environmental conditions, socio-economic and market structures and advances in technology. In the places, where GI nematodes are a major problem, inclusion of resistance trait as one of the breeding objectives to improve overall goal is desirable. Between and within breed variability in the resistance trait opens two broad strategies to be adopted in breeding sheep for nematode resistance namely 1) between breed selection (breed replacement) and cross breeding and 2) within breed selection. These two broad approaches are briefly discussed below.

Breed replacement and cross breeding: The between breed variability in the resistance trait can be used as a criterion for the substitution of susceptible breed with a more resistant one. This depends upon the breeding objective of the particular area and the more resistant breed may not always be the desired one for specific production purposes. However, if comparatively resistant breeds are found to be at par in productivity, or at least fulfil objectives of keeping sheep for that particular area, then replacement of susceptible breed with a resistant one could be implemented. One particular example of this is the Red Maasai sheep, which has been given considerable importance in sub humid coastal Kenya (Baker 1999) for the development of a nucleus-breeding scheme with the ultimate objective of making Red Maasai ram more readily available to the farmers. Continuous upgrading to the desired breed after successive backcrossing, when complete replacement becomes very expensive is one of the suitable alternatives to breed replacement. The upgraded breed becomes indistinguishable after 4th generation of back crossing (Wiener 1994).

Cross breeding involves the process of crossing two or more breeds to incorporate the desirable characteristics in the progenies from the desirable characters present in the separate parental breeds. By taking sceptically the reported difference amongst breeds in nematode resistance, cross breeding programme for improvement in resistance may be embarked upon. In one comparative study in Kenya, Baker (1999) found that crosses between Red Maasai and Dorper were comparatively more resistant (measured in terms of FEC and PCV) than the Dorper breed when exposed to natural mixed and predominantly *H. contortus* infection. The lambs with increasing proportions of Red Maasai from the sire side were comparatively more resistant, indicating that the additive genetic effect was the major type of gene action for resistance trait and no heterosis effect was found. Relatively little work has been done in cross breeding for nematode resistance and this aspect needs to be focused on in the future.

Within breed selection and genetic progress

A. Principles and procedures of selection: Selection is the breeding process in which some animals in the population are preferred over others as parents of the next generation, on the basis of their merits or on those of their relatives or both combined. There is a lot of evidence (as reviewed above) that the nematode resistance trait is heritable and there exists considerable variation among individuals in the extent of nematode resistance within breed. The moderate level of heritability (at least at par with or slightly lower than that for production traits) and considerable amount of variability among sheep for the resistance trait is indicative that the resistance trait can be improved through selection.

The cost of the selection programme should at least be less than the cost of additional benefits attainable from the selection programme. Traits that significantly influence the overall profitability and that are under genetic control should be included in the breeding goal. The effective incorporation of such resistance traits into breeding scheme requires an understanding of epidemiological relationship between resistance and productivity, in addition to the genetic parameters of this relationship (Bishop and Stear 1999.)

Index selection is an optimum selection methodology to improve the several traits simultaneously in which a composite index is prepared by incorporating all the traits of economic importance that significantly contribute toward the breeding (selection) objectives. Correlation at genetic and phenotypic level, the genetic control and phenotypic variance of traits and economic weight for each trait (economic value of per unit change in desired trait) are required for formulation of selection index. Phenotypic and genetic covariance matrices of the traits are

solved to come into index, which is used as the basis for selecting animals as a parent of the next generation (Cameron 1997). A major problem is to assign proper economic value to the resistance trait, which can be affected by the host parasite interactions and effectiveness of alternative control measures (Woolaston and Baker 1996).

B. Response to selection

The response to selection in any trait depends on the extent of genetic control of the trait, the phenotypic variability in the trait within population under selection, the selection pressure applied and the generation interval. In addition, the correlated response is influenced by the extent of genetic correlation between traits concerned.

The correlated response to selection in other production traits, while selecting for resistance is determined by the extent of correlation between traits. In New Zealand, Morris et al (1997) found an increased divergence between two lines of Romney sheep selectively bred for high resistance or susceptibility, but no significant correlated response in live weight was observed. At the same time, yearling fleece yield was greater in the susceptible line when grazed under identical level of challenge whereas the reproductive rate (as measured by lambs weaned per ewe mated) was higher in the resistant line.

Bishop and Stear (1999) modelling genetic and epidemiological relationship with the best available genetic parameter estimates showed a series of responses in resistance and body weight traits under selection. Selection for reduced FEC in their model predicted a large (1.4 times greater) and curvilinear response in decreasing FEC than that predicted from genetic theory alone, due to epidemiological relationship of disease (ie less pasture contamination from resistant sheep) and production. They also showed a correlated and favourable response (increase) on live weight while selecting for lower FEC, which was again higher than that predicted from genetic theory.

The sensitivity of the selection by using imprecise genetic parameters and by giving different economic weights to FEC trait has been reported. Predicted genetic gain assuming zero genetic correlation between production and FEC, while there existed a different favourable relationship between them, slightly under-estimated the response in production index while the predicted response in FEC was over estimated (Eady 1998). Similarly, by giving different economic weights to FEC trait, again assuming zero genetic correlation between FEC and other traits, resulted in a remarkable increase in response for FEC while simultaneously showing a decrease in the response for other traits (Kominakis and Theodoropoulos 1999).

C. Possible constraint in selection for nematode resistance

The co-evolution of the parasite species in the process of selection for nematode resistance is considered as a potential problem. The parasites may adapt to increased host resistance in the process of selection (Kloosterman et al 1992). However, Bishop (personal communication) believes that, the development is unlikely in the short or medium term, because the breed difference in resistance is found to be stable over time and the selection pressure placed by host on parasites is relatively weak due to relatively long generation interval of parasites. Furthermore, Adams (1988) and Albers and Burgess (1988) were unable to detect parasitic (*H. contortus*) adaptation by serially passing this parasite through hosts of different immune status. An experiment carried out in Australia, involving 30 generations of parasite selection, also suggested that parasites might not respond to increasing host resistance at least in the short or medium term (CSIRO 1997). However, continuous surveillance, where selection in the host for parasite resistance is taking place may be necessary in long term.

GENERAL DISCUSSION

The widespread development of resistance in a wide range of GI nematode species to the number of available anthelmintics may one day leave not a single anthelmintic effective in the control of parasite problems. The continuous and uncontrolled use of anthelmintics encourages the resistant parasites to multiply (breed) and establish in progressive way with successive treatments. If proper measures are not taken, the fate of newly developed anthelmintics, which will suppose to be expensive (Windon 1996) will also take the same course. To expand the life (effectiveness) of anthelmintics, suitable alternative measures, which reduce the frequency of its use to only at a strategic point, are essential. Breeding sheep for nematode resistance is one of such possible strategy.

The genetic variability of resistance among individuals within sheep breeds is the basis for selection to improve the trait. The incorporation of resistance trait as one of the criteria in selective-breeding however depends on its economic merits, heritability and genetic correlation with other traits. The resistance trait is subjective in nature and its economic quantification is difficult. Faecal egg count to a greater extent and immunological (antibody, specific immunoglobulin, eosinophil) and haematological parameters (PCV, haemoglobin) to a lesser extent have been tried to quantify the degree of resistance in sheep. Stear et al (1999a) assumes that IgA might be more useful phenotypic marker (indicator) than FEC in *T. circumcincta* infection. Whereas Douch et al (1996) found that selection on the basis of antibody level is only 67% as efficient as that of direct selection based on FEC on reducing faecal egg counts in Merino sheep artificially infected with *T. colubriformis*. It is worthwhile to find out whether parameter like IgA is supplementary to FEC or complementary as an aid to selection. However, selection on the basis of FEC has its own merit as it reduces the pasture contamination and further infection. By modelling, Bishop and Stear (1999) found that selection for reduced faecal egg count results in a large correlated increase in live-weight gain, more than twice as predicted by quantitative genetic theory, due to the reduction in growth rate losses as the disease challenge to the animals decreased.

The amount of genetic control of resistance (heritability), though reported to vary in different circumstances, the general finding is that it is moderately heritable. The low (not significantly different from zero) heritability estimate in early age (1-2 month) of lambs as against moderate heritability in latter age (6 months) indicate that resistance is acquired trait and effective selection can not be embarked in early age based on FEC. Four major transformation approaches namely; square root, cube root, logarithmic and natural log for normalisation of highly skewed distribution of faecal egg counts have been adapted. Least square analysis and restricted maximum likelihood (REML) animal model techniques have been used to divide the total variation into its known and unknown sources of variance and for estimation of parameters. To increase to precision of estimates (reduce measurement variation), multiple samples and multiple measurements in each sample are beneficial (Bishop et al 1996).

The correlation between resistance and production traits (body weight and wool production) are mostly reported to be favourable (negative correlation) though some neutral to slightly unfavourable (positive correlation) relationship has also been found. The moderate level of heritability and favourable correlation between resistance and production traits can be utilised in successful incorporation of resistance trait in the sheep-breeding objective.

Understanding of the major histocompatibility complex (MHC), disease resistance and immune response system relationship will allow genetic improvement to be made by marker assisted selection rather than by direct challenge of population with pathogens (Rothschild et al 2000). Molecular biological technique to identify major gene responsible for nematode resistance in other sheep breeds as found in Scottish Blackface (g2 allele in MHC DRB1 locus) will be one major step forward to enhance the selection in future.

CONCLUSION

Sheep farming is mainly based on grazing system throughout the world and thus the parasite infestation and re-infestation problem in sheep through contaminated pasture is unavoidable. Resistance in nematodes to most of the currently available anthelmintics (benzimidazole, levamisole, closantel, and avermectins) has been reported from one or other parts of the world. Like the anthelmintic resistance in nematode, nematode resistance in host has also been reported and there is considerable evidence that resistance to nematode is genetically controlled. In lambs, the genetic control of the resistance is through control of worm growth mediated by immune response in larval stage whereby worm fecundity is reduced (high genetic correlation between worm length and fecundity). Whereas adult sheep can also regulate the worm burden by preventing establishment of incoming third stage larva. Faecal egg count is by far the most commonly used and reliable indicator of nematode resistance. However, identification of potential phenotypic and genetic markers will be of immense help. Moderate level of heritability of the resistance trait as assessed by the faecal egg counts and mostly favourable correlation of resistance trait with production traits makes selection for nematodes resistance within breed possible. But, as the genetic control of the nematode resistance traits is influenced by many factors, it is essential to have parameter estimates within the flock under selection consideration.

ACKNOWLEDGEMENTS

I am grateful to Dr D Fielding and Dr BR Joshi for editing this paper.

REFERENCES

- Adams DB. 1988. Infection with *H. contortus* in sheep and the role of adaptive immune in selection of the parasites. *International Journal for Parasitology* 18:1071-1075.
- Albers GAA and SK Burgess. 1988. Serial passage of *H. contortus* in resistant and susceptible sheep. *Veterinary Parasitology* 28:303-306.
- Altaif KI and JD Dargie. 1978. Genetic resistance to helminths: The influence of breed and haemoglobin type on the response of sheep for primary infection with *Haemonchus contortus*. *Parasitology* 77:161-175.
- Baker RL. 1999. Genetic resistance to endoparasites in sheep and goats. A review of genetic resistance to gastrointestinal nematode parasites in sheep and goat breeds in sub-humid coastal Kenya. *Animal Genetic Resources Information* 24:13-30.
- Baker RL, TG Watson, SA Bisset, A Vlassoff and PGC Douch. 1991. Breeding sheep in New Zealand for resistance to internal parasites: research results and commercial application. **In:** *Breeding for disease resistance in sheep* (GD Gray and RR Woolaston, eds). Australian Wool Corporation as cited by Bisset et al 1992. Pp. 19-32
- Beh KJ and JF Maddox. 1996. Genetic markers for resistance to gastrointestinal parasites infection in sheep. *International Journal for Parasitology* 26(8/9):879-897.
- Bishop SC and MJ Stear. 1999. Genetic and epidemiological relationship between productivity and disease resistance: Gastrointestinal parasite infection in growing lambs. *Animal Science* 69:515-524.
- Bishop SC, K Bairden, QA McKellar, M Park and MJ Stear. 1996. Genetic parameters for faecal egg count following mixed, natural, predominantly *Ostertagia circumcincta* infection and relationships with live weight in young lambs. *Animal Science* 63 (3):423-428.
- Bisset SA and CA Morris. 1996. Feasibility and implecation of breeding sheep for resilience to nematode challenge. *International Journal for Parasitology* 26(8-9):857-868.
- Bisset SA, A Vlassoff, CA Morris, BR Southey and RL Baker. 1992. Heritability of and genetic correlation among faecal egg counts and productivity traits in Romney sheep. *New Zealand Journal of Agricultural Research* 35:51-58.
- Bouix J, J Krupinski, R Rzepecki, B Nowosad, I Skrzyala, M Roborzynski, W Fedalewicz-Niemczyk, M Skalska, A Malczewski and L Gruner. 1998. Genetic resistance to gastrointestinal nematode parasites in Polish long-wool sheep. *International Journal for Parasitology* 28:1797-1804.
- Cameron ND. 1997. *Selection indices and prediction of genetic merit in animal breeding*. CABI Publishing. CAB International, Wallingford, Oxen OX10 8DE, UK.
- Coop RL, RB Graham, F Jackson, SE Wright and KW Angus. 1985. Effect of experimental *Ostertagia circumcincta* infection on the performance of grazing lambs. *Research in Veterinary Science* 38(3): 282-287.
- CSIRO. 1997. Breeding for reduced production cost in CSIRO animal production. Available at <http://www.prospect.anprod.csiro.au/research/easy/easy.htm>
- Devendra C and GB McLeroy. 1988. *Goat and sheep production in Tropics*. Longman Singapore Publishing Pvt. Ltd, Singapore. P. 115.
- Douch PGE, RS Green, CA Morris, JC McEwan and RG Winton. 1996. Phenotypic markers for selection of nematode resistant sheep. *International Journal for parasitology* 26(8/9):899-911.
- Eady SJ. 1998. Worm resistance in Merino breeding objective: influence of genetic correlation between resistance and production traits. **In:** *Proceedings of the 6th World Congress on Genetics Applied to Livestock Production*. Armidale Australia (January 11-16). 27:141-144.
- Eady SJ, RR Woolaston, RP Lewer, HW Randsma, AA Swan and RW Ponzoni. 1998. Resistance to nematode parasites in Merino sheep: Correlation with production traits. *Australian Journal of Agricultural Research* 49(8):1201-1211.
- Eady SJ, RR Woolaston, SI Mortimer, RP Lewer, HW Randsma, AA Swan and RW Ponzoni. 1996. Resistance to nematode parasites in Merino sheep: sources of genetic variation. *Australian Journal of Agricultural Research* 47(6):895-915.
- Gasbarre LC and JE Miller. 2000. *Genetics of Helminth resistance in breeding for disease resistance in farm animals* (RFE Axford, SC Bishop, FW Nicholas and JB Owen, eds). 2nd ed, CABI Publishing, CAB International, Wallingford, Oxen OX10 8DE, UK. Pp.129-152.
- Hooda V, CL Yadav, SS Chaudhari and BS Rajpurohit. 1999. Variation in resistance to haemonchosis selection of female sheep resistant to *Haemonchus contortus*. *Journal of Helminthology* 73:137-142.
- Jackson F. 1993. Anthelmintic resistance: the state of play. *British Veterinary Journal* 149:123-128.
- Joshi BR. 2000. Evaluation of genetic resistance of native Nepalese sheep breeds against *Haemonchus contortus* infection. *Veterinary Review* 15:27-35.
- Kloosterman A, HK Parmentier and HW Ploeger. 1992. Breeding cattle and sheep for resistance to gastrointestinal nematodes. *Parasitology Today* 8(10):330-335.
- Kominakis A and G Theodoropoulos. 1999. Selection of dairy sheep in Greece for parasitic nematode resistance: defining the aggregate genotypes and evaluating selection scheme. *Animal Science* 69:535-542.
- Miller JE, M Bahirathan, SL Lemarie, FG Hembry, MT Kearney and SR Barras. 1998. Epidemiology of gastrointestinal

- nematode parasitism in Suffolk and Gulf Coast native sheep with special emphasis on relative susceptibility to *Haemonchus contortus* infection. *Veterinary Parasitology* 74(1):55-74.
- Morris CA, A Vlasoff, SA Bisset, RL Baker, CJ West and AP Hurford. 1997. Response of Romney sheep to selection for resistance for susceptibility to nematode infection. *Animal Science*. 64(2):319-329.
- Praslicka J, V Letkova and D Lukesova. 1999. *Alternatives for nematode control in connection with anthelmintic resistance*. *Veterinarni Medicina*, 44(3). Available at <http://wos.mimas.ac.uk/isicgi/CIW...andFunc=AbstractandDoc=19/307andPR=0/11>. Accessed at 04 2000.
- Prichard R. 1994. Anthelmintic resistance. *Veterinary Parasitology* 54:259-268.
- Prichard R, C Hall, JD Kelly, ICA Martin and AD Donald. 1980. The problem of anthelmintic resistance in nematodes. *Australian Veterinary Journal* 56:239-251.
- Rolfe PF, JC Boray, C Fitzgibbon, G Parsons, P Kemsley and N Sangster. 1990. Closentel resistance in *Haemonchus contortus* from sheep. *Australian Veterinary Journal* 67:29-31.
- Rothschild MF, L Skow and SJ Lamont. 2000. The major histocompatibility complex and its role in disease resistance and immune responsiveness. **In:** *Breeding for disease resistance in farm animals* (RFE Axford, SC Bishop, FW Nicholas and JB Owen, eds). 2nd ed, CABI Publishing, CAB International, Wallingford, Oxen OX10 8DE, UK. Pp.73-105.
- Schwaiger FW, D Gostomski, MJ Stear, JL Duncan, QA McKellar, JT Epplen and J Buitkamp. 1995. An ovine major histocompatibility complex DRB1 allele is associated with low faecal egg counts following natural, predominantly *Ostertagia circumcincta* infection. *International Journal for Parasitology* 25(7):815-822
- Singh D, CP Swarnakar, FA Khan, J Jayshankar and PSK Bhagwan. 1999. Heritability of faecal egg counts in Avikalin sheep. *Indian Journal of Animal Science* 69(11):983-985.
- Stear MJ and M Murray. 1994. Genetic resistance to parasitic disease: particularly of resistance in ruminants to gastrointestinal nematodes. *Veterinary Parasitology* 54:161-176.
- Stear MJ, K Bairden, JL Duncan, G Gettinby, QA McKellar, M Murray and DS Wallace. 1995. The distribution of faecal nematode egg count in Scottish Blackface lambs following natural, predominantly *Ostertagia circumcincta* infection. *Parasitology* 110(5):573-581.
- Stear MJ, SC Bishop and G Gettinby. 1997. How host controls worms. *Nature* 389(6646): 27
- Stear MJ, S Strain and SC Bishop. 1999a. Mechanisms underlying resistance to nematode infection. *International Journal for Parasitology* 29:51-56.
- Stear MJ, S Strain and SC Bishop. 1999b. How lambs control infection with *Ostertagia circumcincta*. *Veterinary Immunology and Immunopathology* 72:213-218.
- Swarnakar CP, D Singh, FA Khan and PSK Bhagwan. 1999. Multiple anthelmintic resistance in *Haemonchus contortus* of sheep. *Indian Journal of Animal Science* 69(8):547-549.
- Watson TG, RL Baker and TG Harvey. 1986. Genetic variation in resistance or tolerance to internal nematode parasites in strain of sheep at Rotomahana. **In:** *Proceedings of the New Zealand Society of Animal Production*. Cited by Bisset et al 1992. 46:23-26..
- Wiener G. 1994. Animal breeding. *The tropical agriculturist*. MACMILAN Education Ltd London and Basibgstoke.
- Winton RG. 1996. Genetic control of resistance to helminth in sheep. *Veterinary immunology and immunopathology* 54(1-4):245-254.
- Woolaston RR and RL Baker. 1996. Prospects of breeding small ruminants for resistance to internal parasites. *International Journal for Parasitology* 26(8/9):845-855.
- Woolaston RR and LR Piper. 1996. Selection of Merino sheep for resistance to *Haemonchus contortus*: Genetic variation. *Animal Science* 62(3):451-460.

Assessment of Quality of Frozen Semen Used for Artificial Insemination

Krishna P Paudel¹, Amar Shah², Laxman P Ghimire³ and Bhoj R Joshi¹

¹ AHRD, NARC, Khumaltar

² Animal Breeding and AI Section, DOLS, Pokhara

³ Semen Bank, Bhairahawa

ABSTRACT

With an objective to explore the role of frozen semen in female infertility cases, thirty-six frozen semen straws comprising 20 cattle and 16 buffalo bull semen from Rupandehi, Kaski, Morang and Jhapa districts were examined *in vitro* for the assessment of fertilizing ability of the semen used for artificial insemination. The seminal parameters studied included sperm cell motility per cent, live and dead cell count and hypo-osmotic swelling test (HOST) response using standard protocols. Motility percent was assessed by microscopic examination at 40X magnification at 35 to 37°C by observing proportions of motile cells at five different spots on a slide. Nigrosin-eosin stain was used for the differential count of live and dead sperm cells. Hypo-osmotic sperm swelling response was determined by incubating semen sample at 37°C for 60 minutes in a hypo-osmotic solution (consisting of sodium citrate and fructose; 150mOsmol) and observing the osmotic changes in the sperm cells. Based on above three parameters there is a significant difference in semen quality among bulls for both the species (cattle and buffalo) however, no significant difference was evident between the samples from semen production source (Pokhara), transit storage (Semen Bank Bhairahawa) and the field level (DLSO and LSC samples) implying ideal storage conditions of semen during distribution and storage. In general the quality of the semen used for AI is below the recommended norms of the DLS. The study strongly recommends that a thorough andrological and seminal investigation of the bull used for semen collection be performed before their introduction as a source of frozen semen for artificial insemination. In case of buffalo bull semen as the post thaw quality of semen extended in citrate based buffer was found to be very poor the study also suggests for further exploration on the suitability of other extenders based on zwitter ion buffers.

Key words: Artificial insemination, frozen semen, cryopreservation, fertility, hypo-osmotic swelling

INTRODUCTION

In the semen cryopreservation of farm animals many scientific milestones have passed since the first recorded observation on semen preservation by Spallanzani (1776). As many creative imaginations are behind such scientific achievements, one such similar prediction made by Mantegazza (1866), we believe, had practical implication on the development of cryopreservation of semen to the present state. He predicted “If the human sperm can be preserved for more than four days at the temperature of melting ice without undergoing any change, then it is certain that scientists of future will be able to improve breeds of horses and cattle without having to spend enormous sums of money in transporting thoroughbred stallion and bulls. It will be possible to carryout artificial insemination with frozen semen sent rapidly from one locality to another. It should also be feasible for a husband who dies on the battlefield to fertilize his wife and thus to have legitimate sons even after his own death.” The development in the field of cryopreservation of semen in the last six decades proves that his imagination has been realized to a great extent with regard to reproduction in livestock.

With the adoption of artificial insemination, rapid progress in livestock production mainly aiming at increasing milk production of bovines has been materialized in many parts of the world including Nepal. The national programmes on crossbreeding between the exotic dairy breeds and native zebu cattle have been implemented in Nepal since last four decades. The population of crossbred cattle and buffalo in Nepal is ever increasing; therefore, the demand for frozen semen is also increasing.

Successful storage of semen in frozen form has been possible with chance discovery of glycerol as a cryoprotectant by Polge et al (1949). The principle of cryopreservation involves gradual lowering of temperature

for the gradual depression of metabolic activity of sperm cells for the prolongation of their life span. The technology has succeeded satisfactorily, though not to its biological potential, in exotic breeds but has comparatively less succeeded in many other domesticated animal species (Holt 1997, 2000) including the crossbred cattle and buffalo. The greatest problem still existing with the cryopreservation of spermatozoa is that even in the most successful species with the best preservation techniques to-date available, post thawing survival is restricted to around 50% of the sperm population (Watson 1995). The problem is more severe with crossbred cattle and buffalo semen than that of the purebred taurine cattle (Roy et al 1975, Prasad 1997, Verma 1997, Srivastava 2000).

In Nepal, Artificial insemination has been routinely practiced since last three decades and is one of the common modes of breeding, in crossbred cattle in areas accessible by roads and having the network of DOLS semen distribution. Infertility problems are frequently reported among dairy animal population; however, the role of the frozen semen used for insemination is not studied to the extent it should have been. As a part of the study on infertility in dairy animals, this investigation was conducted to assess the fertilizing ability of the frozen semen *in vitro* based on motility, livability and membrane integrity of the frozen spermatozoa of cattle and buffalo.

MATERIALS AND METHODS

Thirty-nine frozen semen straws (20 cattle and 16 buffalo) from three levels of semen distribution network (Table 1) were sampled for the purpose of the study. Of the straws sampled, observations were recorded from 36 straws for data analysis as three straws (two from field and one from semen storage level) were found to be completely damaged with all sperm cells dead. Production level samples were from Animal Breeding and Artificial Section, Pokhara; storage level samples from Semen Bank, Bhairahawa and field level samples from DLSOs (Rupandehi, Morang and Jhapa).

Table 1. Post thaw seminal parameters of cattle semen used for AI in Nepal

Semen production level: AB and AI section, Pokhara (n = 4)	Mean motility %	38.0
	Mean liveability %	45.0
	Mean HOS responsive cell %	
		31.0 ^b
Regional storage level: Semen Bank Bhairahawa (n = 4)	Mean motility %	38.0
	Mean liveability %	42.0
	Mean HOS responsive cell %	
		25.0
Insemination Center level: (n = 12)	Mean motility %	31.0
	Mean liveability %	35.0
	Mean HOS responsive cell %	
		20.0 ^a

Figures with different superscripts (a and b) are significantly different ($P < 0.05$).

Individual motility was assessed by making visual judgment on percent progressively motile cells and scoring at five different microscopic fields at 40 X magnification at 37°C (Thermo stage controlled microscope at Pokhara) and at around 35°C (summer room temperatures at other places).

Live and dead sperm cell count was carried out following the method of Campbell (1953) using Nigrosin Eosin stain. Hypoosmotic Sperm swelling response was determined by following the method of Jayendran et al (1984) by incubating sperm cells in a hypoosmotic medium for 60 min at 37°C.

RESULTS AND DISCUSSION

Seminal characteristics of the frozen samples from semen production, storage and field levels are summarized in Table 1. The mean motility percent of cattle and buffalo semen at the production level was 38 and 32% respectively. It is extremely important that efforts need to be made to achieve the post thaw motility percent of 50% for attaining satisfactory conception rates from artificial inseminations. Statistical analysis using ANOVA (SPSS) revealed that there was a significant difference in HOS responsive cell % between production and Insemination center level samples implying some discrepancies in handling semen straws (probably exposure to

more than 7 seconds of time outside liquid nitrogen) and subsequent damage to sperm cell as evident from reduced number of HOS responsive cells in the field level semen samples.

The values for motility, livability and HOS responsive cell % were lower for buffalo semen than those for cattle (Table 2). Though it is difficult to achieve good up to 50% post thaw motility in buffalo semen, it is desirable that the semen with less than 30% post thaw motility not be used for inseminating buffaloes in the field. One of the contributing factors for lower conception rates in buffalo appears to be associated with low post thaw motility of the frozen semen of buffalo semen.

Table 2. Post thaw seminal parameters of buffalo semen used for AI in Nepal

Semen production level: AB and AI section, Pokhara (n = 4)	Mean motility, %	32.5
	Mean liveability, %	36.8
	Mean HOS responsive cell, %	23.3
Regional storage level: Semen Bank Bhairahawa (n = 4)	Mean motility, %	28.8
	Mean liveability, %	35.5
	Mean HOS responsive cell, %	19.3
Insemination Center level: (n = 8)	Mean motility, %	24.2
	Mean liveability, %	32.8
	Mean HOS responsive cell %	19.2

Department for Livestock Services (DOLS) has set the requirement of post thaw motility of 50% and 40% for cattle and buffalo semen respectively (DOLS program implementation guideline and norms). These norms can be achieved for in-country produced semen too provided some modifications are made in production and processing protocols. In a separate study changing citrate based buffer to TRIS based one has improved buffalo semen post thaw motility by 10 0 15%. Similarly efforts have also been made to screen semen ejaculates to achieve the DOLS set targets. Merely motility cannot be the reliable parameter for assessing the fertility of semen. Hypo-osmotic sperm swelling test is another very reliable test to assess the functional membrane integrity of sperm cells. Any damage to membrane is likely to cause leakage of key enzymes (acrosin and hyaluronidase) essential for successful fertilization (Paudel 2002).

CONCLUSION

The motility, livability and HOS responsive cell percent of the frozen semen samples used for artificial insemination of cattle and buffalo are lower than required for achieving normal fertility. Immediate measures should be adopted for improving the quality of frozen semen giving more focus on buffalo semen. Change of buffers used for extension of the semen volume could one of the probable strategies.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support provided by NARC and laboratory support by AB and AI Section, Pokhara (DOLS) for undertaking the study on seminal aspects among causes of infertility in dairy cattle (Project No. 31856001, AHRD, Khumaltar)

REFERENCES

- Campbell RG, JL Hancock and L Rothschild. 1953. Counting live and dead bull spermatozoa. *J. Expt. Biol.* 30: 44.
- DOLS. *Program implementation guidelines and norms.*
- Holt WV. 1997. Alternative strategies for the long-term preservation of spermatozoa. *Reprod. Fert. Dev.* 9:309-319.
- Holt WV. 2000. Basic aspects of frozen storage of semen. *Anim. Reprod. Sci.* 62:3-22.
- Jeyendran RS, HH Vander Ven, M Perez-Pelaez, BG Crabo and LJD Zaneveld. 1984. Development of an assay to assess the functional integrity of the human sperm membrane and its relationship to semen characteristics. *J. Reprod. Fertil.* 70:219-228.
- Mantegazza P. 1866. Sullo sperma umano. *Re. Inst. Lomb. Sci. Lett.* 3:183-196.

- Polge C, AU Smith and AS Parkes. 1949. Revival of spermatozoa after vitrification and dehydration at low temperatures. *Nature* 164:666.
- Prasad JK. 1997. Studies on enzymatic changes and *in vitro* fertility test in relation to cryopreservation of crossbred bull semen. *MVSc Thesis*. IVRI, Izatnagar-243 122, U.P. India.
- Roy DJ, JC Biswas, SK Bandopadhyay and PN Bhat. 1975. Study on the freezability of spermatozoa in three genetic groups of crossbred bulls. *Indian J. Dairy Sci.* 13:112-116.
- Spallanzani L. 1776. Opuscoli, difisca animale e vegetabile Opusculo 11 osservazioni sperienze intorno ai vermicelli spermatici dell homo e degli animali. *Moderna* 1776: cf PF Watson. 1990.
- Srivastava S. 2000. Effect of ascorbic acid, caffeine and chloroquine on the freezability of bovine semen. *MVSc Thesis*. IVRI, Izatnagar-243 122, U.P. India.
- Verma NK. 1997. Cryopreservation studies of crossbred bull semen with special reference to buffers, membrane stabilizers and semen enzymes. *MVSc Thesis* IVRI, Izatnagar, U.P. India.
- Watson PF. 1990. Artificial insemination and the preservation of semen. **In:** *Physiology of reproduction* (GE Lamming, ed). Pp.747-869, Churchill Livingstone.
- Watson PF. 1995. Recent development and concepts in the cryopreservation of spermatozoa and the assessment of their post-thawing function. *Reprod. Fert. Dev.* 7: 871-891.

Efficacy of Titepati (*Artemesia vulgaris*), Lazzabati (*Mimosa pudica*) and Supari (*Areca catechu*) Against Gastrointestinal Nematodes of Goats

Sita R Aryal and Swoyam P Shrestha

Animal Health Research Division, NARC, Khumaltar

ABSTRACT

A study was conducted to evaluate the effects of herbal medicine Titepati (*Artemesia vulgaris*, Lazzabati (*Mimosa pudica*) and Supari (*Areca catechu*) against gastrointestinal nematodes in goats. Sixty naturally infected goats were selected on the basis of EPG count and divided into 5 groups, randomly. Titepati, lazzabati and supari were found 70.09, 59.26 and 44.53 percent effective respectively to reduce the EPG count where as albendazole was found 86.36 percent effective. The comparison of means for EPG reduction and weight gain showed that there was no significant difference ($P>0.05$) between titepati and albendazole (positive control) where as both of them were significantly different ($P<0.05$) with the negative control. Thus titepati may be a probable alternative drug against GI nematodes in goats.

INTRODUCTION

Gastrointestinal (GI) nematodes are considered to be the important disease problem in goat (Karki 1987). It causes economic losses by reducing production and productivity of goats. Joshi (1991 cited by Joshi 1994, 1996) found high mortality due to gastrointestinal nematode infection in sheep and goats under intensive grazing management in the mid hill and low hill regions of western Nepal. The subclinical helminth infection caused 72 and 160 percent weight loss in sedentary lambs and kids respectively (Joshi 1996).

Many kinds of anthelmintics have been used to control and treat the GI nematode infestation. The indiscriminate use of chemical anthelmintics for long time may develop resistance. It may also cause public health concern due to possible anthelmintics residues in foods of animal origin. Nepal is rich of medicinal plants, however, little of them are utilized. Thus the present study was conducted to evaluate the efficacy of titepati, lazzabati and supari against GI nematodes in goats.

MATERIALS AND METHODS

Sixty naturally infested goats with gastrointestinal nematodes were selected on the basis of EPG count and divided into 5 groups randomly. Dried mature leaves powder of Titepati (*Artemesia Vulgaris*) and lazzabati (*Mimosa pudica*) were prepared and given orally with feed @ 1 g/ kg body wt. for the 1st and 2nd group respectively. For the 3rd group, dried powder of supari (*Areca catechu*) @ 1 g/3 kg body weight was given orally. The fourth group was given albendazole (as positive control) according to recommended dose of the manufacturer. The 5th group was taken as negative control (without any medicine). The weight of all the goats was also measured simultaneously. After 7 days of treatment, with herbal drugs and with the standards, fecal samples from the treated and control groups were collected, EPG count performed and weight of each goat taken. This was repeated in two different times of the year. Results were recorded and efficacy of all the drugs compared with the result of the negative control group and with the group given standard drug, albendazole. The data were analyzed using SPSS (10.0) multiple comparison package.

RESULTS AND DISCUSSION

Among the three different herbal plants, titepati, lazzabati and supari, examined for the efficacy against GI nematode, titepati was found 70.09% effective, lazzabati 59.26 percent and supari 44.53% effective whereas the standard drug albendazole was found 86.36% effective. There was 15.80% reduction in EPG in the control group also (Table 1). Slight reduction in EPG in control group was not known, however, it may be due to immunity produced in the goats.

Table 1. Reduction on EPG after drug use

Group	Drug used	Mean EPG before drenching	Mean EPG after 7 days of drenching	Mean reduction in EPG	% effective
A	Titepati	642	192	450	70.09
B	Lazzabati	675	275	400	59.26
C	Supari	467	258	208	44.53
D	Albendazole	550	75	475	86.36
E	Control	367	308	58	15.80

Likewise there was 3.10, 3.05 and 2.04 percent increased in weight gain respectively in the groups given titepati, albendazole and lazzabati. Where as there was -0.57% and -2.44% reduced weight in the groups given supari and in the negative control group respectively (Table 2).

Table 2. Effect on weight gain

Group	Drug used	Mean wt before drenching, kg	Mean wt. after 7 days of drenching, kg	Mean increased/decreased wt, kg	% increased/decreased wt
A	Titepati	16.55	17.08	0.53	3.10
B	Lazzabati	18.18	18.54	0.37	2.04
C	Supari	26.16	26.03	- 0.15	-0.57
D	Albendazole	23.88	24.59	0.72	3.05
E	Control	25.78	25.15	- 0.63	-2.44

Table 3. Multiple comparison of means for EPG count

(I) Treatment	(J) Treatment	Mean difference (I-J)	SE	Significance level
Albendazole	Control	4.17*	1.74	.020
	Lazzawati	.75	1.74	.668
	Supari	2.67	1.74	.131
	Titepati	.25	1.74	.886
Control	Albendazole	-4.17*	1.74	.020
	Lazzawati	-3.42	1.74	.055
	Supari	-1.50	1.74	.392
	Titepati	-3.92*	1.74	.028
Lazzawati	Albendazole	-.75	1.74	.668
	Control	3.42	1.74	.055
	Supari	1.92	1.74	.275
	Titepati	-.50	1.74	.775
Supari	Albendazole	-2.67	1.74	.131
	Control	1.50	1.74	.392
	Lazzawati	-1.92	1.74	.275
	Titepati	-2.42	1.74	.170
Titepati	Albendazole	-.25	1.74	.886
	Control	3.92*	1.74	.028
	Lazzawati	.50	1.74	.775
	Supari	2.42	1.74	.170

* The mean difference is significant at 0.05 level.

The comparison of the result of titepati, lazzabati and supari with the standard albendazole and negative control showed that titepati was found most effective followed by lazzabati and supari (Table 2). However, when comparing the means, for the reduction of EPG, of three herbal drugs with each other and with the standard (albendazole), and with the negative control it was found that albendazole and titepati were not statistically different ($P>0.05$) to each other and both of them were significantly different ($P<0.05$) with the negative control. But there was no significant difference ($P>0.05$) among lazzabati, supari and the negative control (Table 3). However, titepati and albendazole were not significantly different ($P>0.05$) with lazzabati and supari.

Eventhough albendazole and titepati were significantly different with negative control ($P<0.05$) why titepati and albedazole were not significantly different with lazzabati and supari was not known.

Likewise when compared the means for the change in weight gain the similar result as in the comparision of means for the reduction of EPG was found. In other words there was no significant difference ($P>0.05$) between standard albendazole and titepati for the effect on increased weight gain whereas both of them were significantly different ($P<0.05$) with negative control but both of them were not significantly different with lazzabati and supari. Likewise there was no significant difference ($P>0.05$) among lazzabati, supari and control groups for the effect on weight gain (Table 4). The reason why there was no weight gain even though there was slight reduction in EPG in the goats given supari was not known. However, the slight reduction in EPG might have not helped for weight gain.

Table 4. Multiple comparisons of means for weight gain

(I) Treatment	(J) Treatment	Mean difference (I-J)	SE	Significance level
Albendazole	Control	1.350*	.569	.022
	Lazzawati	.350	.464	.455
	Supari	.862	.475	.076
	Titepati	.183	.464	.695
Control	Albendazole	-1.350*	.569	.022
	Lazzawati	-1.00	.569	.085
	Supari	-.488	.577	.402
	Titepati	-1.167*	.569	.046
Lazzawati	Albendazole	-.350	.464	.455
	Control	1.000	.569	.085
	Supari	.512	.475	.286
	Titepati	-.167	.464	.721
Supari	Albendazole	-.862	.475	.076
	Control	.488	.577	.402
	Lazzawati	-.512	.475	.286
	Titepati	-.679	.475	.159
Titepati	Albendazole	-.183	.464	.695
	Control	1.167*	.569	.046
	Lazzawati	.167	.464	.721
	Supari	.679	.475	.159

* The mean difference is significant at the 0.05 level.

CONCLUSION

Among the herbal preparations tested titepati was found effective. Thus titepati @1g/kg body weight may be an alternative against gastrointestinal nematodes in goats. Further investigation in larger population is recommended.

REFERENCES

- Joshi BR. 1994. Effects of parasitic gastroenteritis in goats under sedentary management in a low-hill village of western Nepal. A clinical report. *Veterinary Review* 9(1):18-20.
- Joshi BR. 1998. The effect of parasitic gastroenteritis on sheep productivity under intensive grazing management in the Mid-hill region of Nepal. *Veterinary Review* 13:1-4.
- Joshi BR. 1996. The need and the strategies for gastrointestinal nematode control in the sheep and goat population in Nepal. *Bulletin of Veterinary Science and Animal Husbandry, Nepal*. Pp.59-70.
- Karki NPS. 1987. Sheep resources in Nepal and some constraints in migratory system of production. *Paper presented at second national conference of the Nepal Veterinary Association*, 23-25 February 1987.

In Vitro Nuclear Chromatin Decondensation Test: A Quick Method of Assessing Sperm Nucleus Quality

Krishna P Paudel¹ and Satish Kumar²

¹ AHRD, NARC, Khumaltar

² AR Division, Indian Veterinary Research Institute, India

ABSTRACT

A study on decondensation of nuclear chromatin in vitro of fresh, prefreeze and frozen thawed spermatozoa of crossbred bull was carried out to assess the effect cryopreservation on sperm nuclei decondensation. Thirty-two ejaculates of semen from four crossbred bulls (8 from each) were collected, fresh sample examined, the rest extended in tris-fructose egg yolk glycerol extender. Pre-freeze sample at this stage were aliquoted and the remaining parts of the semen filled in French medium straw and stored in liquid nitrogen. Nuclear chromatin decondensation test was performed by incubating the semen samples in borate buffer containing 1% sodium dodecyl sulphate (SDS) and 3.0 mg/ml dithiothreitol (DTT) and observations for decondensation changes at different time intervals were made by stopping the reaction with 2.5% glutaraldehyde. The decondensation changes were apparent from coiling of sperm tail, swelling of sperm head and granulation and fragmentation of chromatin material. The changes in chromatin material and their importance with reference to semen quality are described. The frozen-thawed sperm nuclei tended to decondense quicker than their fresh and prefreeze counterparts as evident from significantly higher number of decondensed nuclei at 15 min. of incubation. However, after 25 min. and later the decondensation changes recorded in all the three categories of spermatozoa were similar. The test is advocated for its routine use to detect abnormalities in chromatin if any before the bull is certified for semen collection and later when felt necessary.

Optimising Growth Potential of Indigenous Khari and Sinhal Goat Breeds of Nepal With Health and Nutrition Management

Bhoj R Joshi¹, Bhola S Shrestha² and Kalyani Mishra³

¹ NARC, Singha Durbar Plaza

² RARS, Lumle

³ Animal Breeding Division

ABSTRACT

Goats are an important source of household income and means of livelihood for the rural farmers of Nepal. The productivity of indigenous goat breeds under traditional management and subsistence production system is low because of poor nutrition, health care and other management practices. However, the actual potential of these animals under optimal health and nutrition management have not been evaluated so far. Hence, studies were carried out to identify the growth potential of indigenous goat breeds under optimal health and feeding management, so that the production potential of these animals could be known and technologies could be developed for increased production and higher economic returns for the farmers. These experiments were carried out at ARS, Lumle during 2000-2001 to determine the voluntary feed intake, response of supplementation at early age and post weaning feed lot production potential of Khari and Sinhal goats under different feeding regimes. All animals used in the studies were vaccinated against the epidemic disease PPR and Enterotoxemia and treated against the parasites strategically. Evaluation of voluntary feed intake (daily dry matter intake) of goats ranged from 3.9-5.4% of their live weight. Daily intake was higher when offered with fodder tree leaves (5.4% of body weight) as compared to ground grass (3.9%). The average daily gain (ADG) of Khari kids (between one to five months age) supplemented with creep feed ad libitum was 72 g, which was significantly higher ($p < 0.01$) than those in the non-supplemented group (35 g). The final body weight of kids at the age of five months in supplemented group was 13.8 kg as compared to 8.8 kg in non-supplemented group. The average daily concentrate intake during the period was 230 g/kid and the net benefit of supplementation was Rs219/kid for the specified period under prevailing market price. In a feedlot study, ADG in Sinhal (59.5 ± 5.87 g/day) and Khari (52.5 ± 4.43 g/day) goats were not significantly different ($p > 0.05$), whereas at different level of concentrate intake, in proportion to daily dry matter (DM) requirements, the level of concentrate supplementation had significant effect on ADG ($p < 0.05$). The ADG of goats offered 50% and 40% of their DM requirement through concentrates were significantly higher (65.7 ± 6.43 and 60.71 ± 4.54 g respectively) than those of goats supplemented with only 25% concentrate of their DM requirements (43.9 ± 5.84 g). Economically, concentrate supplementation at 40% DM intake was found to be more profitable under intensive feedlot management.

Key words: Growth potential, indigenous goat, health, nutrition, management

INTRODUCTION

Goat keeping is an important component of subsistence farming system in Nepal. They are important means of immediate cash income for the resource poor farmers who are unable to invest in large ruminants. Goats are only second to buffaloes for household income generation from livestock sector in Nepal (Gatenby and Shrestha 1990). They are being raised primarily for meat, manure, skin, and hair (Pashmina). Besides they are also being used as pack animals particularly in the far western high hills of the country. The goat population in Nepal is estimated to be 6.4 millions (FAO 2000) with 4 recognized goat breeds; Chyangra in Trans-Himalayan region, Sinhal in high hills, Khari in low to mid hills and Tarai goats in Tarai plains of Nepal. Despite the large population, Nepal is still not self sufficient in fulfilling goat meat demand, and thus a large number of live animals worth billions of rupees are imported from neighboring countries annually. This has been primarily resulted from the low level of off-take arising from overall poor herd productivity (slow growth and high mortality) under traditional subsistence production system. Poor nutrition and health care has been recognized as

the root cause for poor productivity under this management system. Farmers have also reared exotic goat breeds (Jamunapari, Barbari, Beetal, etc) for crossbreeding. Especially Jamunapari goats were found to be relished by farmers due to its greater body size at market age. However, the overall productivity of the crossbred was also not found to be as expected.

It has also been suggested that production from indigenous goat breeds could be increased if proper nutrition and health care could be provided. Indigenous goats (especially Khari and Tarai goats) are highly prolific and some authors have reported higher total outputs (meat/doe/annum) from these goats as compared to exotic crossbred goats (Oli 1987, Neopane 1997). However, it is observed that milk yield in native does is inadequate for rearing the kids, and it is not uncommon to find high mortality in the underfed and stunted kids. In this regard, it would be important to investigate the responses to nutrition supplementation and proper health care, so that the growth and productivity potential of the native goats could be determined, which will help to improve the present production system to market oriented commercial production system in the country.

MATERIALS AND METHODS

Three experiments were carried out at ARS, Lumle during the year 2000-2001 to determine the voluntary feed intake (DM intake) of goats, response of supplementation at early age and post weaning feedlot production potential of Khari and Sinhal goats under different feeding regimes.

In the first experiment, twelve adult goats were randomly allocated into two groups. Goats were provided either with fodder tree leaves or ground grasses *adlibitum* in addition to 150g commercial concentrates as basal diet for a period of 15 days. After that period feeding regimes were swapped between groups. Voluntary feed intake (offered and refusal) was recorded daily and DM content of offered feeds were recorded at weekly intervals.

In the second experiment, fourteen twin Khari goat kids (1-month age) were randomly allocated into two groups, one each from twin pairs. Kids in one group were separated from the does during the daytime and supplemented with commercial concentrate feed for a period of 4 months, whereas, the kids in next group were reared traditionally with mother flocks and not supplemented with concentrate feed. The kids in the first group were also allowed to suckle their mothers at two hourly intervals in the daytime. Both groups were provided with seasonally available green forages *adlibitum*. Body weight gain at weekly intervals in each group and daily feed intake was recorded during the study period. The growth data were analyzed using t-Test in MINITAB computer package.

In the third experiment, eleven Khari and eleven Sinhal goats, between 6-8 months age was allocated randomly into three treatment groups after matching for age, sex and body weight. All animals were reared individually under stall-feeding management. Feed was offered daily and intake was recorded on DM basis. Feed allowance was calculated at the rate of 5% of body weight on DM basis. The animals were allocated randomly into three treatment groups as follows:

Treatment group 1:	50% of DM from concentrate + green grass (<i>adlib</i>) providing 50% of DM
Treatment group 2:	40% of DM from concentrate + green grass (<i>adlib</i>) providing 60% of DM
Treatment group 3:	25% of DM from concentrate + green grass (<i>adlib</i>) providing 75% of DM

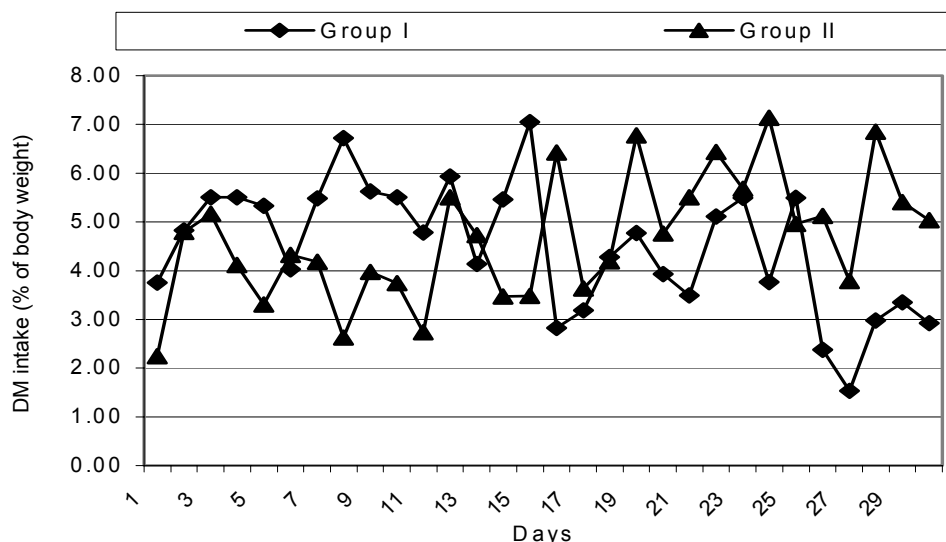
Feed and concentrate supplementation was adjusted fortnightly according to the change in body weight. Body weight gain at fortnightly intervals and daily feed intake was recorded. Fecal samples were collected and examined by McMaster method according to MAFF (1986) for fecal egg counts to determine the parasitic burden at monthly intervals. Although there was no parasite burden under stall-feeding management, the animals were treated with fenbendazole as recommended dose at two months intervals regularly. All animals were vaccinated against PPR and enterotoxaemia. Growth data were analyzed using ANOVA in Minitab package.

RESULTS

Daily dry matter (DM) intake

The average DM intake of goats for a 30-days period on fodder tree leaves and ground grasses in a crossover trial are presented in Figure 1. The average daily DM intake of goats offered fodder tree leaves was 5.45% of live weight,

which was significantly higher ($p<0.05$) than those fed with green grasses (3.9% of body weight). The voluntary feed intakes of animals fluctuated over the days.



Group I – fodder tree leaves followed by ground grass. Group II – ground grass followed by fodder tree leaves.

Figure 1. Voluntary dry matter intake in goats offered with fodder tree leaves and grasses

Response of young kids to creep feeding

The responses in body weight gain of kids in two groups are presented as Table 1. The initial average body weight (at the age of one month) of kid in both groups was 5.2 kg. After 120 days trial period, the final average body weight of the kids in supplemented group was 13.8 kg, while those of non-supplemented group was only 8.8 kg. The respective average daily weight gains during the period were 72 g and 35 g, the difference being highly significant ($p<0.01$). The average daily concentrate intake of kids in supplemented group was 230 g.

Table 1. Total and daily weight gain of goat kids in different groups

Group	Goats, n	Initial weight, kg	Final weight, kg	Total wt gain, kg	Av daily gain, g
Supplemented	7	5.2	13.8	8.6	72
Non-supplemented	7	5.2	8.8	3.6	35

The average monthly body weight of the kids in two groups is presented as Figure 2. A clear distinction in growth trends between the groups was evident after 30 days of supplementation.

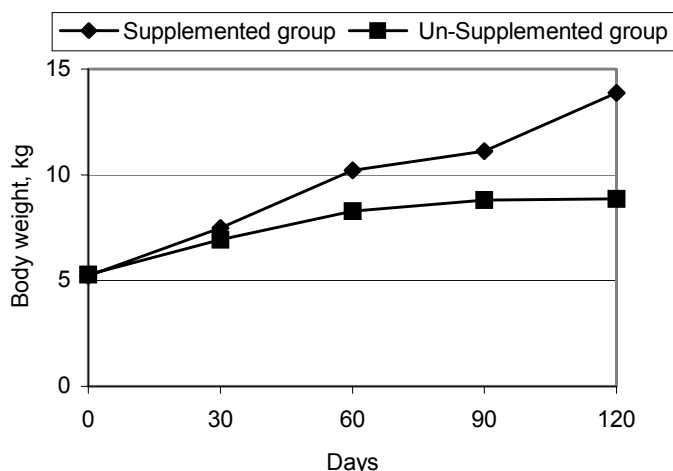


Figure 2. Body weight of kids in two groups at monthly interval.

Growth response of Khari and Sinhal goats to concentrate feed supplementation

Weight gain of 6-8 months old goat kids was monitored for up to 175 days from August 2000 to January 2001 under feedlot management system. The growth performance of both goat breeds in different treatment regime is presented in Table 2. The average daily weight gains in Sinhal goats were 65.7 g, 61.4 g and 48.6 g in T1, T2 and T3 groups respectively, whereas the daily weight gain in Khari goats were 65.7g, 59.9 g and 41.1 g in respective treatment groups.

Table 2. Total and daily weight gain of goats under different level of concentrate supplementation

Breed	Group	Goat, n	Initial weight, kg	Final weight, kg	Total weight gain, kg	Average daily weight gain, g
Sinhal	T1	4	17.8	29.3	11.5	65.7
	T2	4	18.1	28.9	10.8	61.4
	T3	3	18	26.5	8.5	48.6
Khari	T1	3	14.8	26.3	11.5	65.7
	T2	4	11.1	21.6	10.5	59.9
	T3	4	12.2	19.4	7.2	41.1

The fortnightly body weight and average daily gain of different goat breeds in different feeding regimes are presented in Figures 3 and 4 respectively.

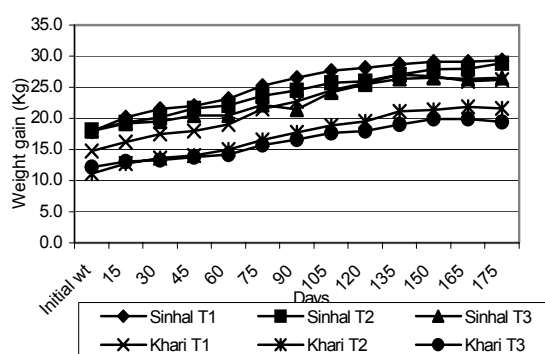


Figure 3. Fortnightly body weight in Khari and Sinhal goats under different feeding regimes

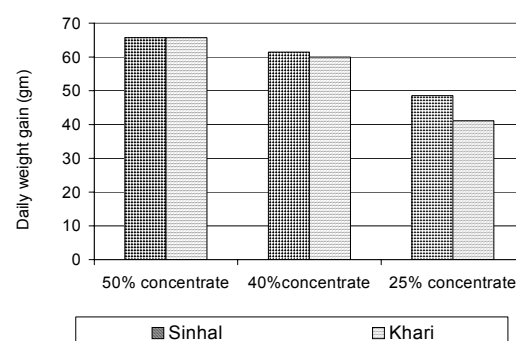


Figure 4. Average daily weight gain in Khari and Sinhal goats under different feeding regimes

The effect of breed, treatments and sex of goats on growth performance is presented in Table 3. Initial body weight of the goats were taken as covariates while analyzing the growth data. The average daily weight gain was not significant ($p>0.05$) between two goat breeds, while the growth was significantly different between the treatment (level of concentrate) groups ($p<0.05$) and sexes of goats ($p<0.05$). The average daily gain in Sinhal goats was higher (59.5 g/day) than that in Khari (52.5 g/day) but the difference was not significant. The average daily gain of goats receiving 50% of DM requirement through concentrates (T1) had higher average daily weight gain (65.7 g) as compared to the groups receiving 40% concentrate (T2) and 25% concentrate (T3). Similarly, the average daily gain in male was significantly higher (64.0 g/day) than that of female (44.4 g/day)

Table 3. Effect of breed, treatments and sex on growth performance of goats

Factor	Total body weight gain, kg	Av daily weight gain, g
Overall mean	9.79±0.64	55.92±3.67
Breed	($p>0.05$)	NS ($p>0.05$)
Sinhal	10.41±1.03	59.48±5.87
Khari	9.18±0.77	52.47±4.43
Treatment	($p<0.05$)	($p<0.05$)
T1 (50% concentrate)	11.5±1.13	65.71±6.43
T2 (40% concentrate)	10.62±0.79	60.71±4.54
T3 (25% concentrate)	7.69±1.02	43.93±5.84
Sex	($p<0.05$)	($p<0.05$)
Male	11.19±0.88	63.96±3.89
Female	7.78±0.68	44.44±5.04

Feed utilization efficiency

The average monthly weight gain and concentrate feed intake of kids in supplemented group is given in Figure 5. It is evident from the figure that feed supplementation during the first month was quite efficient (weight gain/ kg feed) as compared to other three months of supplementation.

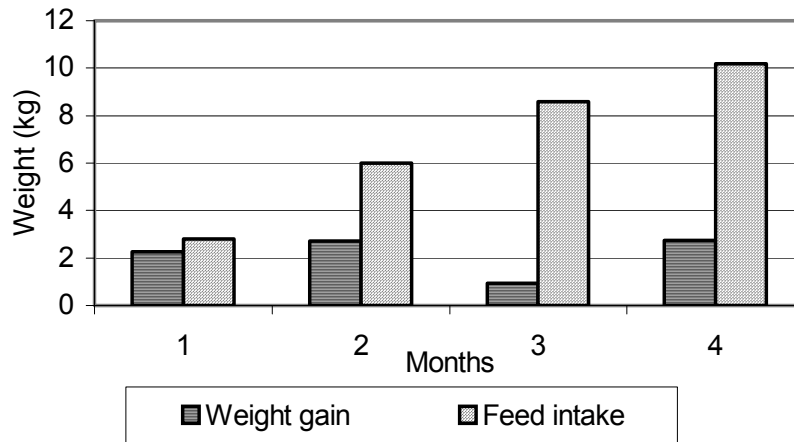


Figure 5. Weight gain and feed intake pattern in goat kids supplemented with concentrates.

The feed intake (concentrate and roughage) of goats under different feeding regimes (treatments) is presented in Table 4. The total concentrate intake per kg of live weight gain in both breeds was higher in diet groups with lower proportion of DM requirement (25%) through concentrate, whereas, lowest total DM intake per kg of live weight gain was found in the groups provided with higher proportion of concentrate (50% of DM).

Table 4. Feed intake of goats in different treatment groups

Breed	Treatment	Concentrate intake, kg	Roughage intake, kg	Concentrate, kg/kg Live wt gain	Roughage, kg/kg Live wt gain
Sinhala	T1	75.35	448	6.55	38.96
	T2	67.77	445	6.28	41.20
	T3	49.4	441.5	5.81	51.94
Khari	T1	70.1	342	6.10	29.74
	T2	53.5	336.5	5.10	32.05
	T3	35.6	352	4.94	48.89

Economics of feed supplementation in kids

Cost benefit analysis of concentrate feed supplementation to the kids at early age is presented in Table 5.

Table 5. Cost and benefit analysis of supplementation in goat kids.

Group	Input/ Costs		Outputs/Return		Margin, Rs
	Total feed intake, kg/head	Feed cost, Rs/head	Total live wt gain, kg/head	Value of live weight, Rs	
Supplemented	27.6	331.2	8.6	946.0	614.8
Non-supplemented	0	0	3.6	396.0	396.0

Margin over concentrate cost.

As the other costs (labor, treatments, etc) remain similar for both groups, the economic benefit of concentrate supplementation is clearly visible. A net margin of Rs219.0 per kid was obtained in supplemented group over non-supplemented group.

Economics of feed supplementation in feedlot goats

The partial budgeting (financial analysis) of feedlot goat management in different feeding regime is given in Table 6. The analysis revealed that concentrate supplementation @ 40% of the DM requirement in Khari goats gave a highest return per goat as compared to other treatment groups. While in Sinhal, there was not marked

variation in return per goat between group supplemented with the concentrate @ 50% and 40% of the DM requirement.

Table 6. Economic analysis of supplementation under different feeding regimes

Breed	Group	Inputs			Outputs	Margins
		Concentrate Intake, kg	Concentrate cost, Rs	Live wt gain, kg	Value of live wt, Rs	
Sinhali	T1	75.35	904.20	11.5	1265.00	360.80
	T2	67.77	813.24	10.8	1188.00	374.75
	T3	49.40	592.80	8.5	935.00	342.20
Khari	T1	70.10	841.20	11.5	1265.00	423.80
	T2	53.50	642.00	10.5	1155.00	513.00
	T3	35.60	427.20	7.2	792.00	364.80

Margin over concentrate cost.

Monitoring of parasitic burdens

Faecal samples of goats (both Khari and Sinhali in all treatment groups) were subjected to microscopic examination at monthly intervals to know the extent of parasitic burden. During the trial periods, no eggs were detected on faecal samples examined in both breeds, which was due to maintenance of animals under conditions unsuitable for parasitic infection.

DISCUSSION

The voluntary dry matter intake (DMI) of animal is a function of animals (rumen capacity, functional stage); feed (palatability, digestibility, physical structure, moisture content) and the environment in which animal is raised. The daily dry matter intake capacity is essential for making nutrient allowance to the animals. The DMI in goats has been reported to range from 3.9-7.8% with higher DMI in dairy goats (Singh et al 1989). The DMI of Nepalese hill goats were also found to range from 3-7% of live weight. The DMI of goats while offered fodder tree leaves were higher (5.45% of live weight) as compared to those offered with ground grasses (3.9%). It might be due to higher moisture content of the ground grass and rumen capacity of the goats might have limited the DMI.

The growth performance of the Khari goat kids was greatly enhanced by supplementation of concentrate *ad libitum* at early stage (creep feed) reaching an average of 14 kg body weight at the age of 5 months with average daily gain of more than 70 g. The body weight obtained under this feeding system was greater than the average 12-month body weight (12-15 kg) of Khari goats under traditional feeding management system (Shrestha 1994, Neopane, 1997). This illustrates the growth potential of Khari goats and the importance of supplementary nutrition especially at young age, which will also contribute significantly in the later stages of production. Under such intensive management system, 12-month weight of Khari goats could reach about 25 kg, and about 30 kg at 14-month, probably the appropriate slaughter age for these animals. Furthermore, the average daily gain of Khari kids under creep feeding is higher than those of Jamunapari or Barbari crossbred goat kids (Upreti 1999), Barbari goat kids (Singh and Rout, 2000) and similar to that of Jamunapari kids under feedlot system as reported by Roy and Singh (2000). The finding also suggest for improving nutrition rather than cross breeding for improving productivity in Nepalese goat breeds.

Supplementation of concentrates to feed lot goats at 40% of daily DM requirement is found to be economically viable. Under such system, the growth potential of Khari and Sinhali goat breeds are similar and not less than those of Jamunapari or Barbari goats under similar system. Thus there is a clear indication that indigenous goat breeds are equally potential for higher growth rate which could be exploited by better nutrition and health management, which ultimately will contribute for improving the present goat production to a viable and commercial production system in the country.

CONCLUSION

- The DMI of goat ranged from 3-7% with a mean of 5% of their live weight, being lower while consuming succulent feed.
- The growth rate of kids significantly improved on supplementation with concentrate feeds at early age.

- Supplementation of young kids, particularly twins, with concentrates at *adlibitum* is essential and profitable and could be adopted in commercial goat production.
- The growth potentials of Khari and Sinhal goats are similar.
- Supplementation of concentrates @40% of their body weight is suitable for better growth and higher economic return in the fattening goats.
- Under feedlot system, 14- month age is probably the proper slaughter age for Khari goats.

ACKNOWLEDGEMENTS

The authors are grateful for the managerial support of Lumle management, technical support from technicians of Livestock Health and Production Unit and financial support from Hill Agriculture Research Project (HARP) under HARP PP 07/99 for these studies.

REFERENCES

- FAO. 2000. At <http://www.fao.org>. Agriculture Statistics.
- Gatenby RM and NP Shrestha. 1990. Livestock production in Eastern hills of Nepal. *PAC Technical Paper No. 123*. Pakhribas Agriculture Research Centre, Nepal.
- MAFF. 1986. Ministry of Agriculture, Fisheries and Food. Manual of veterinary parasitological laboratory techniques. *Reference Book no 418*.
- Neopane SP. 1997. The genetics of productivity traits in Nepalese hill goat flock. *PhD Thesis*. University of London, London, UK.
- Oli KP. 1987. Goat breed comparison study in Hattikharka Panchyat. *PAC Technical Paper 93*. Pakhribas Agriculture Center, Dhankuta, Nepal
- Roy R and LB Singh. 2000. Improvement and sire evaluation of Jamunapari goats for milk production (AICRP on goat improvement- Jamunapari). *Annual Progress Report (1999/2000)*. Central Institute for Research on Goats. Makhdoom, Mathura, India.
- Shrestha HR. 1994. Goat production system, Nepal (3-P-87-0084). *Final technical report*. Nepal Agriculture Research Council and IDRC, Canada.
- Singh N, K Sharma and JL Ogra. 1989. Nutrient requirements of goats in comparison to other ruminants. **In:** *Goat rearing* (NK Bhattacharya, ed). Central Institute for Research on Goats. Makhdoom, Mathura, India.
- Singh SK and PK Rout. 2000. Genetic improvement of Barbari goats for milk and meat production (AICRP on Goat Improvement- Barbari). *Annual Progress Report (1999/2000)*. Central Institute for Research on Goats. Makhdoom, Mathura, India.
- Upreti CR. 1999. Comparative performance of seven goat breeds (Khari, Sinhal, KxJ, KxB, KxKi, Jamunapari and Barbari) at ARS, Bandipur. *Annual Technical Report (1998/99)*. Agriculture Research Station, Bandipur, Tanahun, Nepal.

Replacement of Maize by Wheat with Supplemental Methionine and Lysine for Broiler Production in Low Protein Diets

Netra P Osti, Shree K Khanal and Megh R Tiwari

Animal Nutrition Division, Khumaltar

ABSTRACT

One hundred and ninety two day-old broiler chicks were procured from ordinary market of Kathmandu. Chicks were randomly assigned into 4 dietary treatments with 6 replications. A ration consisting 19 percent crude protein (CP) in starter diets and 16 percent CP in finisher diets with supplemental methionine and lysine without wheat grain incorporation was formulated for control (T₀) group. In T₁, T₂ and T₃ treatments groups proportion of maize was replaced by wheat with 10, 20 and 30 % respectively. Results showed that there was no significant difference in feed consumption. However, body weight gain and feed efficiency differed from control. It is concluded that in the period of maize scarcity wheat grain can replace maize with however some compromise in body weight gain. It is also suggested that further research should be directed toward the nutrient utilization of wheat-based diets in poultry production.

Key words: Lysine, methionine, wheat grain

INTRODUCTION

Poultry is the emerging business in urban and semi urban areas. It is also easily available animal protein sources for human beings. Maize is the second most important staple food crop after rice and supplies bulk of poultry feed ingredient. Currently maize is grown on 819010 ha of land with an average yield 1.8 t/ha (Pathik 2002). Yellow maize is used for poultry feeding due to its high energy and yellow pigment content. For this reason, the price of yellow maize during scarcity goes up beyond the affordable set back. Wheat is the third important cereal crop after rice and maize. Its productivity is steadily increasing from 1.4 tons/ha in 1990 to 1.806 tons/ha in 2001 (NWRP 2001). Wheat grain content 3120 Kcal/kg metabolizable energy (ME), which is nearly comparable to maize (3350 Kcal/kg) and the market price for wheat is comparatively stable than maize. However, it does not contain yellow pigmentation that is why poultry fed industries do not like to use wheat grain for feed formulation. In this experiment an attempt was made to replace maize by wheat with supplemental methionine and lysine for broiler production in low protein diets.

MATERIAL AND METHODS

One hundred and ninety two day-old vencob broiler chicks were procured from ordinary market of Kathmandu. Chicks were randomly divided into 4 dietary treatments with 6 replications. A ration consisting 19 percent crude protein (CP) in starter diets and 16 percent CP in finisher diets with supplemental methionine and lysine without wheat grain incorporation was formulated for control (T₀) group. In T₁, T₂ and T₃ treatments groups proportion of maize was replaced by wheat with 10, 20 and 30% respectively (Table 1 and 2). Chicks were fed *ad libitum* diets and raised in a colony cage system. Treatment diets were normally fed two times a day and leftover feed was collected every morning. Data on weekly feed consumption and body weight gain was recorded once a week of feeding period. Feed efficiency was calculated as feed to gain ratio. Data were subjected to analysis of variance for completely randomized design using leaner model (Mintab 1996). While Tukey's W procedure was used for mean comparison (Steel and Torry 1960).

Table 1. Composition and calculated nutrient content of broiler starter (1-3 week) diets with different level of wheat and supplemental methionine and lysine

Ingredient	Percent wheat in diets			
	0	10	20	30
Rice polish	18.00	17.00	18.00	17.00
Maize grit	47.00	37.00	27.00	17.00
Fish meal	3.00	3.00	3.00	3.00
Soybean meal	20.00	19.75	19.00	19.00
Mustard oil cake	2.00	2.00	2.00	2.00
Sunflower cake	4.50	4.50	4.50	4.50
Wheat grain	0.00	10.00	20.00	30.00
Soybean oil	3.75	4.75	5.00	5.25
Salt	0.25	0.25	0.25	0.25
Bone meal	0.50	0.50	0.50	0.50
Limestone	0.75	0.75	0.75	0.75
Vit + Min	0.50	0.50	0.50	0.50
Lysine	0.20	0.20	0.21	0.21
Methionine	0.10	0.11	0.13	0.14
Calculated nutrient content				
Metabolizable energy (MEK cal/kg)	3137	3165.70	3179.10	3147.20
Crude protein	19.19	19.10	19.03	19.05
Calcium	0.74	0.78	0.86	0.86
Phosphorous	0.66	0.66	0.71	0.70
Lysine	1.20	1.20	1.20	1.20
Methionine	0.50	0.50	0.50	0.50

Table 2. Composition and calculated nutrient content of broiler finisher (3-7 weeks) diets with different level of wheat and supplemental methionine and lysine

Ingredient	Percent wheat in diets			
	0	10	20	30
Rice polish	26.00	25.50	24.25	24.00
Maize grit	50.00	40.00	30.00	20.00
Fish meal	2.00	2.00	2.00	2.00
Soybean meal	13.00	13.00	13.00	12.00
Mustard oil cake	3.00	3.00	3.00	3.00
Sunflower cake	1.75	1.75	1.75	3.00
Wheat grain	0.00	10.00	20.00	30.00
Soybean oil	2.50	2.75	4.00	4.00
Salt	0.25	0.25	0.25	0.25
Bone meal	0.50	0.50	0.50	0.50
Limestone	0.75	0.75	0.75	0.75
Vit+Min	0.25	0.50	0.50	0.50
Lysine	0.41	0.40	0.40	0.42
Methionine	0.15	0.16	0.18	0.19
Total	100	100	100	100
Calculated nutrient content				
Metabolizable energy (MEKcal/kg)	3152.50	3136.05	3184.43	3160.70
Crude protein	16.02	16.10	16.09	16.32
Calcium	0.67	0.71	0.72	0.72
Phosphorous	0.70	0.71	0.70	0.71
Lysine	1.20	1.20	1.20	1.20
Methionine	0.50	0.50	0.50	0.50

RESULTS AND DISCUSSION

Feed consumption

Average cumulative weekly feed consumption (g/bird) of broiler fed with different level of wheat and supplemental methionine and lysine from 1 to 7th week of feeding period is presented in Table 3. The highest feed consumption was recorded where 30 percent of wheat grain was included followed by 20, 0 and 10%. However, there were no significant differences among the four dietary treatments. Inclusion of wheat grain in broiler diets improved feed intake, this may be due to low CP diets and methionine and lysine supplementation. In a complex design, Steenfeldt et al (1998) demonstrated that enzyme supplementation improved digestibility of non-starch polysaccharides (NSP) and efficient utilization of NSP and nitrogenous compound in high wheat grain based diets. Similarly, in another trial Steenfeldt et al (1998) concluded that enzyme supplementation of wheat-based diets improves performance of broilers chickens, which is related to a concomitant reduction in intestinal viscosity.

Table 3. Average cumulative feed consumption (g/bird) of broilers fed with different level of wheat and supplemental methionine and lysine from 1 to 7th week of feeding period

Level of wheat, %	Cumulative weekly feed consumption, g/bird						
	1	2	3	4	5	6	7
0	87.62	336.33	723.73	1291.12	1930.77	2627.43	3350.08
10	87.21	332.48	722.06	1288.04	1911.41	2586.37	3299.16
20	88.09	335.09	719.57	1295.82	1948.70	2633.82	3357.11
30	87.48	335.20	734.41	1321.08	1957.85	2654.20	3379.31
Mean	87.60	334.77	724.94	1299.01	1937.18	2625.46	3346.41
CV, %	2.84	2.69	3.04	3.63	3.34	3.08	2.89
Probability	0.95	0.86	0.69	0.57	0.61	0.48	0.53
Pooled SD	2.648	9.530	22.810	22.810	82.40	82.40	98.60

Body weight gain

Results showed that except in 3rd, 4th and 5th week all the feeding period, the cumulative body weight gain of broiler chicken differed significantly. In the 6th week of age the highest body weight gain was recorded from chicks fed on control ration followed by 20, 10, and 30 percent wheat grain incorporated treatments groups. Similarly, in the 7th week of age chicks fed with wheat grain inclusion ration revealed more or less stabilized body weight gain. Despite a positive response of wheat grain incorporation on body weight gain in 6th and 7th week of age, the body weight gain of chicks was found to be higher in 4th and 5th week of age for T₀ group. This experiment showed that for better nutrient utilization of wheat further research should be directed to enzyme supplementation (Steenfeldt et al 1998) and other feed additive to improve body weight gain.

Table 4. Average cumulative body weight (g/bird) of broilers fed with different level of wheat and supplemental methionine and lysine from 1 to 7th week of feeding period

Level of wheat, %	Cumulative weekly body weight, g/bird							
	Initial wt	1	2	3	4	5	6	7
0	41.50	83.67	165.21	350.42	593.54	897.17	1164.70	1263.10
10	39.57	81.63	173.75	363.17	579.96	811.67	993.33	1116.25
20	40.25	86.35	179.17	366.92	588.75	840.67	1031.25	1186.67
30	39.92	91.82	186.80	358.74	542.86	774.05	960.30	1133.21
Mean	40.31	85.86	176.23	359.81	576.28	830.89	1037.40	1174.81
CV, %	4.49	7.12	7.79	7.02	8.52	8.51	11.81	8.03
Probability	0.281	0.012	0.005	0.283	0.201	0.055	0.050	0.016
Pooled SD	1.766	5.061	11.92	26.25	47.99	57.62	100.1	79.4

Feed efficiency

Table 5 present the average cumulative feed efficiency of broilers fed with different level of wheat and supplemental methionine and lysine from 1 to 7th week of feeding period.

Except in the 3rd week significantly different in feed efficiency was recorded all the weeks. At the age of 6th week, the mean feed efficiency was 2.56. Relatively better-feed efficiency was found in control group (T₀). This may be due to poor nutrient balance in wheat compared to maize. Therefore, Steinfeldt et al (1998) supplemented enzymes to improve nutrient utilization.

Table 5. Average cumulative feed efficiency of broilers fed with different level of wheat and supplemental methionine and lysine from 1 to 7th week of feeding period

Level of wheat, %	Cumulative weekly feed efficiency						
	1	2	3	4	5	6	7
0	1.05	2.04	2.08	2.19	2.16	2.28	2.66
10	1.07	1.92	2.00	2.23	2.36	2.62	2.97
20	1.02	1.87	1.96	2.21	2.32	2.57	2.84
30	0.96	1.80	2.05	2.45	2.53	2.78	2.99
Mean	1.02	1.91	2.02	2.27	2.34	2.56	2.86
CV, %	6.02	6.88	5.86	8.25	7.49	11.88	7.33
Probability	0.006	0.005	0.308	0.020	0.020	0.043	0.006
Pooled SD	0.047	0.101	0.117	0.165	0.121	0.260	0.172

CONCLUSION

Results of this experiment indicated that wheat also might be used in poultry feed with some compromise in body weight gain. Consequently, it will help to reduce the cost of production of broiler chicken and reduce the food problem of human beings. Further research should be directed in utilization of wheat in poultry ration.

REFERENCES

- Minitab. 1996. Minitab for windows. Minitab Inc.
- NWRP. 2001. Annual report, 2000/2001. National Wheat Research Program. Bhairahawa, NARC, Nepal.
- Pathik DS. 2002. Maize research achievements and constraints. Sustainable maize research production system for Nepal. *Proceedings of a Maize Symposium*, 3-5 Dec 2001, Kathmandu, NARC and CIMMYT.
- Steel RDG and JH Torrie. 1960. *Principle and procedures of statistics with special reference to biological sciences*. McGraw-Hill Book, Co. Inc. New York, NY.
- Steenfeldt S, A Mullertz and JF Jenson. 1998. Enzyme supplementation of wheat based diets for broilers. 1. Effect on growth performance and intestinal viscosity. *Animal Feed Science and Technology* 75(1):27-43.
- Steenfeldt S, M Hammershoj, A Mullertz and JF Jenson. 1998. Enzyme supplementation of wheat based diets for broilers. 2. Effect on apparent metabolizable energy content and nutrient digestibility. *Animal Feed Science and technology* 75(1):45-64.

Study on Some Epidemiological Aspects and Treatment of Bovine Piroplasmosis in Morang District of Nepal

M Neupane¹, Sadu N Deo¹, Swoyam P Shrestha² and Madhav R Acharya²

¹ Regional Laboratory, DOLS

² AHRD, Khumaltar

ABSTRACT

Upon examination of 275 suspected samples from May 2000 to September 2002, 100 samples (36.36%) were found to be positive for piroplasmosis. Among the positive cases, the percentage of *Theileria* and *Babesia* crossbred cattle but some of the cases of babesiosis were also from indigenous cattle. *Boophilus microplus*, *Hyalomma anatolicum* and *Nirihipecephalus haemaphysaloides* were identified as the tick species present in the positive animals. Both Butalex (Buprvaquone) and Berenil (*Diminazine aceturate*) were found to be highly effective in treating clinically sick animals with the efficacy of 86.7 and 92.0 percent for theileriosis and babesiosis respectively.

Key words: Bovine piroplasmosis, epidemiological aspects, Morang district

A Case Study on Participatory Approach of Phewa Lake Fisheries Management, Research and Conservation for Livelihood Improvement of Fishers in Pokhara, Nepal

Tek B Gurung¹, Suresh K Wagle¹, Jay D Bista¹, Ram P Dhakal¹, Purushottam L Joshi², Rabindra Batajoo¹,
Pushpa Adhikari¹ and Ash K Rai²

¹ Fisheries Research Center, Pokhara <fishres@fewanet.com.np>

² Fisheries Research Division, Lalitpur, Nepal

ABSTRACT

This case study is focused on a participatory fisheries management of Lake Phewa by incorporating a fragile fisher community known as “Pode” or “Jalari” living around lakes of Pokhara Valley. The community was deprived of traditional agricultural land, skill, job and income in early 1960s. Thus, most of them had a nomadic life traveling from lakes, rivers and wetlands carrying a cast net for fishing to feed their family till 15-20 years back. In early 1960-70 when fish catch declined in lakes due to over fishing, the only one source of their livelihood was threatened. Meanwhile, Pokhara Fisheries Station was established in 1962 at the bank of Lake Phewa with a mandate to support for rehabilitation with job and income through subsistence cage aquaculture. At the beginning only a single 50-m³ cage was given to a family. The technical guarantee of fish production by fisheries station was considered as collateral for repayment. At present, fish production in Lake Phewa is estimated to be 150 kg. ha⁻¹, producing about 75 mt fish from cage fish culture and open water recapture fisheries in 2002. The income from fish production is shared among the local fisher families, which has brought substantial changes in livelihood of the fisher community. Cage aquaculture is one of such a farming system by which the deprived community has been able to alleviate poverty. Indeed, the present achievement is attributable to the fact that the community could access communal waters despite of the fact they were landless and lacked traditional agriculture skills. This strength of the community associated can be taken as an attractive entry point to improve the livelihoods of other deprived communities for bringing them in mainstream of other parts of the country. Presently, children of the community attend schools, and have achieving college level degree in the universities, however, few years before a single literate member in the community was difficult to find. Recently, the community has realized importance of resources for sustainability. They are self-motivated for removing water hyacinth, weed and devised the rules and regulation for conservation of native fisheries and other lake resources.

Key words: Conservation, lake fishery management, Pokhara, research

INTRODUCTION

Small-scale fishers, the poorest of the rural poor in developing countries, are faced with seemingly impossible obstacles in their attempts to better themselves (Pollnac 1988), especially form inland water resource. However, the small-scale marginal fishers and exploited group of producers are impeded by the existing economic and social power structures. Such obstacles are known to overcome through the organizational form of participatory approach. This may be the reason that participatory approaches are commonly regarded as an essential part of the sustainable livelihood (FAO 2000). It is the customer oriented or focused programs where targeted group are participated throughout the process: learning about the situation, identifying problems, discussing alternatives, selecting solutions, designing and implementing activities, evaluating and disseminating results (Chat 2000). The target groups use their traditional knowledge to identify the problems and solutions ensuring that poor and those excluded with low awareness can also participate. This also creates an environment where outsiders can also work with community and help to improve their capacities (Chat 2000).

Here, we describe one of a participatory approach on fisheries (fishery and aquaculture), where focus is on effective mechanisms to transfer fishers technologies by adopting the theory of learning by doing for livelihood enhancement of one of derived ethnic community, considered as excluded in socio-economic context of Pokhara Valley, Nepal. The fisheries can be categorized as one of such skill and art where close associations among different stakeholders might play much crucial role for the achievement of the goal of social benefit through job and income opportunities in the society.

Natural resources are one of the assets of the society. Such resources possess multitude of use to different stakeholders directly or indirectly. Lake fisheries are one of such important resources in Pokhara valley. Fish production in the lakes of Pokhara Valley is expanding through the wise use of inland water resources (Sharma 1990). Fish production in Lake Phewa is promoted on the basis of conservation biology of indigenous fishes and the available food resources. This combination of two strategies: stocking with plankton feeding carps and their cage culture is the main leading factor behind the promotion of fish production in Lake Phewa (Rajbanshi et al. 1984, Swar and Gurung 1988).

Who are traditional fishers: *Jalari* ?

"Jalari" or "Podes" in Pokhara are one of the ethnic communities, who entirely depend on fishing for their livelihood. It is not known exactly when "Jalari" or "Pode" community involved in fishing occupation. The mother tongue of the community closely resemble with *Newari*: A language of people living in Kathmandu. Therefore, it is often said that they have been migrated into Pokhara. Generally, "Pode" settled down close to lakes and rivers in Pokhara area for livelihood with fishing. These represent one of the mid hill fisher communities (Gurung and Bista 2003). In Pokhara area, some others involved in fishing are Gurung, Magar, Damai, Kami, Kumal, and even Brahmin. These perhaps indicate the consequences of growing population and employment opportunities that could provide by fisheries in the area.

Beginning of participatory approach of fisheries program in Phewa Lakes: Participatory customer oriented work can take as many different forms as there are contexts and innovative development practitioners (Lawless and Hughes 2003). Among the various stakeholders the Fisheries Research Station, Pokhara was established in 1962 with the aim of livelihood enhancement of local people through sustainable fisheries and aquaculture technology generation/improvement for food, employment and income. The participatory approach with the *pode* community was initiated around 1972. The aim of the project was to assist the local landless and jobless deprived fisher community living around the lake. At the beginning the fisher's families were trained for cage fish culture management practices. Later, loan for cage material, bamboo frames and fingerlings for cage fish culture were offered (Swar and Pradhan 1992).

Fisher group mobilization and group formation: A fisher group association known as Fish Growers Association was established when cage fish culture program was started around 1972 in Lake Phewa. This was established for easy mobilization and dissemination of the improved and necessary technology to the targeted community. However, it was only in early 1990 that the fisheries association was registered. Later this association was mobilized to manage the rules and regulation for gill net operation in Lake Phewa. In year 2000, a women group was also formed as a part of the association. This women group has been found more practical and effective to control over illegal fishing during monsoon season at the inlet streams of the lake. It has been found that mostly the traditional fishers do not indulge on unconventional fishing such as use of electricity, explosives and poisons as fishing methods. It is usually, urban people living away from the locality who often visit the water resources for unconventional fishing in near by water sources.

There are several small and medium sized swamps, old ponds, lakes, and pits in various parts of the country, where water are filled temporally during the monsoon and remain till late winter Several deprived and poor ethnic groups belonging to traditional fishers are known to live (Shrestha 1995) near by water resources. The number of fisher has been estimated to increase several folds in recent days due to increased poverty and population in the country (Gurung 2003). It is anticipated that case study described in this paper can be used as one of the modalities where degraded marshes and pond belonging to public sector could be developed to enhance the livelihood of deprived fisher community.

Partners of participatory approach of fisheries management, research and lake resource conservation

For sustainable lake fisheries management- restocking with depleted fish, exotic carps (which do not breed in confined water), and cage fishery of plankton feeder fish and conservation of *Tor spp* through mobilization of local fishers have been adopted. The Fish Grower's Association, Fisheries Research Center, Pokhara, Agriculture

Development Office, Agriculture Development Bank and few other local organizations are the main stakeholders of the present participatory approach.

Characteristic features of Fewa lake

Phewa Lake is situated at the southwestern part of Kaski District (Figure 1) in between $28^{\circ}10'N$, $82^{\circ}05'E$, at 742 m above sea level. The watershed area of lake Phewa covers approximately 110-km² with the geometrical length of 17 km and 7 km width. The feeding sources of the lake are two perennial streams: Harpan Khola and Andheri Khola and numerous seasonal streams. The total surface area of the lake is about 523 ha. However, recently the area is estimated only 443 ha with a 23 m of maximum depth (Lamichhane 2000).

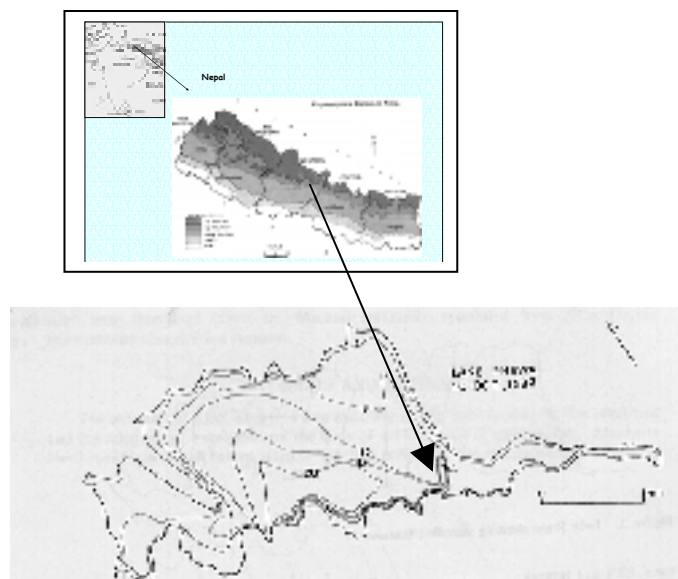


Figure 1. Map showing the location of lake Phewa in Pokhara valley, Nepal.

The lake has main single outlet, however, before that water has been diverted towards the canal for the purpose of electricity generation and irrigation. The lakeside is one of the most popular tourist spots, where about 1700 wooden plank boats are operated for tourism in the lake. The western end of the lake is dense and crowded with residential houses, hotels, restaurants and other catering facilities for tourist. It is believed that the lakesides constitute one of the important economic centers of the valley.

Several limnological, socioeconomic, hydrological studies have been carried on Lake Phewa (Ferro 1980, 1981/82, Fleming 1981, Nakanishi 1986, Swar and Pradhan 1992, Davis et al 1998, Rai 2000). These studies revealed that in earlier 1970s, the lake was mesotrophic, but the lake is gradually progressing towards eutrophication, although oligotrophic status of the lake has also been detected.

The most severe environment problems of the lake are rapid urbanization of its surrounding area, where sewage has been directed into the lake without any treatment (Lamichhane 2000). Several factors such as increased tourism and non point sources of phosphorus and nitrogen can also increase the substantial nutrient loads into lake ecosystem (King and Mace 1974, Liddle and Scorgio 1980, Hadwen et al 2003).

The annual water temperature in Lake Phewa ranges about 15-29°C (Figure 2). The transparency of Lake Phewa ranges from 1.2 to 4.10 m, with maximum value in March 2001 probably due to low productive water in winter while lowest in July 2000 probably due to silt transportation in the lake by rainwater.



Fish culture using plankton feeder fish in floating cages of approximately 50 m³ with bamboo frames are one of the popular ways of fish production in Phewa Lake (Swar and Pradhan 1992, Gurung 2001). Later, the cage aquaculture was supported by FAO, UNDP in 1975-78 for the supply of cage materials (Swar and Pradhan 1992) and other technical assistance from Japanese International Co-operation Agency (JICA).

At present socioeconomic perspective, cage culture of planktivorous fish is identified as an extensive and profitable small-scale enterprise in Nepal (Sharma 1990). Nylon or polyethylene mended knot-less floating cage of approximately 5 m long, 5 m wide and 2 to 2.5 m deep are the most popular among fish farmers. Usually, mortality and escaping fish ranged 10-20%. In such cages 2-7.4 kg fish/m³/year could be obtained depending on trophic status of the water bodies (Table 1A). Since, carps depend on natural plankton food, therefore the most important characteristics of Nepalese cage fish culture is its economic sustainability without any supplementary feed.

385

removing nutrients and material from aquatic to terrestrial environment through: organic matter and nutrients load → phytoplankton → zooplankton → fish → human consumption and or nutrients load → phytoplankton → fish → human consumption. This implies that cage fish culture with plankton feeder fish could be one of alternatives for recycling the nutrients and organic load entering into the lakes and reservoir (Gurung 2001).

Table 1A. Change in production rate (kg/m³/y) of fish from the cages in Phewa Lake

SN	Year	Production rate	Source
1	1979	5.5	Pradhan and Shrestha 1979
2	1980	3.4	Waglw 2000
3	1985	-	Swar and Gurung 1988
4	1985	3.4	Swar and Pradhan 1992
5	1989	-	Rai and Mulmi 1992
6	1990	1.33	Sharma 1990
7	1998	5.0	Wagle 2000

Table 1B. Category of cage farmers owning more than one cage each family in lake Phewa

SN	Range of production cage owned by a family	Fishers family, n
1	15-20	5
2	10-15	10
3	5-9	34
4	1-4	8

Table 2. Present status of cage fish culture, numbers of farmers engaged and estimated production in last 3 years

Year	Production cage, n	Fishers engaged, n	Fingerlings stocked into cage,	Fish harvested, n	Fish produced from cage, kg
2000	213	56	107500	63500	37274
2001	227	58	144500	68100	47000
2002	253	58	12700	75900	48300

Source: Fish Grower's Association, Phewa lake, Pokhara.

At the beginning one cage was given to each fisher family, which only provided partial income and job to the fishers (Sharma 1990). Swar and Pradhan (1992) calculated that in prevailing socio-economic state annual income from 4-5 cages to a family comprising of 5 members should be adequate to cover all expenses. After owning cages more than one supply of sufficient number of fingerlings became the main bottleneck for fish production. Later, a fish hatchery was constructed near by Lake Begnas, Pokhara with the support of JICA, which fulfills present demand for fingerlings. At present some of families hold as much as 16 cages producing about 3000-4000 kg of marketable fish per annum (Table 1B) since the fingerling supply from the newly established hatchery and nursing facilities is consistent. Therefore, it is anticipated that such a family may have an annual income exceeding 200-300 thousand Nepalese Rupees a year. The data collection from farmers showed that in the year 2000, the fish production from cage culture was 37.2 Mt while in year 2002 it was about 48.3 Mt (Table 2).

However, fish farming was never a traditional occupation of the community but the present case and experiences shows that aquaculture could be successful regardless of one's occupational background. Similarly, pond aquaculture has never been the traditional occupation of most Africans countries (Graaf and Janssen 1996), but the present success stories evidenced that it is not necessary that aquaculture should essentially be a traditional occupation to become successful.

Generally, fish from lakes and rivers possess higher market demand. This might be for the reason fish are grown on natural plankton food only. If this is true, then it attributes that market price of caged fish may increase in near future as they are produced from natural waters. Since, fish produced in cages consume minute plankton, which contain phosphorus and nitrogen in them. The consumption of these organisms by fish helps in removing unwanted nutrients from water bodies. This is the reason that subsistence cage aquaculture is also explained as one of the environment friendly farming approach.

Open water fishery

Fishing is traditional occupation to "Pode" or "Jalari" community in Pokhara. Here, commercial capture fishery using gill net was widely adopted around 1963 (Rajbanshi et al 1984). Since the gill net fishery could not sustain

without sound stocking program, therefore, restocking of fish seem initiated in the lake from 1977. Fishery in Phewa Lake is depending on both exotic and indigenous species. The fishery is carried out using gill nets of different mesh size up to 200 mm. Before, 1960s the fishery was more cast net dependent, later fisher started to use the gill net for off shore fishing. The main commercial species around 1960-75 was *Tor* spp, *Acrossocheilus hexagonolepis*, *Chagunius chagunio*, *Labeo dero*, *Labeo angra*, *Mastacembelus armatus* etc (1980, Bista et al 2001). However, after substantial decrease of the catch of these species restocking with introduced species was started (Shrestha et al 2001). Now, in recapture fishery substantial contribution comes from the catch of introduced species, where highest catch of 50.7 Mt has been shown (Wagle and Bista 1999). It should be remember that such estimate is based on 20% addition on existing catch, assuming that fish harvest were unrecorded from several sources. The present data has been recorded only at two sampling station at the bank of Lake Phewa. The lists of native fish species of Lake Phewa, which contribute substantially in open water capture fishery, are enlisted in Table 3. The exotic fish species introduced in the lake for enhancing recapture fishery in the lake is given in Table-4.

Table 3. List of native fish species in Lake Fewa

SN	Specific name	Local name	Remarks
1	<i>Tor putitora</i>	Sahar	One of the major species but represented occasionally
2	<i>Tor tor</i>	Sahar	One of the major species, hardly represented in catch
3	<i>Acrossocheilus hexagonolepis</i>	Katle	One of the major species but represented occasionally
4	<i>Labeo dero</i>	Gardi	Well represented in catch
5	<i>Cirrihina reba</i>	Rewa	Well represented in catch
6	<i>Mastacembelus armatus</i>	Chuche bam	Well represented in catch
7	<i>Xenentodon cancila</i>	Dhunge bam	Well represented in catch
8	<i>Channa gachua</i>	Bhoti	Well represented in catch
9	<i>Channa striatus</i>	Bhoti	Well represented in catch
10	<i>Barilius barna</i>	Lam Fageta	Well represented in catch
11	<i>B. bola</i>	Fageta	Well represented
12	<i>B. vagra</i>	Faketa	Well represented
13	<i>Barilius bendelisis</i>	Fageta	Well represented
14	<i>Mystus bleekeri</i>	Junge	Sometimes represented
15	<i>Puntius sophore</i>	Bhitte	Well represented
16	<i>P. sarana</i>	Kande	Only occasionally represented
17	<i>P. titius</i>	Bhitte	Well represented
18	<i>P. ticto</i>	Bhitte	Well represented
20	<i>Nemacheilus rupicola</i>	Gadela	Almost not represented in catch
21	<i>Garra annandalei</i>	Buduna	Almost not represented in catch
22	<i>Clarias batrachus</i>	Magur	Sometimes represented
23	<i>Psilornchus</i> sp	Tite	Migratory from Set river

Table 4. List of exotic fishes in Lake Phewa

SN	Specific name	Local name	Remarks
1	<i>Aristichthys nobilis</i>	Bighead carp	Low priority for stocking
2	<i>Hypophthalmichthys molitrix</i>	Silver carp	Low priority for stocking
3	<i>Ctenopharyngodon idella</i>	Grass carp	Low priority for stocking
4	<i>Labeo rohita</i>	Rohu	High priority for stoking
5	<i>Cirrhinus mrigala</i>	Naini	High priority
6	<i>Catla catla</i>	Bhakur	High priority for stocking
7	<i>Cyprinus carpio</i>	Common carp	Low priority for stocking

The total production of fish contributed by recapture fishery in Lake Phewa is given in Figure 4A. Fish production rate in Lake Phewa ranged from 0.1 kg/ha in 1985 to about 174 kg/ha in 2001. It has been estimated that annual fish production in Asia is 5.5 million tons, comprising of the worlds inland fish production The estimated fish production from Asian reservoirs is only 20 kg /ha /year. The total fish production in Phewa Lake is estimated to 174 kg/ ha /year in 2001 (Fugure 5). This evidenced that Lake Phewa is one of the productive lake in Asia and has been highly eutrophic in recent days (Bista et al 2001).

Market channeling

Marketing is one of the essential components for sustainable agro enterprises. Pokhara town is the major traditional market for fish product. Only a part of the total fish production is known to be supplied in Katkmandu

and adjacent districts, especially during winter when fish production surplus the consumption in the town. However, opposite to it, in summer when harvest is low, fish are marketed from outside of the Pokhara.

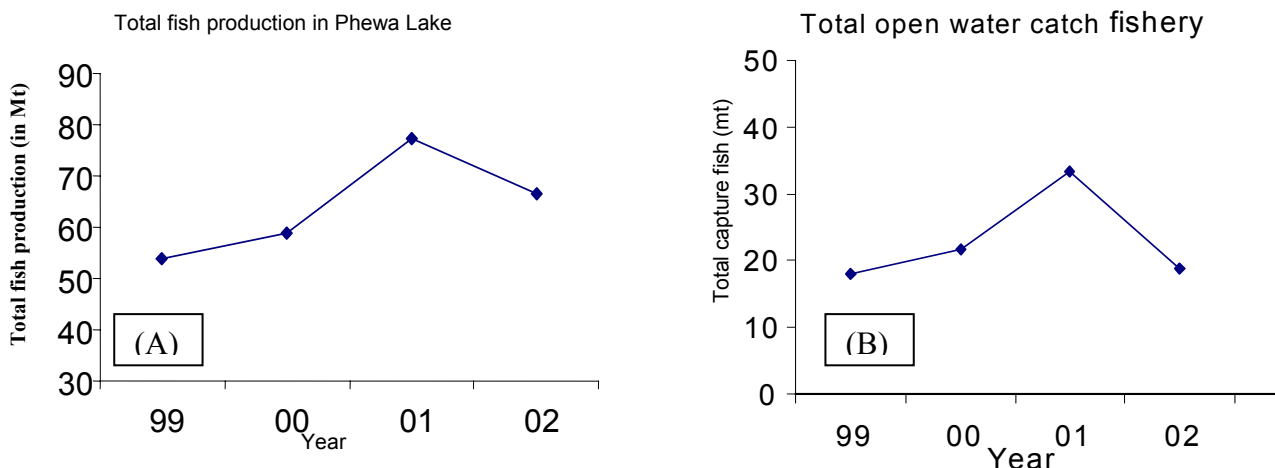


Figure 4. (A) Total fish production from Lake Phewa and (B) contribution of total recapture fishery.

(Source: Fish Growers Association, Phewa, Pokhara)

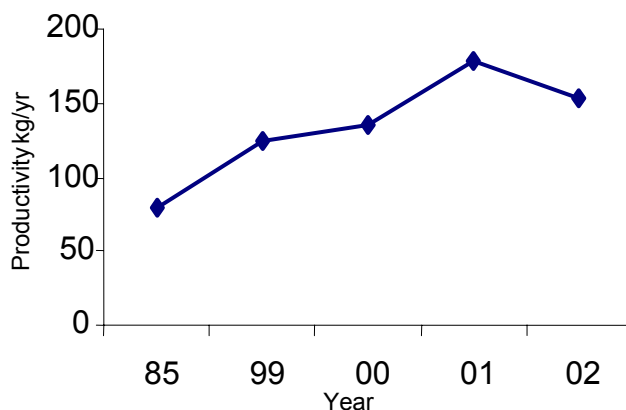


Figure 5. Annual fish productivity of Lake Phewa

Marketing arrangement for cage aquaculture products: A tripartite meeting among the Fish Growers Association, Fisheries Research Center, Agriculture Development Office and contractor determine and fixed the price of fish product in the market. The Fish Growers Association fixed the schedule for marketing of the fish for individual farmers. At beginning, the fishers used to harvest caged fish early in the morning bring at fisheries office premises around 6 AM. The office provided a coupon for the weight and number of fish harvested, and then arranged to send for contractor in the market. The contractor, after selling the fish everyday in the market needs to contact the office every week with the cash. At the fisheries office premises money were paid to fishers for their harvest on the basis of the coupon provided to them. If there remains no loan to be paid, fisher could take all money. However, if loan still remained to be paid then money was deducted up to 50% for repayment. Recently, live fish are marketed for better opportunities in the market. In this practice, the contractor sends a vehicle with container and aeration facilities at production site.

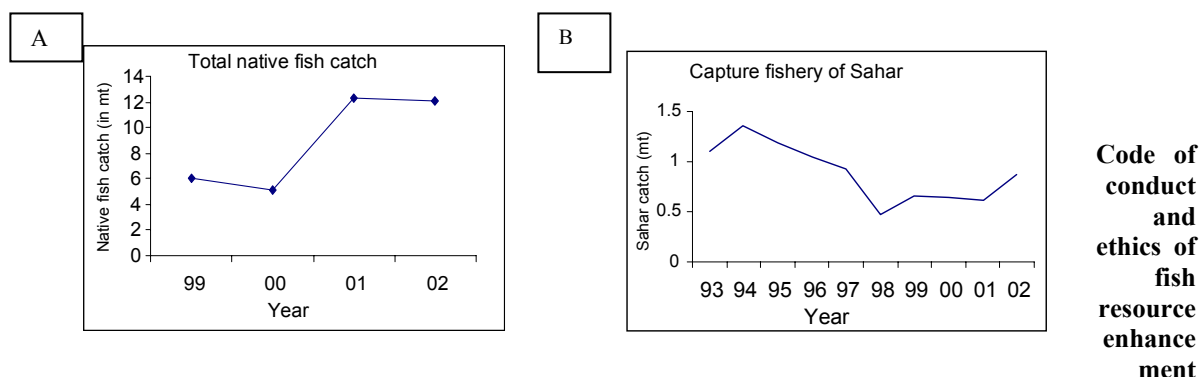
Marketing arrangement for fishery products from recapture fishery: Fish captured from lake are collected mainly at two locations at Phewa Lake. One is known as Gai Ghat near by the Royal Palace, the other main one is located at Sedi just at the northern side of the lake. The marketing is well organized for fish products form recapture fishery. The prices for the different fish species are determined at the tripartite meeting among the fisher community members, official from fisheries office and contractor. At present, the contactor can purchase only the fish caught from the lake weighing more than 2 kg is body weight. Other smaller fish captured from the

lake are marketed by women fisher in local market. The contractor collects the fish from fixed location of Sedi every morning. Where, fishermen are given a coupon to claim the money from the contractor. The fish are brought at Chilling center owned by the contractor for processing. The chilling facilities are located at the southern end of Phewa Lake. The fish items sold from the contractor as fresh, processed fillet and smoked items.

The weakest market channel for sustainable fishery and aquaculture development is the supply of twine, cage net materials in Pokhara. In near future attempts should be made towards the development of fishing and fish farming gear enterprise establishment in Pokhara area.

Conservation initiation of fish species

Several thousand tones of Mahseer (*Tor putitora*) are known to be harvested every year during 60 in Lake Phewa (Ferro 1983). Comparing to these the present volume of Mahseer harvest from the lake could be due to drastic depletion in their abundance from Lake Phewa. At present the annual catch record is given in Table 6A, B. There are 23 native species reported from Lake Phewa (Table 3). Previous studies revealed that except the dominance of few hardy fish such as *Channa spp* and intervention by *Clarias batrachus*, most of the species reported from the lake occurred as usual. However, certainly the proportion of specific fish in Lake Phewa has been under gone to change due to various environmental reasons. Among such fish perhaps most notable are large bodied carps such as Mahseer (*Tor spp*) and *Acrossocheilus hexagonolepis* (Kattle) in the lake, which has been drastically decreased in lake since in comparison to the catch record shown by Ferro (1980). The reason why *Tor* species has been vulnerable is because this specie is most rewarding as they grow as large as 40 kg or more and their market demand is highly valued. Other reason is that, Mahseer migrate upwards in shallow water towards the inlet stream. This occasion becomes the opportunity for the local people to kill the fish using even sticks and other sharp objects (Shrestha 1995).



Code of conduct and ethics of fish resource enhancement

and conservation

Figure 6. A. Indigenous

Following the code of conduct for responsible fisheries of FAO (2002) for the well being for people, both for present and future generations and should therefore be conducted in a responsible manner to sets out principles and standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognises the nutritional, economic, social, environmental and cultural importance of fisheries, and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users. The code of conduct for sustainable fisheries is set out in different meeting of the stakeholders. In different meeting following code have of the conduct have been set up:

Fish culture areas: Cage for fish culture can only be set at three locations at Phewa lake. The identified sites are Khapaudi, in front of Fisheries Research Center and Sedi Area. Other areas have been restricted for setting of the cage culture facilities.

Fishing zone: Fishing by any means is prohibited in front of the Royal Palace, 100 m area near by the facilities of Fisheries Research Center, near by 100 m area of Barahi temple and inlet stream of Harpan Khola.

Fishing Method: The restricted methods fishing are the use of explosive, poisoning, and electric current in natural water bodies. Fishing by line and hook, gill net, cast net are allowed. However, gill net smaller than 100 mm mesh size at pelagic area of the lake is restricted.

LESSON LEARNED

The lesson learned under this program since last 3-4 decades are

- The participatory program under which deprived and ethnic groups are involved take long time to be self sustain, self reliance and motivated to bring in main stream of the society in under developed countries socio economics. They need long and continuous supportive program to make them sustainable. This might be due to their vulnerable and insecure status in the society.
- The participatory approach could only be sustainable if the income generation from the fisheries is sustainable to the targeted communities. If income generation from the fisheries is not sustainable to run the family the participatory approach will be terminated.
- The deprived community inclined to depend on their collaborators on many social issues besides the technical one. At the time the collaborators are expected to play a role of parenthood.

IMPLICATION OF THE PROGRAM

The participatory fisheries program of Phewa Lake is considered as one of the successful participation of targeted group, extension and researchers involved. One of the successful adoptions the model developed at Pokhara can be seen at Kulekhani Reservoir in Makawanpur District of Nepal. There are several shallow ponds, swamps, and inundated lands with monsoon rain in southern plains of southern Tarai. Water in such inundated land remains till late winter. Water in such lands could be managed by various ways. The fisher community is considered as one of the poorest group in the society. The wasteland with temporary inundation and several marshlands in the terai can be utilized as one of the fisheries cooperative programs. Initiation for such a participatory approached are expected from the extension agents working under the Agriculture Development Offices at the district level.

CONCLUSION

Costa-Pierce (1998) described a case study of cage fish culture in Indonesian: Saglung and Cirata Reservoir, where fish production was about 24,496 Mt per year. However, the cage aquaculture in these reservoir are neither environmentally nor socially sustainable. Because, the benefits of floating cage aquaculture, which originally was guaranteed to the displaced people by provincial legislation, and designed to give them exclusive ownership over the production and marketing sectors of the industry, have been usurped by the politically powerful and consolidated in the hands of the urban rich from Jakarta (Costa-Pierce 1998). Contrasting to these experiences the owner of extensive cage fish farming system in natural lakes of Nepal is the deprived community themselves. In future care should be taken on such aspect that ownership should remain within the hands of deprived fisher community or someone who are economically deprived.

Recently, it has been showed that tourist can adversely affect the ecology of pristine ecosystems through the addition of nutrients and other chemicals into the water column (King and Mace 1974, Buttler et al 1996) and by direct physical disturbance to sediment and vegetation (Liddle and Scorgio 1980, Hadwen et al 2003). Such studies in Lake Phewa have not been yet carried out, though the lake is under high pressure of tourism development. The tourism is becoming one of the most potential economic sectors of Nepal. In future care must be taken not to exaggerate any activities for the perspective of economic development, however, much importance should be given for the longer sustainability of the lake ecosystem in harmony with developmental activities. If these points could be considered, the participatory approach of fishery in Phewa Lake has sustainable future and the people involved can be mobilized for not only in lake fishery management but also in lake resource conservation activities.

ACKNOWLEDGMENTS

We wish to extend our sincere thanks to all fisher community engaged in fisheries related occupation in Pokhara, many staffs of Pokhara Fisheries Research Center and Agriculture Development Office, Kaski, and Agriculture Development Bank, Pokhara for their cooperation. This paper is a part of the study funded by Nepal Agriculture Research Council.

REFERENCES

- Bell R. 1998. *Community based fisheries management: Lake Malombe, Malawi*. The World Bank/CBNRM Initiatives.
- Bista JD, Dhakal RP, Gurung TB. 2001. Changing environmental status and their impact on flora and fauna of two major lakes (Phewa and Rupa) of mid hill region, Pokhara, Nepal. *Paper presented in the symposium of international year of mountain*, Kathmandu, Nepal.
- Buttler B, A Birtles, R Pearson, K Jones. 1996. *Ecotourism, water quality, and wet tropics streams*. Australian Centre for Tropical Freshwater Research, James Cook ? University, Townsville.
- Chat TT. 2000. An experience with participatory research in Tam Giang Lagoon, Thua Thien-Hue. *Stream Journal*, NACA 1-4:3-4.
- Costa-Pierce BA. 1998. Constraints to the sustainability of cage aquaculture for resettlement from hydropower dams in Asia: An Indonesian case study. *Journal of Environment and Development*
- Davis MF, TB Gurung, BC Shrestha, SB Jones, GD Wylie, BD Perkins and JR Jones. 1998. Use of subsurface plankton layer to benefit a cage culture fishery in Lake Phewa, Nepal. *Verh. Internat. Verein. Limnol.* 26:940-947.
- FAO. 2000. Report on the workshop on participatory approaches in aquaculture Bangkok, Thailand, 28 Feb-1 Mar 2000. *FAO Fisheries Report No. 630*.
- FAO. 2002. *Code of conduct for responsible fisheries*. FAO.
- Ferro W. 1980. Data on the fishery in Pokhara Valley and their implication for the fishery management. *Journal of the Institute of Science*, Tribhuvan University, Nepal 3:22-236.
- Ferro W. 1981/82. Limnology of the Pokhara Valley Lakes Nepal. *Journal of Nepalese Research Center*. V/VI: 27-52.
- Fleming WM. 1981. *Phewa Tal Management Program: Benefits and costs of forestry and soil conservation in Asia and the Pacific* (LS Hamilton, ed). East-West Environment and Policy Institute. East-West Center, Westview Press/Boulder, Colorado. Pp.217-286.
- Graaf de G and H Janssen. 1996. Artificial reproduction and pond rearing of the African catfish *Clarias gariepinus* in sub-Saharan Africa- A handbook. *FAO Fisheries Technical Paper 362*.
- Gurung TB and JD Bista. 2003. Livelihood improvements through fisheries in the Poda Community in Pokhara, Nepal. *Stream Journal* 23: 1-3.
- Gurung TB. 2001. A review on status, potentiality and limitation of cage fish culture in Nepal. *Paper submitted to Hill Agriculture Research Program of DFID*, Kathmandu, Nepal.
- Gurung TB. 2003. *Fisheries and aquaculture activities in Nepal*. *Aquaculture Asia*. Vol. VIII (1):14-19.
- Hadwen WL, AH Arthington, TD Mosisch. 2003. The impact of tourism on dune lakes on Fraser Island, Australia. *Lakes and Reservoir Research and Management* 8:15-26.
- King JG and ACJ Mace. 1974. Effects of recreation on water quality. *J. Water Pollut. Control Fed.* 46:2453-9.
- Lamichhane DB. 2000. *Phewa lake watershed area: Studies on settlements and environmental appraisal*. Kul Bahadur Lamichhane, Lakeside, Baidam, Pokhara, Nepal.
- Lawless G and W Hughes. 2003. The potential role of cooperatives in Wisconsin's Aquaculture Industry. *Prepared for Wisconsin Aquaculture Advisory Council*. University of Wisconsin Center for Cooperatives.
- Liddle MJ and HRA Scorgio. 1980. The effects of recreation on freshwater plants and animals: a review. *Biol. Conserv.* 17:183-206.
- Meynell PJ. 1984. Small-scale fisheries cooperatives: Some lessons learned for the future. *COPAC occasional paper No. 2*. Rome, Committee for the Promotion of AID to Cooperatives.
- Nakanishi M. 1986. Limnological study in Phewa, Begnas and Rupa lakes: **In: Studies on distribution, adaptation and evolution of microorganisms in Nepal Himalayas, Second report** (Y Ishida, ed). Kuzo Dogura, Kyoto, Japan.
- Pokharel KK. 1999. Fish biodiversity of lakes in Pokhara Valley. *Proceedings of III national conferences on science and technology*.
- Pollnac R. 1988. *Evaluating the potential of fishermen's organisations in developing countries*. ICMRD, International Center for Marines Resource Development, the University of Rodhe Islands.
- Pradhan BR. 1987. Potential of reservoir fisheries in Nepal. *Paper prepared for the workshop on reservoir fishery management and development in Asia*, 23-28 Nov 1987, Kathmandu, Nepal.
- Rai AK. 1998. Trophic status of Fewa, Begnas and Rupa lakes in Pokhara Valley, Nepal: Past, present and future. *Journal of Lake Sciences* 10 (Suppl):181-201.
- Rai AK. 2000. Evaluation of natural food for planktivorous fish in lakes of Phewa, Begnas and Rupa in Pokhara valley, Nepal. *Limnology* 1:81-89.
- Rajbanshi KG, BR Pradhan and DB Swar. 1984. Aquaculture practices in lake Begnas, Pokhara valley, Nepal. *2nd IPFC working group meeting*, New Delhi, India.
- Sharma BP. 1990. *Economic of cage culture of carps in the lakes of Pokhara valley*, Nepal. Kathmandu..
- Shrestha MK, RK Batajoo, GB Karki. 2001. Prospects of fisheries enhancement and aquaculture in lakes and reservoir of Nepal. *Paper presented in symposium on "Coldwater fishes in the TransHimalayan Region*, 10-13 July 2001, Kathmandu.
- Shrestha TK. 1995. *Fish catching in the Himalayan waters of Nepal*. RK Printers Pvt Ltd, Teku, Kathmandu.
- Swar DB and BR Pradhan. 1992. Cage fish culture in lakes of Pokhara valley, Nepal and its impact on local fishers. *Asian Fisheries Science* 5:1992:1-13.

- Swar DB and TB Gurung. 1988. Introduction and cage culture of exotic carps and their impact on fish harvested in Lake Begnas, Nepal. *Hydrobiologia* 166:277-283.
- Wagle SK and JD Bista. 1999. Catch efforts and capture fishery in lakes of Pokhara valley: status and management perspective: **In:** *Proceedings of Third National Workshop on livestock and fisheries research in Nepal*. Khumaltar, Lalitpur.

An Outbreak of *Aeromonas Caviae* Infection in Rainbow Trout Fish at Godawari

Asha Rayamajhi

Fisheries Research Division, Godawari, Lalitpur, <rayamajhiasha@hotmail.com>

ABSTRACT

The rainbow trout (*Oncorhynchus mykiss*) has been cultured in raceways of Fisheries Research Division, Godawari since 1988. An unknown disease, which caused about 32% mortalities. Bacterial fish isolate was cultured on Tryptic Soy Agar (TSA) and was incubated for 24 hours at 31°C. The bacterial isolate cultured from lesion of trout skin was identified as *Aeromonas caviae* by applying standard biochemical test and API 20E Strip system. The *A. caviae* reported from Godawari has not previously been recorded. The results of sensitivity test revealed that applied antibacterial agents namely oxolinic acid, streptomycin, tetracycline, norfloxacin, nitrofurantoin and sulfamethoxazole were all effective against *A. caviae*. External and internal organs of trout fish were stained in haematoxylin and eosin (HE) examined histologically by contained shrunken glomeruli in bowman's capsule of kidney. Some pyknotic nuclei were observed in the regenerating epithelial cells and also debris in the lumen of renal tubules. Hemopoietic tissues and blood congestion in sinusoids of liver were recorded. Hypertrophy, hyperplasia and some pyknotic nuclei were observed in epithelium cells of secondary gill lamellae and odema was seen in epithelium cells of primary and secondary gill lamellae of trout.

Key words: Hyperplasia, hypertrophy, odima, pyknotic nuclei

INTRODUCTION

Success of aquaculture farming is completely dependent on the health status of the cultured fish. But the incidences of fish disease have increased with the intensified fish culture practices. Among the exotic fish species the rainbow trout was introduced in Nepal in 1988 for commercial farming. However, culture practice of trout has already been started in private sector. Successful fish farming operations could be achieved by diagnosis and prevention of infectious disease occurred in fresh water fish. The diagnoses of pathogenic diseases are considered most useful to prevent huge loss of fishes.

There are increasingly more instances being reported of particular bacteria, which commonly cause disease in humans, also causing disease in aquatic animals. Conversely, bacteria belonging to the genus *Aeromonas* was first recognized as causing disease in aquatic animals (Zimmerman 1890) and also these bacteria frequently causes disease among cultured and feral fishes (Cipriano 2001). Consequently, motile aeromonads are responsible for hemorrhagic septicemia and other ulcerative condition in fishes (Cipriano 2001). In the United States, motile aeromonads have been considered as causing disease in cultured warm water fishes including minnows, bait fishes, carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), and tilapia. Moreover, aeromonad pathogen may also affect to a variety of cold water species (Cipriano 2001).

Over the last 15 years, *Aeromonas* has been increasingly recognized as a primary opportunistic agent of diseases in human (Janda 1991). It is also considered as an opportunistic pathogen of human causing diarrhea, several fish species hold soft tissue wound infections (Holmberg et al 1986, Janda and Duffey 1988, Altwegg and Geiss 1989). Aeromonads are ubiquitous and autochthonous to the aquatic environment. They have been isolated from fresh, chlorinated and non-chlorinated water with highest numbers occurring during the warmer month of the year (Hazen and Fliermans 1978, Hazen et al 1979, Kaper et al 1981, Burke et al 1984). Moreover higher numbers of aeromonads have also been detected from sludge, sewage and aquatic sediment. Favorable temperature ranged from 22-37°C to culture depending upon the species of *Aeromonas*.

The aeromonads group bacteria have been reported pathogenic to fish by several investigators: causes 37,500 fish death during a 13 days period in one location. Motile aeromonads causes disease in salmon group fish such as hemorrhagic septicemia. On the other hand it can be isolated from apparently healthy fish (Austin and Austin, 1987). Several factors have been reported as *Aeromonas* is a disease potentiators depending upon changes in water temperature and organic matter content (Huizinga et al 1979), handling and transport of fish (Shotts 1991) and social stress (Peters et al 1988). Peters et al (1988) demonstrated that social stress could lead to higher infection in rainbow trout fish. Popoff (1984) classifies the genus *Aeromonas* consisting of three motile species such as *A. hydrophilla*, *A. caviae*, and *A. sobria* and a single non- motile psychrophilic species *Aeromonas salmonicida* with three subspecies (*Salmonicida*, *Masoucida* and *Achromogenes*).

During May to August 1998, a bacterial disease resulted serious losses of rainbow trout fish in Godawari, raceway ponds. During the disease outbreak, water temperature was 21°C. Outbreak of unknown disease was the first evidence in Nepal for rainbow trout fish that occurred at Fisheries Research Center, Godawari. The first indication of the infection was observed as an appearance of reddish tinge lesion on the body surface (Figure 1), operculum region, and tip of mouth. These lesions were slowly spread out in circular or oval shapes (Figure 1). Hemorrhage around the eyeball was found on some infected fish. In most of the cases damaged fin rays were observed. Even those fins were surrounded by white cotton like coat. The infected fish showed darkened body, lethargy and loss of appetite.

Therefore research was conducted to identify unknown disease of trout at Aquatic Animal Health Research Institute, Bangkok. The research was financially supported by East Asia Aquatic Disease Control Project (SEAADCP). Biochemical tests and API 20 E STRIP methods were carried out to identify unknown bacteria. Moreover condition of cells of some important external as well as internal organs including liver, kidney and lesions part of skin with musculature were studied by histological process.



Figure 1. Reddish tinge lesion on the skin of rainbow trout.

MATERIALS AND METHODS

Isolation of bacteria from diseased fish

Total 10 trout of average sizes 150-300 g were collected from raceways of Fisheries Research Division, Godawari. One loop full swab from skin lesion of fish was initially cultured on routine plating media called Tryptic Soy Agar (TSA) for primary culture. The inoculated plate was incubated at 31°C for 24 hours. Bacterial colony growing in the TSA plates was sub-cultured to achieve a pure culture, at the start of work in Aquatic Animal Health Research Institute, Bangkok.

Primary characterization tests were done on the bacterial culture. The isolates were further characterized using different biochemical tests and API 20 E STRIP system. All media were prepared according to the instruction of the manufacturer. Drug resistance patterns were determined by the disc diffusion method on Mueller-Hinton agar supplemented with 0.85% NaCl, using some antimicrobial agents namely: nitrofurantoin (300 µg) tetracycline (30 µg), oxolonic acid (2 µg), norfloxacin (10 µg) streptomycin (10 µg) and sulfamethoxazole (1.25 µg).

Sampling procedure for histology

Skin and underlying musculature including external and internal organs (gills, kidney, and livers) were dissected from freshly killed individual fish and fixed in 10% neutral buffered formalin for 24 hours. After fixation in 10% buffered formalin, the tissues were cut into 5 mm thick sections and placed in decalcifying solution for 5 days.

After decalcifying the tissues were processed over night for 12 hours. The cassettes containing tissues were then embedded in 56°C wax. Than prepared blocks were sectioned at 5 µm using a rotary microtome. Sections were floated out in 45°C water bath until flat, then the sections were placed on slides and the slides were kept over night in an oven at 36°C. Then, the staining process was carried out according to haematoxylin and eosin (HE) methods to study the cell structure.

RESULTS

Bacteriological analysis

The results of biochemical and API 20 E STRIP taste are shown in Table 1. Bacteriological analysis of moribund trout fish revealed the presence of an *Aeromonas* strain in pure culture, which was identified as *A. cavia*.

Sensitivity test of antibiotic discs

The sensitivity of *A. cavia* to several antibacterial agents was tested according to the disc diffusion method. The result revealed that the strain was susceptible to the entire tested antibiotic discs namely oxolinic acid (2 µg), streptomycin (10 µg), tetracycline (30 µg), norfloxacin (10 µg), nitrofurantoin (300 µg), and sulfamethoxazole (1.25 µg). The result of sensitivity test is shown in Figure 2 and Table 2.



Figure 2. Sensitivity test using antibiotic discs.

Table 1. The results of biochemical reaction test and API 20E strip system

SN	Characteristics	Response	Characteristics	Response
1	Gram stain	-	OPNG	+
2	Shape	Short rod	ADH	+
3	Colony morphology	Spherical	LDC	-
4	Mortality	+	ODC	-
5	Oxidase reaction	+	CIT	-
6	Catalase	+	H ₂ S	-
7	O/F test	F	URE	-
	Fermentation of sugar		TDA	-
8	Glucose	+	IND	+
9	Sucrose	+	VP	-
10	Lactose	-	GEL	+
11	Mannitole	+	GLU	+
12	Maltose	+	MAN	+
13	Salicin	+	INO	-
14	Xylose	-	SOR	-
15	Gas from glucose	-	RHA	-
16	TSI	A/A	SAC	+
17	Citrate utilization	-	MEL	-
18	Esculin hydrolysis	+	AMY	+
19	Starch hydrolysis	+	ARA	+
20	Gelatin hydrolysis	+	OX	+
21	Growth in KCN broth	-	NO ₂	-
22	Nitrate reduction	+	N ₂	-
23	MR	+	MOB	+
24	VP	-	OF-O	+
25	Indole test	-	OF-F	+
	Decarboxylase reduction			
26	Arginine	-		
27	Lysine	+		
28	Ornithine	+		

+, Positive response. -, negative response. A, Acidic response.

Table 2. Sensitivity test of antibiotics for bacterial isolates

SN	Antimicrobial agents	Code	Disc potency	Resistant susceptible	Zone diameter	Intermediate	Results
1	Oxolinic acid	OA-2	2 µg	10	-	11	31
2	Tetracycline	Te-30	30 µg	14	15-18	19	25
3	Streptomycin	S-10	10 µg	11	12-14	15	22
4	Norfloxacin	NOR-10	10 µg	12	13-16	17	31
5	Nitrofuratoin	F/M-300	300 µg	14	15-16	17	25
6	Sulfamethoxazole	SXT	1.25 µg	10	11-15	16	16

Histopathology

The histopathological studies revealed the presence of shrunken glomeruli in bowman's capsule (Figure 3a). Other kidney changes were observed as debris in the lumen of renal tubules (Figure 3b). Some dense pyknotic nuclei were present in the regenerating epithelial cells of renal tubules (Figure 3b), whereas normal architecture of skin and underlying musculature was observed in histological examination. Some hemopoietic tissues and blood congestion were seen in liver substance (Figure 3c). Hypertrophy, hyperplasia, and some pyknotic nuclei (Figure 3d) were also observed in epithelium cells of secondary gill lamellae of gills. Odema was seen in secondary gill lamellae and in some places of primary gill lamellae (Figure 3e).

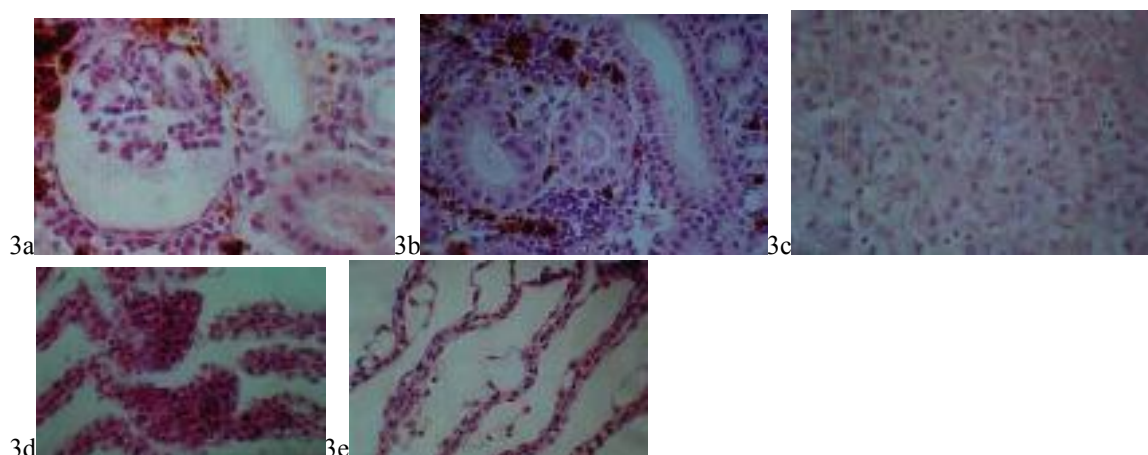


Figure 3. a, Shrunken glomeruli in bowman's capsule; b, Pyknotic nuclei and debris in the lumen of renal tubules; c, Blood congestion in sinusoids of liver; d, Hyperplasia and hypertrophy in epithelium cells of gill; e, Odema in secondary gill lamella.

DISCUSSION

A gram-negative bacterium identified as *A. caviae* was determined to be the causative agent of the disease described. Three of the extracellular proteins including aerolysin, lipase and serine protease are produced from the aeromonad groups and have been implicated as pathogenic toxic substances (Austin et al 1996). Therefore motile aeromonads appropriately receive much notoriety as pathogens of fish (Cipriano 2001). It is also considered as susceptible to initiate disease in cold water species (Cipriano 2001). Among salmonoid fish, rainbow trout appears to be more susceptible to development of motile aeromonad septicemias (Cipriano 2001). However, Austin and Austin (1989) have shown *A. hydrophila*, *A. sobria* and *A. caviae* comprise the most predominate clinical isolates that are typically associated with fish.

The motile aeromonad septicemias are generally mediated by stress (Cipriano 2001). Among the aeromonad group, *A. hydrophilla* is able to grow at 5°C may be indicative of their potential as a public health hazard. However, most *A. hydrophilla* were reduced to non-detectable levels on catfish filets cooked to 70°C (Huang et al 1993).

The identified organism was differentiated as a gram-negative by the staining reactions and *A. caviae* strain by profile of biochemical results. Results of biochemical tests such as hydrolysis process of esculin, fermentation process of mannitol and sucrose, indole production test all showed positive reaction, which is confirmation test

(Cipriano 2001). However lysine and ornithine decarboxylase reaction were not consistent and showed negative result as well as no gas was produced from the glucose supporting the confirmation diagnosis (Cipriano 2001).

Histological study of skin and underlying musculature, gills, spleen, and kidney of trout showed that identified isolate maybe responsible to make changes in structure of the normal cells of those organs. Likewise, hemopoietic tissues and blood congestion in sinusoids of liver (Figure 3c), hypertrophy, hyperplasia and some pyknotic nuclei in epithelium cells of secondary gill lamellae (Figure 3d) and odema in primary and secondary gill lamellae (Figure 3e) of trout could be the cause of environmental stress condition to fish or associated with the bacterium infection. This may indicate that the bacterium is capable to affect the normal cell structure of different external and internal organs of trout.

REFERENCES

- Altwegg M, HK Geiss. 1989. *Aeromonas* as a human pathogen. *Critical Review in Microbiology* 16:253-286.
- Austin B, DA Austin. 1987. *Bacterial fish pathogenesis: disease in farmed and wild fish*. Ellis Horwood Limited, Chichester, UK and John Wiley and Sons, NY, USA. Boulanger.
- Austin DA, D McIntosh, B Austin. 1989. Taxonomy of fish associated *Aeromonas* spp., with the description of *Aeromonas salmonicida* subsp. *Smithia* subsp. *Nov. Systematic and Applied Microbiology* 11:277-290.
- Austin B, M Altwegg, PJ Gosling, S Joseph. 1996. Genus *Aeromonas*. P.267.
- Burke V, J Robinson, M Gracey, D Peterson, K Partridge. 1984. Isolation of *Aeromonas hydrophila* from a metropolitan water supply: Seasonal correlation with clinical isolates. *Applied Environmental Microbiology* 48:361-366.
- Cipriano RC. 2001. *Aeromonas hydrophila* and motile aeromonad septicemias of fish. *Fish Disease Leaflet* 68. West Virginia, U.S. Pp.1-25.
- Janda JM. 1991. Recent advances in the study of the taxonomy, Pathogenesis, and infectious syndromes associated with the genus *Aeromonas*. *Clinical Microbiology. Review* 4:397-410.
- Janda JM, PS Duffey. 1988. Mesophilic aeromonads in human disease: Current taxonomy, Laboratory identification, and infectious disease spectrum. *Review of Infectious Disease* 10:980-997.
- Hazen TC, CB Fliermans, RP Hirsh, GW Each. 1978. Prevalence and distribution of *Aeromonas hydrophila* in the United States. *Applied environmental microbiology* 36:731-738.
- Hazen TC, CB Fliermans. 1979. Distribution of *Aeromonas hydrophila* in natural and man made thermal effluents. *Applied Environmental Microbiology* 38:166-168.
- Holmberg SK, WL Schell, GR Ganning. 1986. aeromonad intestinal infections in the United States. *Annals of Internal Medicine* 150:683-689.
- Huang YW, CK Leung, MA Harrison, KW Gates. 1993. Fate of *Listeria monocytogenes* and *Aeromonas hydrophila* on catfish fillets cooked in a microwave oven. *Journal of Food Science (USA)* 58:519-521.
- Huizinga HW, GW Each, TC Hazen. 1979. Histopathology of red sore disease *Aeromonas hydrophila* in naturally and experimentally infected largemouth bass *Micropterus salmonoids* (Lacepede). *Journal of Fish disease* 2:263-277.
- Kaper JB, H Lockman, RR Colwell, SW Joseph. 1981. *Aeromonas hydrophila*: ecology and toxigenicity of isolates from an estuary. *Journal of applied microbiology* 50:359-377.
- Peters G, M Faisal, T Lang, I Ahmed. 1988. Stress cause by social interaction and its effect on susceptibility to *Aeromonas hydrophila* infection in rainbows trout *Salmo gairdneri*. *Dis. aquat. Org.* 4:83-89.
- Popoff M. 1984. *Aeromonas*. In: *Bergey's manual of systemastic bacteriology*. Vol. 1 (NR Krig and JG Holt, eds). Williams and Wilkins, Baltimore, MD. Pp.545-548.
- Shotts EB. 1991. Selective isolation methods for fish pathogens. *Journal of applied Bacteriology Symposium Suppl.* 70:755-805.
- Zimmerman OER. 1890. Die bakterien unserer Trink-und Nutzvaser, Ber Naturewiss. Ges. Chemnitz 11:86.

Broodfish Management Status and Suggestions to Control Inbreeding in Carp Hatcheries

Suresh K Wagle¹ and Neeta Pradhan²

¹ Fisheries Research Centre, PO Box 274, Pokhara, Kaski fishres@fewanet.com.np

² Fisheries Research Division, Godawari, Lalitpur Email: pradhannita@yahoo.com

ABSTRACT

Carp polyculture in Nepal is entirely dependent on the seeds produced from fish hatcheries scattered throughout the terai region of the country. Over sixty hatcheries established in the private and public sector have been breeding four exotic and three native fish species. Induced spawning of both the exotic and native carp by hypophysation has been practiced extensively since early 1980s. At present, all hatcheries function as isolated genetically closed units raising their own stock of breeders and producing fish seed for distribution to grow-out areas. There is growing concern that hatch stock may be deteriorated due to poor broodstock management and inbreeding depression. Poor reproductive performance, retarded growth and morphological deformities of hatchery produced seeds have been unsubstantially claimed. In this paper, effective population size (N_e) and the rate of inbreeding (ΔF) have been estimated on the basis of numbers of new individual recruited as broodstock each year and the variance of their reproductive success. The study is based on the data collected for 1999 to 2001 from 3 hatcheries representing broodstock management in terai and mid hill region of the country. Effective population size ranges from as low as 2 to a maximum of 31, and the rate of inbreeding from 1.6% to 27.6% per year. Rapid inbreeding of hatchery stocks of the carp is apparent. Possible ways to control accumulation of further inbreeding in hatchery stock has been suggested.

Key words: Brood stock, effective population size, fish hatchery, inbreeding

INTRODUCTION

Aquaculture in Nepal involves the cultivation of native and exotic carps. Carp aquaculture in Nepal is polyculture. The general practice is to rear together seven carp species in the same pond: common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), bighead carp (*Aristichthys nobilis*), rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*) and catla (*Catla catla*). With the notable exception of common carp, which mature and spawn easily in ponds, all major carps attain maturity but do not spawn naturally in the confined environment. Induced spawning of these carps by hypophysation has been common practice in Nepal since 1970/71 (Karki 1998). Today hatchery-produced fry/fingerlings dominate the overall aquaculture production of the country. About 54 hatcheries have been established in the private sector. These hatcheries contribute 76% to the total seed production (75 million), the rest coming from the public sector (DoFD 2002).

Most hatcheries rear their own broodstock and usually do not recruit brood stock from natural sources (river, lakes) or exchange breeders between farms. Each hatchery therefore can be considered as an isolated, self-sustaining and genetically closed system (Eknath and Doyle, 1990). It is now well established that, in genetically closed systems, potential selective pressures exerted in finite and often small culture populations by various farm management practices such as the choice of founder stock, the numbers of breeders maintained, the method of replenishing broodstock, stocking density, feeding regime, etc can result in 'indirect' selection on important life history traits, inbreeding and genetic drift (Doyle 1983).

It is usually observed that most of the hatchery operators lack knowledge of simple broodstock management practices and do not follow any principles or guidelines in selecting adequate sized brooders and mating

unrelated male and female spawners. Ignorance of appropriate hatchery procedures leads to negative selection due to the use of fish of undesirable size and leftover broodstock and mating breeders' generation after generation from closely related or finite population (Huassain and Mazid 1999).

Once a hatchery is constructed, the general practice is to stock with the brood stock that are easy to acquire. Common practice in small hatcheries often involves the use of a small number of brood fish of each species because the fecundity of carps allows adequate seed production in this situation. The connection between number of breeders or the effective population size (N_e) and inbreeding is important to the hatchery operators. Within a closed population under selection, mating between relatives is more likely because the number of ancestors is relatively small (Pante et al 2001). Moreover, the high fecundity of fish permits high selection intensities. A small number of breeding individuals may produce all of the progeny in each succeeding generation and this leads to increased inbreeding. Further, the practice of mating unequal number of males and females also increases the probability of inbreeding (Falconer 1989).

Over successive generations, low effective population sizes lead to inbreeding depression with reduced growth rates, loss of fecundity and poor survival (Kohinoor et al 2002). Unsubstantiated claims that stock deterioration in hatchery population due to poor broodstock has been often reflected in farmers' complaints in terms of retarded growth, reduction in reproductive performance, morphological deformities, increased incidence of disease and mortality of hatchery produced carp seeds. The types of traits most frequently reported to show inbreeding depression in fish species has been: increased fry abnormalities (Kincaid 1976, Stiles 1981), reduced survival (Kincaid 1976), reduced growth rate (Moav and Wohlfarth 1968, Ryman 1970, Fujino 1978, Gjerde et al 1983), and lowered reproductive success (Kincaid 1976, Mrakovcic and Haley 1979).

Presumably, a large quantity of such poor seed is being used in aquaculture. Moreover, there is stock enhancement plan to mitigate the effect of damming in hydel reservoir (for instance Kali Gandaki) through the stocking of hatchery-produced seeds of several native species. There is widespread concern that stocking of such genetically poor quality stocks in lakes, rivers and 'gholes' might cause serious feral gene introgression in wild stocks, which would ultimately adversely affect aquaculture and inland openwater fish production in the country. To avoid loss of genetic diversity and inbreeding depression problems in hatchery populations, proper broodstock management strategies and effective breeding plans for commercially important fish species need to be designed and implemented.

The objective of the present study is to obtain practical estimates of the rates of inbreeding in Nepalese hatcheries involved in large-scale production and distribution of fish seed to grow-out areas; and if significant, suggest way of controlling inbreeding in broodstock populations.

Effective population size and inbreeding in relation to current brood stock management

Inbreeding can be defined as the mating together of individuals that are related to each other by common ancestry (Falconer 1989). The degree of relationship between mating pairs is measured by the coefficient of inbreeding (F). It is inversely related to the population size (N_e). In finite genetically closed aquaculture populations, during hatchery propagation, it is quite possible that among the relatively few individuals randomly selected for mating, some pairs are more closely related than others (Eknath and Doyle 1990). Inbreeding occurs when genetically closely related individuals used for breeding and the progeny for replenishment of broodstock come from within the same farm.

The key parameter for estimating rate of inbreeding is the effective population size (N_e). It reflects the actual number of individuals that contribute progeny to the next generation. To derive this parameter, the breeding structure in a given hatchery should be known.

In general, the breeding procedure followed in fish hatcheries involves selection of potential breeders about 2-3 months prior to the breeding season, followed by induced spawning until the seed production target is met. A spawning set used for breeding usually refers to mating between two males and one female. Replenishment of the broodstock occurs as and when found necessary. After the seed production/distribution target is met, the individuals as replenishment stock are selected from the 'left-overs'. No systematic breeding effort is made to prepare replenishment stock representative from each spawned sets.

The number of breeders used for seed production is usually less than the total number of individuals in the broodstock ponds in hatcheries. The reasons for this are: selection of small number of brood stock, high

fecundity of carp, limited nursery restrict the rearing of large number of broodstock for spawning, loss of broodstock from the broodstock ponds due to periodic harvesting of individuals showing a decline in reproduction, mortality after spawning, and diseases.

Although many breeders mature and breed in the farm during a production cycle, the effective population size is determined not by the total number of breeders used for seed production but by the number of individuals that eventually contribute progeny for the replenishment of the broodstock. In most of the hatcheries, the progeny for the replenishment stock come from a few parents and usually from a last segment of breeding season (Figure 1).

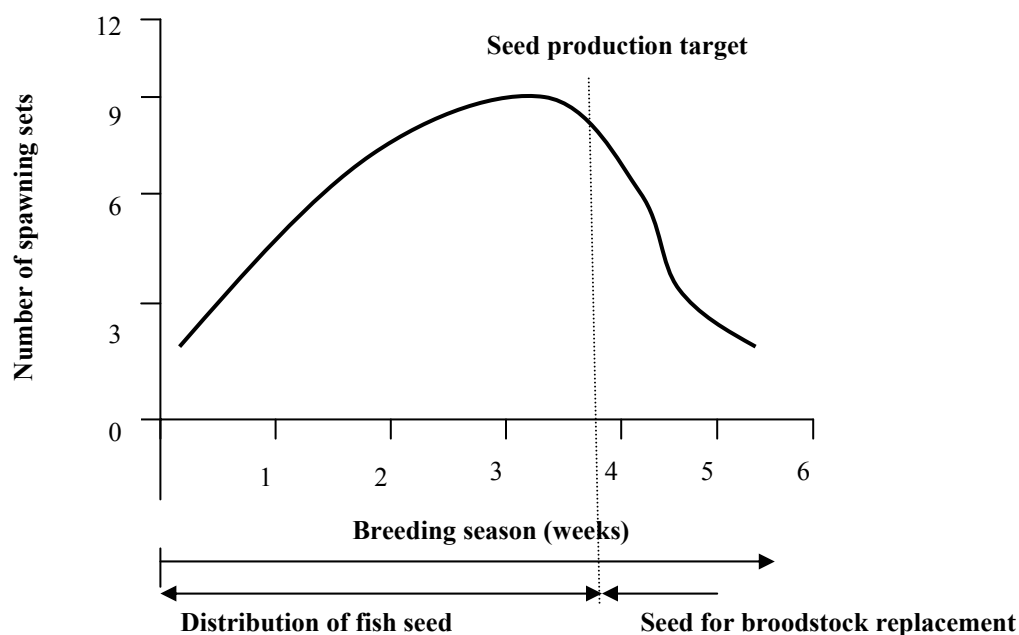


Figure 1. Number of a spawning sets during a typical breeding season. Replenishment stock occurs during the last segment of breeding season (modified from Eknath and Doyle 1990).

Effective population size is also determined by (1) the number of males and females contributing progeny. Unequal sex ratios reduce N_e , with the less numerous sex having the greatest effect. In induced propagation of carp, a spawning set, depending on the size of brooders, consists of two males and one female or three males and two females; (2) variability in the number of progeny per spawning and the number of progeny that are finally recruited to the broodstock ponds; (3) temporal variations in the number of breeders and the age structure of the broodstock. Overlapping generations is common in aquacultured species, which further complicate the estimation of N_e and can potentially lead to mating between relatives of all kinds.

In brief, broodstock management in hatcheries in Nepal is not sound with respect to maintenance of genetic variation. Conventional techniques for estimating inbreeding rates based on pedigrees cannot be applied because the data necessary for such analysis are not available. Doyle and Talbot (1986), Eknath and Doyle (1990) have derived simple expressions for estimating N_e in extensive aquaculture system and rate of inbreeding based on Hill's (1979) formulations. The approach is to derive N_e as a function of the number of new individuals of each sex recruited to the broodstock population each year and the variance of their reproductive success. The rate of inbreeding can then be calculated using standard techniques.

MATERIALS AND METHODS

This study is based on data on seven carp species for two years breeding season during (1999-2001) from the three fish hatcheries of Nepal. Data were collected through questionnaires. The various parameters derived (using the primary data) to estimate N_e and ΔF following Hill (1979) and Eknath and Doyle (1990) are as follows:

A. Primary data collected from the hatcheries

T= Total number of male and female breeders maintained in the farm.

S= Total number of males and females actually spawned for fish seed production.

N_n= Number of new breeders of each sex added to the broodstock pond (N_{nm}= males; N_{nf}= females).

N_r= Number of new individuals that contribute to replenish the broodstock (N_{rm}= males; N_{rf}= females)

B. Derived parameters

Generation length (L): Generation length has been fixed at 2 years for common carp, silver carp and bighead carp and 3 years for other species. This seems to be more realistic assumption because the general practice in hatcheries is to recruit relatively larger individuals during their second and third year of life, although a small proportion of male matures in the first year.

Variance of family size and replacement success

Family size refers to the number of progeny of a parent that become breeding individuals in the next generation. There are two groups in the broodstock: individual whose progeny are retained in the farm for the replenishing the broodstock (fertile parents), and the progeny from the rest which are sold to grow-out areas (infertile parents). Among the fertile parents, the opportunity to eventually replenish broodstock differs because of variation in survival of their progeny; in other words, there will be non-random variation in family size. One important consequence of this variation is that a greater proportion of the next generation may come from a smaller number of parents. Variance of family size will be different for males and females because of their mating scheme. Male and female parents are assumed to produce equal numbers of males and females among their progeny.

Variance of family size is assumed to follow a Poisson distribution with zero values followed (Eknath and Doyle 1990). The sum of squares (SS) for each sex consists of weighted SS of the infertile and fertile parents around the population mean plus the SS of the members of each group around their group means (Doyle and Talbot 1986). The variance of family size of a female (V_f) may be calculated as:

$$SS_f = N_{of} \left(\frac{N_t}{N_{nf}} \right)^2 + N_{rf} \left(\frac{N_t}{N_{rf}} - \frac{N_t}{N_{nf}} \right)^2 + N_t$$

$$V_f = \frac{SS_f}{N_{nf}}$$

Where N_t= total number of new breeders added to the broodstock (N_{nm}+N_{nf}); N_{of}= (N_{nf}-N_{rf})= the number of new females that do not contribute progeny to replacement of broodstock ('infertile females'); V=variance of family size from all causes (V_f for females; V_m for males).

The annual effective population size (N_e) may be calculated as (Hill 1979 simplified by Doyle and Talbot 1986):

$$\frac{1}{N_e} = \frac{1}{16N_{nm}L}(2 + V_m) + \frac{1}{16N_{nf}L}(2 + V_f)$$

The annual rate of inbreeding accumulation (ΔF) was obtained from the formula (Falconer 1989):

$$\Delta F = \frac{1}{2N_e}$$

RESULTS

The estimated effective population (N_e) and annual rates of accumulation of inbreeding are presented in Table 1. The hatcheries are listed according to their size in an ascending order. These hatcheries occupied an area ranging

from 1.4 to 3.0 ha for brood stock management. Seed production of all the seven major carp species takes place in these hatcheries.

A large number of breeders are maintained in brood stock ponds (T in Table 1) but the numbers of breeders used for seed production (S) is frequently less than the total number. S ranges from 15% to 93% and 9% to 70% of T for male and female, respectively. The number of new breeders (N_n) recruited to the broodstock is approximately 33% of T. However, it is important to note that the new breeders that eventually contribute progeny to the replenishment of broodstock (N_r) are low. It is approximately 22.2% for male and 18.9% for female of the total number of breeders of the broodstock. When parents have an equal chance of contributing progeny to the next generation, the variance of family size (V) will be 2. In the present observation, V is much greater than 2 indicating the non-random opportunities of contributing progeny. The variance of family size for females is more than 2 times greater than the variance observed for males because of the particular mating system followed. The effective population size (N_e) ranges from as low as 1.8% to a maximum of only 31%; consequently, the rate of accumulation of inbreeding (ΔF) ranges from 1.6% to 27.6%.

Table 1. Calculation of effective population size (N_e) and annual rate of inbreeding in fish hatcheries (variables are explained in the text M= males, F= females)

Farm	Species ¹	T		S		N_n		N_r		V		L	N_e	ΔF %
		M	F	M	F	M	F	M	F	M	F			
FDC, Bhairahawa	CC	287	297	207	145	32	31	7	4	17.1	29.5	2	19.73	2.53
	SC	251	208	123	68	19	22	6	5	11.9	14.9	2	20.79	2.40
	BC	137	120	74	41	23	25	8	6	10.0	13.3	2	27.67	1.81
	GC	120	53	60	37	19	27	6	6	16.8	13.1	3	31.02	1.61
	Rohu	96	47	15	11	18	15	3	3	18.6	21.6	3	17.66	2.83
	Naini	65	82	31	23	9	8	2	2	14.4	15.7	3	11.91	4.20
	Catla	22	18	3	6	4	5	2	2	7.3	6.7	3	11.82	4.23
FRC, Pokhara	CC	93	40	27	16	34	19	9	4	8.3	31.4	2	15.51	3.22
	SC	24	37	16	11	11	7	4	2	6.3	19.1	2	8.49	5.89
	BC	45	30	18	10	44	28	13	5	8.4	33.0	2	21.54	2.32
	GC	44	36	22	13	9	5	3	2	5.8	13.3	3	11.10	4.50
	Rohu	70	59	12	6	27	14	5	2	12.6	53.4	3	10.30	4.85
	Naini	10	8	2	1	6	4	2	1	7.2	21.3	3	6.53	7.66
	Catla	19	7	9	5	8	6	3	2	6.9	18.7	3	10.55	4.74
FRC, Tarahara	CC	86	59	80	40	7	23	3	4	37.5	10.4	2	4.84	10.34
	SC	29	19	14	9	18	10	6	3	6.7	20.3	2	11.22	4.45
	BC	16	12	8	5	8	3	5	2	2.2	14.7	2	4.43	11.30
	GC	29	22	9	6	10	3	5	1	3.4	41.9	3	3.16	15.80
	Rohu	28	20	16	8	10	5	4	2	5.5	22.5	3	8.43	5.93
	Naini	29	23	15	9	13	11	5	3	7.0	18.3	3	18.28	2.73
	Catla	26	23	6	4	5	2	2	1	3.6	36.0	3	1.81	27.67

On the average, ΔF of Silver carp, Rohu and Naini is between 4.25% to 4.86%. ΔF of Common carp in hatcheries is about 5.37% at 2 years generation length (L), if L is fixed at 1 year the ΔF will be approximately doubled. The four commonly preferred species for aquaculture in Nepal, Catla, Grass carp, Common carp and Bighead carp, are probably the most highly inbred. These species exhibits ΔF levels ranging from 4.2% to 27.7%, 1.6% to 15.8% and 1.8% to 11.3%, respectively, for Catla, Grass carp and Bighead Carp.

DISCUSSION

The rate of accumulation of inbreeding (ΔF) is high particularly for the four most desirable carp species. It appears that species by species some or most of the hatcheries are rapidly inbreeding their stocks.

In this study, the annual rate of inbreeding resulting from the mating of older individual in the broodstocks are unknown. This aspect requires data pertaining to the number of mature individuals in each age class, broodstock age distribution, contribution to total reproduction of each group and expectation of breeding life (Eknath and Doyle 1990). Such data are very difficult to obtain from any aquaculture system. Nevertheless, the analysis presented here provides approximations to the asymptotic rate of increase in inbreeding and should be a valuable guide for understanding the genetic consequences of routine broodstock management decisions.

It is well established that inbreeding affects traits associated with reproductive capacity and physiological inefficiency (Falconer 1989). The deleterious effects of inbreeding in aquaculture have been reviewed by Kincaid (1983). In hatcheries, substantial variation in growth and reproductive performance of aquaculture stocks is a widespread phenomenon. Continuing decline in the rates of fertilization, hatching, fry survival and decrease in the volume of milt particularly among the grass carp and Silver carp in Indian hatcheries (Eknath and Doyle 1990). It is thought that these variations are due to the physiological condition of breeders including their readiness to spawn and to variation in water quality. Decline in growth rates, particularly in grow-out areas, has been attributed to the productivity and availability of natural food.

To prove that inbreeding is one of the major causes of the observed decline in growth and reproduction performance, one has to cross-breed stocks from different hatcheries and demonstrate heterosis effect, if any. This is a workable hypothesis because the founder stocks of Chinese carp and Common carp in almost hatcheries have originated from different hatcheries. The hatchery populations, therefore, can be considered as isolated sub-populations of original ancestral population of source hatcheries. Genetically, they are isolated inbred lines of the same population.

A hatchery should have short-term and long-term plans to avoid the risk of inbreeding and negative selection, and to build genetically improved stocks. There are several possible ways of reducing the accumulation of inbreeding:

The base population should be collected from natural waters (lakes, rivers etc) or from a known source. The fast-growing and best-looking individuals from nursery/growout ponds should be selected for raising as broodstock and few individuals from as many stocks as possible for each species is required. Increasing the number of breeders as much as possible in order to select the best performers in terms of size, maturation and breeding efficiency. While increasing the total breeding population, one has to consider the economics and the resources necessary for maintaining the increased population and also those required for spawning them effectively.

It is often recommended that by maintaining full pedigree records of stocks one can reduce inbreeding by avoiding mating between close relatives (Hussain and Mazid 1999). Organizing broodstock population structure by pedigrees may be expensive, and it is highly complex to be handled by hatchery personnel. It is, however, worthwhile to pedigree the stocks wherever such opportunities exist in order to delay the rate of accumulation of inbreeding. A rotational line-crossing system can be implemented easily but requires a good marking scheme and maintenance of proper records on lines.

A more realistic approach to the problem is to use effective population size, the size of an ideal population having the minimum amount of drift and inbreeding (Ryman and Stahl 1980). The effective number of parents (N_e) is influenced by several factors, however, the ratio among the breeders being the most conspicuous in the context of fish breeding as shown:

$$N_e = (4N_{\text{♂}} \times N_{\text{♀}}) / (N_{\text{♂}} + N_{\text{♀}})$$

Where $N_{\text{♂}}$ and $N_{\text{♀}}$ are the actual numbers of male and female parents, respectively. With the limited number of breeders the largest effective number of parents is obtained when both sexes are equally frequent. When sex ratio is highly skewed the effective number of parents is best approximated by the least numerous sex (Figure 2). There is practical limit at which ΔF is only slightly affected by a further increase of N_e and this limit occurs approximately at 40-60 effective parents (Ryman and Stahl 1980) (Figure 3). In discussing effective number of parents, the management of actual number of parents (N_a) should be taken in consideration.

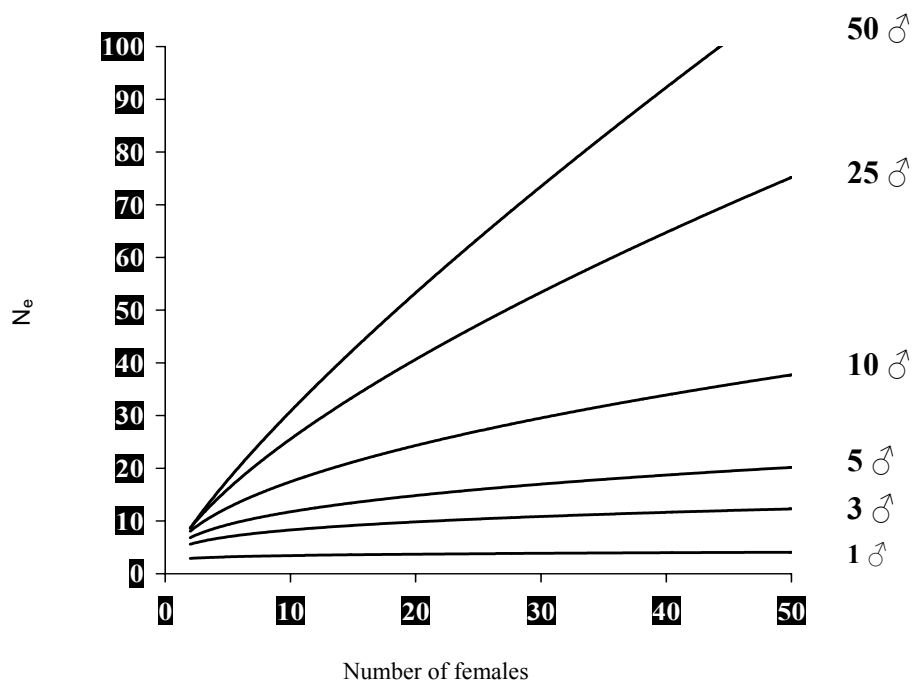


Figure 2. Relationship between actual number of parents (N_a) and effective population size.

Besides maximizing N_e , a well-planned selective breeding and line-crossing program would improve desirable trait in founder stocks. Systematic line crossing schemes— serves to eliminate the mating of full sibs and therefore, effectively to reduce the rate of inbreeding accumulation below that found in random mating populations of equal population size at least during the early generations (Kincaid 1983). Selection program can be incorporated into most systematic line crossing schemes. There is need for the establishment of ‘brood banks’ where wild germplasm can be preserved maintained and genetically improved broodstock developed.

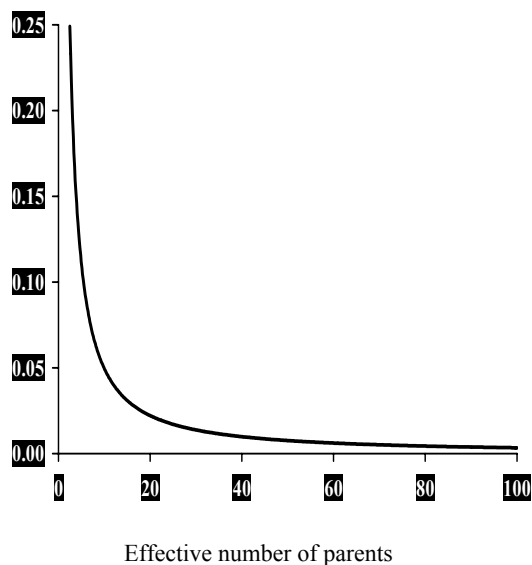


Figure 3. Increase of inbreeding per generation (ΔF) as a function of the number of effective parents (Source: Ryman and Stahl 1981).

The most immediate practical approach is to reduce the variance of family size and thereby increase the effective population size. In simpler terms, individuals for replenishment of broodstock should be chosen equally from all families or spawning sets. If an equal number of parents are taken from each family, there will be no variation of family size and the resulting effective population size will be essentially twice the actual number (Gall 1987). A more exact expression is $N_e = 2N - 1$ (Crow and Kimura 1970). Where N is the number of breeding individuals.

Overlapping generations (Hill 1979) is also expected to increase rate of inbreeding in aquacultured fish (Eknath and Doyle 1990). Fish populations maintained as separate year classes for short period, and some crossing between year classes at regular intervals (for example far two or three generations) will restore genetic variability for the population as a whole.

REFERENCES

- Crow JF and M Kimura. 1970. *An introduction to population genetics: Theory*. Harper and Row, New York. 591pp.
- DoFD. 2002. *Fisheries profile booklet*. Directorate of Fisheries Development (DoFD), Department of Agriculture, HMG/N, Kathmandu, Nepal.
- Doyle RW and AJ Talbot. 1986. Effective population size and selection in variable aquaculture stocks. *Aquaculture* 57:27-35.
- Doyle RW. 1983. An approach to the qualitative analysis of domestication selection in aquaculture. *Aquaculture* 33:167-185.
- Eknath AE and RW Doyle. 1990. Effective population size and rate of inbreeding in aquaculture of Indian major carps. *Aquaculture* 85:293-305.
- Falconer, DS. 1989. *Introduction to quantitative genetics*. 3rd ed. Longman, New York.
- Fujino K. 1978. Genetic studies on the Pacific abalone: II. Excessive homozygosity in growth in deficient animals. *Bull. Jpn. Soc. Sci. Fish.* 44 (7):767-770.
- Gall G A E. 1987. Inbreeding. **In:** *Population genetics and fishery management* (N Ryman and F Utter, eds). University of Washington Press, Seattle, USA. Pp.47-87.
- Gjerde B, K Gunnes and T Gjedrem. 1983. Effect of inbreeding on survival and growth in rainbow trout. *Aquaculture* 34 (3-4):327-332.
- Hill WG. 1979. A note on the effective population size with overlapping generations. *Genetics* 92:317-322.
- Hussain MG and MA Mazid. 1999. Broodstock management status and some suggestions to control negative selection and inbreeding in hatchery stocks in Bangladesh, Naga. *The ICLARM Quarterly* 22(4):24-27.
- Karki 1998. Review of pond fisheries in Nepal. **In:** *Proceedings of the present status of fisheries research, development and education in Nepal* (BR Pradhan, SK Wagle, O Yamada and Y Takano, eds). NARC/JICA. Pp.109-112.
- Kincaid HL. 1976. Inbreeding in rainbow trout (*Salmo gairdneri*). *J. Fish. Res. Board Can.* 33(11):2420-2426.
- Kincaid HL. 1983. Inbreeding in fish populations used for aquaculture. *Aquaculture* 33:215-227.
- Kohinoor AHM, MS Islam, MY Mia, MA Rahman, MG Hussain, MG Mazid, BJ McAndrew and DJ Penman 2002. Evaluation of different stocks of Chinese carps in Bangladesh: design and preliminary trials. **In:** *Proceedings of a Workshop on Genetic Management and Improvement Strategies for Exotic Carps in Asia* 12-14 February 2002, Dhaka, Bangladesh (DJ Penman, MG Hussain, BJ McAndrew and MA Mazid, eds). Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh. XXXP. Pp.59-67.
- Moav R and GW Wohlfarth, 1968. Breeding schemes for the improvement of edible fish, *Prog. Rep. 1962*. Fish Breeding Assoc. Israel. 44pp.
- Mrakovcic M and LE Haley. 1979. Inbreeding depression in the zebra fish *Brachydanio rerio* (Hamilton Buchana). *J. Fish. Biol.* 15:323-327.
- Pante MJ R, B Gjerde and I McMillan. 2001. Effect of inbreeding at harvest in rainbow trout, *Onchorhynchus mykiss*. *Aquaculture* 192:201-211.
- Ryman N and G Stahl. 1981. Genetic perspectives of identification and conservation of Scandinavian stocks of fish. *Can. J. Fish. Aquat. Sci.* 38:1562-1575.
- Ryman N. 1970. A genetic analysis of recapture frequency of released young of salmon (*Salmo salar* L.). *Hereditas* 65 (1):159-160.
- Stiles S. 1981. *Recent progress on directed breeding experiments with long island sound oysters*. ICES, Statutory Meeting, Mariculture Committee, World Hole, CM. 1981/F:33.

Cage Culture of Rainbow Trout (*Onchorynchus Mykiss*) in Stagnant Water of Lake and Reservoir

Jay D Bista¹, Tek B Gurung¹, Suresh K Wagle¹, Ganesh B Karki² and Ram P Dhakal¹

¹Fisheries Research Centre, PO Box 274, Pokhara, Kaski <fishres@fewanet.com.np>

²Fisheries Development Center, Kulekhani, Markhu

ABSTRACT

The present study was conducted as a means to utilize the empty carp harvested cages during winter in mid hill lakes. In summer, production cages are used to grow plankton feeder carps, however, in winter since carp do not show satisfactory growth due to low water temperature and low productivity of plankton. Thus, mostly carp are harvested in winter and remain empty for 3-4 months until the next generation of carp seed are not supplied to farmers. The present experiment showed that in a cage of 5 m x 5 m x 2 m dimension about a stocking rate of 5 trout per cubic meter, a total of 25 kg trout can be produced with a per day growth rate of trout in lakes and reservoir was up to 0.88 g. We showed that in trout farming during the winter from November to March when water temperature remain within 13-22°C, trout can be grown satisfactorily in mid hill stagnant lakes and reservoirs. The present work reveals that marginal farmer can achieve a benefit of about 2735 Nepalese Rupees per cage in a period of 100 days. Mechanism for trout seed supply to enhance the further adoption of the technology is recommended.

Key words: Cage culture, lake, rainbow trout, reservoir, stagnant water

INTRODUCTION

In Nepal present cage fish culture system is extensive type wherein fish depends on natural foods for their growth and survival. In Nepal cage fish farming system started in 1972 (Sharma 1979, Swar and Pradhan 1992, Gurung 2001). It is well adopted as a means of livelihood of rural and fisher community in present days. Lakes of Pokhara valley and Indasarovar reservoir of Kulekhani, Makwanpur district are the successful example of cage fish culture (Rai and Mulmi 1992, Pradhan and Shrestha 1979). In cage fish farming system farmers use the carp fish species like silver carp (*Hypophthalmichthys molitrix*) and big head carp (*Aristichthys nobilis*), which are well known planktivorous fish. The lakes and reservoir of mid hills and high hills are not fully utilized under aquaculture. The temperature ranges between 12-30°C in lakes and reservoir of mid hill reasons. In winter temperature of these waters drop down upto 12-13°C and carp fish cannot grow well at low temperature and farmers harvest their product before winter. The winter season is the slag season for carp culture. Therefore, this season can be utilized for other fish species, which can grow fast in winter temperature of these waters.

Rainbow trout *Oncorhynchus mykiss* is a cold water and high oxygen demanding fish. It is a popular food fish and has been introduced in Nepal since 1960, with greater success from Japan in 1989. Trout farming is a fairly recent activity in Nepal. The fish is well known for high food qualities containing 18 amino acids. It is carnivore fish species of North American origin. The best growth performance of this fish takes place between the temperature of 12°C and 15°C. Above 15°C activity decreases quickly and when it is warmer than 19°C, this fish becomes lethargic and disinclined to feed. It can be raised in raceways ponds and cages. Floating cage culture has several advantages. It can be started with small investment and can get maximum yield from limited area in controlled condition. Rainbow trout lives in a wide range of temperature 1°C to 23°C but fish grows well in water temperature between 10°C to 18°C (Yamazaki 1991).

MATERIALS AND METHODS

Study sites

Lake Phewa: Lake Phewa situated at 742 masl is the biggest lake in Pokhara valley. The surface area, water volume, maximum and average depth of lake are 5.23 km², 39.32 *10⁶ tons, 24 m and 7.5 m respectively. Harpan Khola is the main perennial stream, which flows directly into the lake. However, 110 km² catchments area is the main water source of the lake during the monsoon period.

Lake Begnas: Lake Begnas situated at 650 masl is the second biggest lake in Pokhara valley. The total water surface area water volume, maximum and average depth of the lake are 3.28 km², 17.96 *10⁶ tons, 10 m and 6.5 m respectively. Syankhudi Khola is the main perennial stream, which flows directly into the lake from west to south. However, rainwater is collected from 19 km² catchments area is the main water source of the lake during the monsoon period to fill up the lake.

Indrasarobar reservoir: It is situated at an altitude of 1430 masl in the mid hill reason is about 70 km southwest from Kathmandu. This reservoir was impounded in 1982 by damming Kulekhani stream and its tributaries for electricity generation. The reservoir has a basin of 126 km² from which the runoff water during monsoon is collected to fill up the reservoir the water level in the reservoir fluctuates upto 54 m making water surface area from 220 ha at highest level to 75 ha to least level. Because the inlet of tunnel leading to the powerhouse is located at 46m above ground level and 46 m of water always remain in the bottom of the reservoir. Planktivorous fish species are culture in cages without supplying artificial feed and showed potential for cage culture (Pradhan and Swar 1992, Rai 1989, Rai and Mulmi 1992).

The rainbow trout fingerlings used in this experiment was obtained from Trishuli Fisheries Research Center. The fish were transported in oxygen injected tanks especially designed for fish transport with minimum mortality. These fingerlings were kept in different cages for 2 days and segregated according to the design of the experiment. Rainbow trout of the mean weight 50 g were in lakes and 15g in reservoir were stocked in floating net cages each of 50m³ (5-x 5-x 2-m) in size. The mesh size of the floating cage was 25 mm. Net cages were set near by the Fisheries Office in the lake and reservoir, where depth was approximately 4-6 m. The stocking rate was 5 fish/m³ in lakes and 8 fish/m³ in reservoir in each cages. In these cage trout was stocked in November 2002 when water temperature in the lake and reservoir reached in a range of 18-21⁰C. The fish were provided 35% protein content pelleted feed at the rate of 3% of their body weight. Feeding frequency was 3 times a day from 10 am to 5 pm. Fish growth as an increase in the body weight was measured once a month and water temperature everyday during experimental period.

Trout from the cage was harvested in April 2003 when water temperature reached about 22 ⁰C. Few cages were left without harvesting to examine the effect of higher temperature on general condition of trout. The mortality and escaped fish was negligible (1-2%) during the experiment.

For water quality measurement sample was collected near by the cage for DO, pH, nutrients such as ammonia, nitrite-nitrate. The pH was measures using portable meter. DO was measured using Winkler method of titration. The nutrient was measured using UNESCO method. Daily temperature was collected using the simple alcohol thermometer.

RESULTS

Some of the water quality parameters of experimental site are given in Table 1. Water temperature measured at the time of fish stocking during November was 20⁰C and 21⁰C, respectively, in Lake Phewa and Begnas. Temperature decreased continuously after stocking until January (14.5 and 15.0⁰C respectively).

The pH level ranged from 7 to 9.20 in study sites. Low level of dissolved oxygen (3.3 to 4.6 mg/l) occurred for the first two months of experiment. Later DO levels were remarkably higher (6.4 to 8.8 mg/l) throughout the trout raising period in cages. Water pH in both lakes was slight to moderately alkaline. Ammonium-N concentrations were higher (0.13 to 0.26 mg/l) at the progressive stage of experiment during February to April.

Table 1. Range and mean values of selected water quality parameters in trout cage culture facilities in the lakes Phewa and Begnas

Description	Water quality	
	Range	Mean±SD
Lake Phewa		
Temperature, °C	14.5-22.0	18.33±2.82
Dissolve oxygen, mg/l	3.30-8.10	6.38±1.96
pH	6.00-8.00	7.28±0.71
Ammonium-N, mg/l	0.004-0.26	0.09±0.09
Nitrite+Nitrate-N, mg/l	0.00-0.19	0.06±0.04
Lake Begnas		
Temperature, °C	15.00-24.50	19.42±3.29
Dissolve oxygen, mg/l	3.50-8.80	6.75±2.37
pH	7.90-10.80	9.67±0.98
Ammonium-N, mg/l	0.074-0.32	0.17±0.10
Nitrite+Nitrate-N, mg/l	0.01-0.24	0.13±0.11
Indrasarobar Reservoir		
Temperature, °C	13.00-20.50	16.33±2.96
Dissolve Oxygen, mg/l	5.40-8.20	6.98±0.98
pH	7.00-9.20	8.08±0.75
Ammonium-N, mg/l	0.01-0.087	0.038±0.03
Nitrite+Nitrate-N, mg/l	0.022-0.448	0.18±0.16

In general, the growth curve of trout in the lakes Phewa, Begnas and Indrasarowar reservoir, irrespective of initial size, followed an exponential increase throughout the study period (Figure 1A, B, C). Starting with 50 g, 50 g and 15.0 g stocking size, average body weight of trout could reach 119.4 g, 107.0 g and 77.5 g during 100 days of experimental period in lakes Phewa, Begnas and Indrasarowar reservoir, respectively. Absolute growth rates were highest (0.66 to 0.89 g/day) in the first two months of experiment i.e. November and December when water temperature was in declining trend. The lowest absolute growth rates (0.18 to 0.41 g/day) were obtained at the end of experiment irrespective of water bodies (Figure 2).

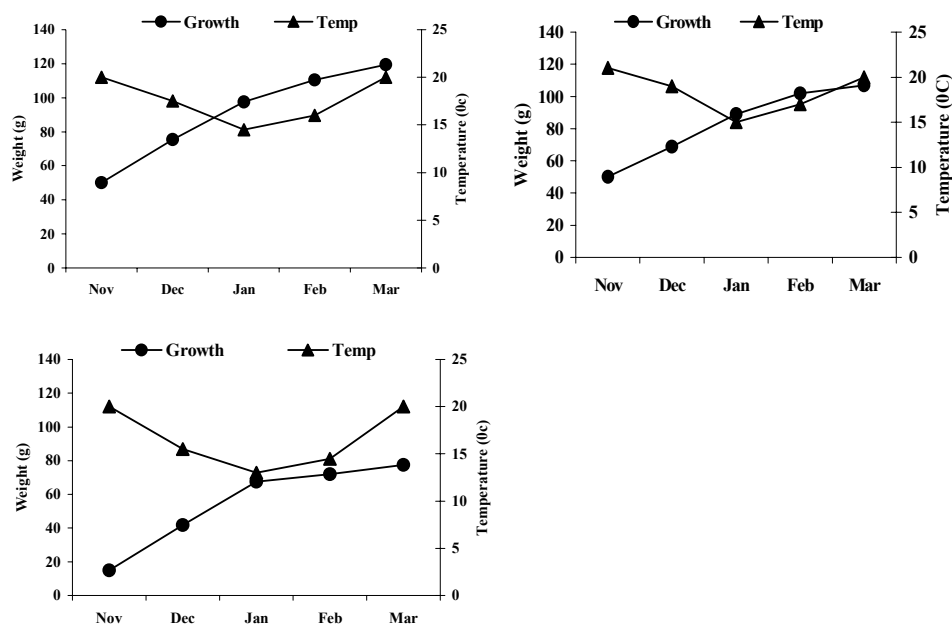


Figure 1. Absolute growth of rainbow trout during the experimental period in lakes and reservoir, (A) and (B) Phewa and Begnas Lake and (C) Indrasarobar Reservoir.

Initial relative growth rate was highest (9.6%) for trout raised in cages in Kulekhani reservoir since the relatively small size of fish was stocked (Fig 1C). As the growing period progressed, the relative growth sharply declined (0.16 to 0.25%) in all lakes and reservoir (Figure 2). However, relative growth rates of trout were not significantly different ($P>0.05$) among lakes and reservoir.

Trout were harvested in late April at water temperature between 22.0-22.5°C in all experimental sites. Negligible fish mortality was observed during grow out period.

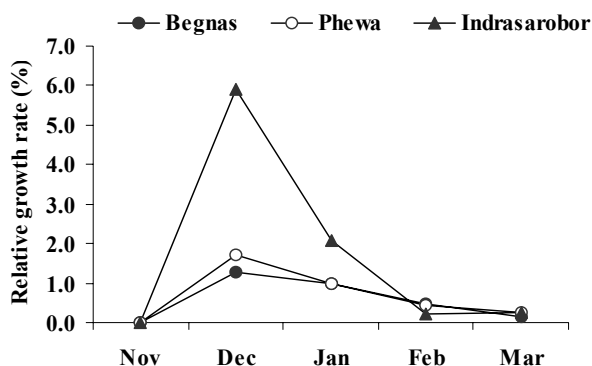


Figure 2. Relative growth of caged rainbow trout in lakes and reservoir.

However, few fish were left in order to find out the maximum seasonal duration for survival and growth. Fish mortality started due to increased temperature in Lake Phewa and Indrasarobor reservoir when water temperature reached 23.0°C on 20th April and 5 May 2003, respectively and all fish died when water temperature exceeded 24.0°C in Lake Phewa.

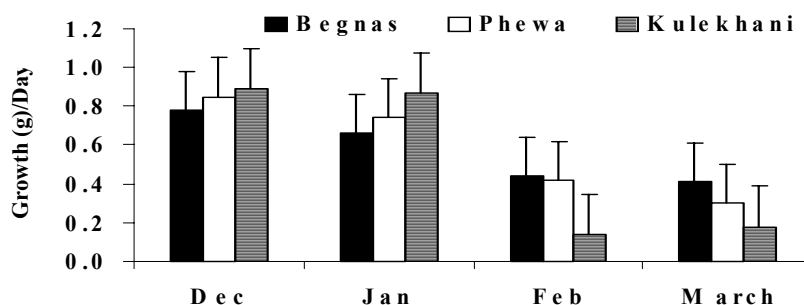


Table 2. Cost-benefit estimates of small scale trout farming in lakes and reservoir during winter

SN	Items	Cost, Rs/unit	Total cost, Rs
1	Feed cost, Rs	35	2415.00
2	Fingerling cost	7	1750.00
3	Total cost	-	4165.00
Income from 25 kg of trout production from one cage			
1	Fish selling	300 Rs/kg	6900.00
Net income			
1	Fish selling	-	2735.00

DISCUSSION

Rainbow trout survived and grew well in Lakes Phewa, Begnas and Indrasarobar reservoir for about 100 days during the experimental phase at temperature between 13.8⁰C to 22.0⁰C from November 2002 to mid April 2003. The result demonstrated that trout farming in mid hill lakes and reservoir can be one of the alternative opportunities for cage farmers to increase their income through trout farming into the cages during winter. Similar approach of trout farming has been reported in many other countries such as United States, where channel cat fish are cultivated in summer and after their harvest, rainbow trout are grown in same cage in winter (Beem and Gebhart 2000).

It was evident that growth of trout was generally decreased with increasing water temperature in experimental sites as expected (Figure 1). The relative growth rate followed the similar pattern of absolute growth rate. Maximum water temperature tolerable to trout was recorded until early April in lakes and reservoir. The present study showed that trout farming can also be successfully carried out in stagnant water resources like Phewa and Begnas Lakes of mid hills during winter months. The present finding also showed that trout farming in cages in Indrasarobar Reservoir could be carried out from November to March at temperatures between 10.2-19.9⁰C.

Trout is a cold-water fish and cannot survive in the water temperatures above 23⁰C for an extended period of time (Huet 1972, Yamazaki 1991, Beem and Gebhart 2000). This limit of temperature for trout farming exceed in waters of lakes Begnas and Phewa and Indrasarobar Reservoir during May to October, when only carps could survive and grow well (Swar and Pradhan 1992, Rai and Mulmi 1992). Therefore, a farmer can increase the income by cultivating carp in summer and trout in winter in those lakes and reservoir.

Dissolved oxygen concentration above 8.0 mg/L is considered suitable for trout culture (Bardach et al 1972, Huet et al 1972). During the experiment the dissolved oxygen reached a minimum value of 3.0-3.5 mg/l in November and December. Such a low DO for longer time period can negatively impact over the growth of trout, however, substantial impact was not seen during the experiment. Though the experiment was performed in stagnant waters but air turbulence and mixing process during winter in the lake and reservoir might have supported the growth.

The acute lethal concentrations of ammonia for a variety of fish species lie in the range 0.2-2.0 mg/l NH₄, with trout being the most sensitive and common carp, being the most resistant (USEPA 1976, Lloyd 1980). Salmonids appear to be more sensitive than non- salmonids (Erickson, 1985) and unionized ammonia is highly toxic and level of 0.02 mg/l is generally regarded as the maximum acceptable limit for salmon (Shepherd and Bromage 1988). In the present study highest total ammonium nitrogen was 0.26 and 0.32 mg/l respectively, for lakes Phewa and Begnas during February and March accompanied by 16-20⁰C temperature and 7.0-9.5 units of pH. Excessively high pH and temperature cause serious ammonia toxicity problems in waters with large load of feed (Chiu 1988). With the relatively low water temperature and neutral pH (7.0) during these months in water bodies of Phewa, Begnas and Indrasarobar, there was no serious incidence with unionized ammonia (NH₃-N).

In the present study average growth rate of trout in cages was 0.58 g, 0.56 g and 0.52 g/day, respectively, for lakes Begnas, Phewa and Indrasarobar reservoir with varying water temperature. Rainbow trout growth is better when water temperature is in between 15-18⁰C (Yamazaki 1991). However, in constant temperature Joshi (1999) reported that trout growth was higher in raceway (1.5 g/day) compared to cage culture in pond (0.75 g/day) and pond culture (0.69 g/day). The average growth of caged trout in cage in lakes and reservoir in present study was 0.88 g/day when the water temperature was below 18⁰C. This growth rate falls somewhere in between the previous reported growth of trout in different system (Joshi 1999). Therefore, the growth rate of caged trout in present study was satisfactory in general.

A simple cost-benefit analysis of small-scale trout farming in winter in the mid hill lakes and reservoir showed that the net benefit is about 2735 Nepalese Rupees (Table 2). Here, labor, cage depreciation cost has been excluded from the analysis. This is because in winter the empty cages after harvesting carps will be in use and can obtain additional bonus from cage fish culture even in winter. In general winter season is considered as slack seasons in hills. However, farmer has the opportunity to use the slack period for cultivation of trout.

General conclusion of the study is that trout can be grown in cages in Lakes Phewa, Begnas and Indrasarobar Reservoir from a large fingerling to a harvestable fish during November to April. Rainbow trout survived and grew well in a caged fish culture system in these water bodies and they adapted well to prevailing environmental

conditions. Since the approximate growing season for carps is April to November, a system of growing planktivorous carp in the summer and rainbow trout in the winter seems highly feasible as a small-scale aquaculture enterprise for additional income to support the livelihood of hill people.

ACKNOWLEDGEMENTS

We wish to express our gratitude to the staffs of Kulekahni Fisheries Development Center, and participating farmers in this study. This study was a part of HARP funded project (PP 46/00) to Pokhara Fisheries Research Center.

REFERENCES

- Bardach JE, JH Ryther, DW McLarney. 1972. *Aquaculture: The farming and husbandry of fresh water and marine organism*. John Wiley and Sons. New York.
- Been M and G Gebhart. 2000. *Cage culture of rainbow trout*. Longstone University, Agricultural Research and Extension Program. PO Box 730. Longstone OK 73050.
- Boyd CE and CS Tucker. 1998. *Ecology of pond aquaculture, pond aquaculture water quality management*. Kluwer Academic Publication. Pp.8-75.
- Cripps SJ and A Berghheim. 2000. Solid management and removal for intensive land based aquaculture production systems. *Aquaculture Engineering* 22(1-2):137-153.
- Chiu YN. 1988. Water quality management in intensive prawn ponds. **In: Technical considerations for the management and operation of intensive prawn farms** (YN Chiu, LM Santos and RD Juliano, eds). UP Aquaculture Society, Iloilo City, Philippines. Pp.102-128.
- Erickson RJ. 1985. An evaluation of mathematical models for the effects of pH and temperature on ammonia toxicity to aquatic organisms. *Water Research* 19: 1047-1058.
- Gurung TB. 2001. A review on status, potentiality and limitation of cage fish culture in Nepal. *Paper submitted to HARP*. Hill Agriculture Research Project.
- Huet M. 1972. Text book of fish culture: Breeding and cultivation of fish. *Fishing News Books Limited*, Surrey England.
- Joshi PL. 1999. Growth of rainbow trout in different culture systems. **In: Proceedings of 3rd National workshop on livestock and fisheries research in Nepal** (SP Neopane and RC Khanal, eds). National Animal Science Research Institute. Pp.90-93.
- Lloyd R. 1980. Ammonia. **In: Water quality criteria for fresh water fish** (JS Alabaster and R Lloyd, eds). FAO. Pp.85-102.
- Martyshev FG. 1983. *Pond fisheries*. Amerild Publication, New Delhi.
- Pradhan BR and BC Shrestha. 1979. Economic importance of cage fish culture in Pokhara Valley, Nepal. *Paper presented on 4th Fisheries Development workshop*, Janakpur, Nepal.
- Rai AK and RM Mulmi. 1995. Observation of planktivorous fish species in floating cages in Indrasarobar Reservoir. *J. Nat. His. Mus.* 13(1-4):3-8.
- Shepherd J and N Bromage. 1988. *Intensive fish farming*. Blackwell Science London.
- Sharma RN. 1979. Cage fish culture in Nepal. **In: International workshop on pen and cage fish culture of fish**, 11-12 Feb 1979, Tigbauan, Iloilo, Phillipines. IDRC and Aquaculture Department, SEAFDEC. P.93.
- Swar DB and BR Pradhan. 1992. Cage fish culture in the lakes of Pokhara Valley, Nepal and its impact on local fishers, *Asian Fisheries Science* 5:1-13.
- USEPA. 1976. *Quality criteria for waters*. US Environmental Protection Agency. EPA, Washington.
- Yamada T. 1998. Comparative study on hatchability, abnormalities and advance rate of rainbow trout. *Onchorynchus mykiss*. alevins. **In: Present status of fisheries research development and education in Nepal** (BR Pradhan, SK Wagle, O Yamada and M Takano, eds). Pp.78-81.
- Yamazaki T. 1991. Culture of foreign origin fishes. *Farming Japan*. 25th Anniversary 25. 1:41-46.

Cold Water Mountain Aquaculture: Technology Adoption and Livelihood in Nepal

Sadhu R Basnet¹, Gopal P Lamsal¹, Purushsottam L Joshi², Ash K Rai² and Tek B Gurung³

¹ Fisheries Research Center, Trishuli, Nuwakot

² Fisheries Research Division, Godawary, Lalitpur

³ Fisheries Research Center, Pokhara, Kaski

ABSTRACT

This paper briefly describes cold-water aquaculture in the mountains of Nepal. Here, the cold water aquaculture is fish husbandry carried out in small scale utilizing the near by rural water resources having water temperature <20°C. One of the most suitable fish species to rear in cold waters is rainbow trout (*Onchorynchus mykiss*) in Nepal. This popular cold-water species was introduced in Nepal from Japan in 1989. At present the total production of the country including that of private sector has reached about 19 Mt, of which the contribution of private sector is about 66% to total production in 2002. At present there are 5 private cold water fish farm located in Nuwakot, a hill district of Nepal. The cold-water fish farming technology is expected to adopt with the infrastructure development in rural hills of the country. At present the trout productivity in private sector ranges from 12-18 kg/m². This productivity needs to be enhanced gaining practical knowledge and technical skills on trout farming. This paper highlights the status and prospects of cold-water fish farming as one of the potential livelihood means for people living in the hills.

Key words: Cold water, mountain aquaculture, technology adoption

INTRODUCTION

Nepal is predominantly a mountainous country, where approximately 83% of the total area is occupied with hills and mountains. These mountains are known to serve as water reserve pillars. Nepal also serves as watershed areas where most of the monsoon cloud converts into the rain after striking the rain laden cloud into the Himalayas, then flows in the Bay of Bengal. This is one of the reasons that Nepal possesses ample aquatic resources and rich in aquatic biodiversity. A total of 195 fishes also enrich the aquatic biodiversity of Nepal. Rajbanshi (2001) compiled 92 cold-water fish species in Nepal. These fishes contribute substantially to the rural economy of the hills and mountains through capture fishery in the country. Fish is one of the favorite foods for most of the Nepalese people. In previous years, the potential of fisheries and aquaculture in terms of fish production, supplementing family income, betterment of environment and rural development has been demonstrated repeatedly in the country in the past through support of FAO/UNDP, ADB, IDRC, JICA and other donor agencies. Despite these, efforts about 60% fish in Kathmandu valley alone is known to be supplied from India.

Presently, warm water fish production is the main backbone of aquaculture contributing about 18000 Mt annual productions in Nepal (DoFD 2002, Gurung 2003). Modern fish culture in Nepal has a short history. It started first as pond aquaculture with indigenous carps in early 1960s. In Nepal, major aquaculture systems adopted are Carp polyculture in pond, enclosure and cage. Presently seven species of commercially valuable carps are cultivated in Nepal (Gurung 2003). These includes three indigenous species, Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*), Bhakur (*Catla catla*) and four exotic species: Common carp (*Cyprinus carpio*), Silver carp (*Hypophthalmichthys molitrix*), Bighead carp (*Aristichthys nobilis*) and Grass carp (*Ctenopharyngodon idella*). Beside these several native and exotic fish species can be brought under the fish farming practices (Bardach et al 1975, Gurung et al 2002) suitable to prevailing socio-economic conditions of Nepal. Fisheries contribute only 0.81% to the national GDP (DoFD 2000). Despite its significant dietary contribution, the per capita consumption

of fish was about 1.4 kg/year in 2002 (DoFD 2001/02). The main reasons for the low fish consumption rate in Nepal are the scarcity of fish and poor economic conditions prevailing in rural areas. Cold water aquaculture is one of the important fish production technologies well developed in Europe, America, some parts of Japan, Russia (Bardach et al 1972, Huet 1972, Martyshev 1983). In Nepal, socio-economical analysis of the cold water fish farming has been shown to be technically and economically feasible (Nepal 200). There are tremendous scope for expansion and intensification of trout production in the country. However, carp farming technology developed in the country in the past was only suitable for limited warm water area while a large proportion of cold-water regions were not represented. There are still many opportunities for intensifying the warm region aquaculture potentialities. Moreover, to engage a large fraction of population for job and income generation the development of cold water fish farming technology is indispensable. Considering this fact, HMG has well emphasized the development of cold-water fish culture in Nepal. For example, culture of exotic salmonids, rainbow trout (*Onchorhynchus mykiss*) has been developed for expansion in private sector for livelihood enhancement of hilly rural people. Here, our objective is to describe the status of cold-water fish aquaculture in Nepal as a means of livelihood practices in hills and mountains of Nepal.

MATERIALS AND METHODS

Data on rainbow trout farming were collected from Trishuli and Godawari Fisheries Research Center located in mid hill mountains of Nepal. At present trout production from private sector has been started in few parts of the country especially in those of mid hills where market and technological feasibilities are high such as Pokhara and Kathmandu Valleys. The published materials on mountain aquaculture were collected from different sources. Different data were collected from the monthly and annual technical report published from Trishuli and Godawari Fish Farms. The private sector farmers especially from Nuwakot district were trained and encouraged for different aspect of mountain aquaculture. To test the production performance of rainbow trout (*Onchorhynchus mykiss*), outreach research in participation of local farmer belonging to Nuwakot and Kaski were carried out in their own field.

Breeding activities

Technology for propagation of trout in Nepal is adopted as practices described in Bardach et al (1972). The brood were maintain and grown in the above two farms and were 2+ years old. Male and female brood are sorted in the month of August-September and fed with dry pellets at the rate of 2-3% of body weight. The pellet feed for brood contains at least 35-40% of crude protein. The pellets feed were prepared at Trishuli Fish Farm. Fertilization is external. The eggs are washed with cleaned water several time and incubated in Atkin's incubator for 20-28 days depending on water temperature. The alevins are then transferred to running water troughs where they were fed with crumble diets, which were prepared at Trishuli Fisheries Research Center.

Fry were also reared in small raceways and feeding troughs continuous water supply as described in Huet (1972). In addition fry were also fed with buff liver One-two month's old fingerlings were transferred in larger raceways for growth. The fingerlings were fed with 35% of protein containing crumble feeds. The fingerlings were segregated for their size differences once in a month. The larger fingerlings were removed and transferred. The 10-15 g size fingerlings were segregated and stocked for production. The stocking density was 20-30 fish m⁻². For production purposes trout were reared for about 8-9 months. At the beginning, the fish were sold Kathmandu. However, the marketing was easy and there are huge market opportunities for trout.

In 1994 for the first time, trout was started to rear in private sector. The farm was located at Ranipauwa area of Nuwakot district. The details of private farmers are given in Table 1. The farmers owned about land area. Some trout farmers have also opened restaurant, near by his farm, which is located near by the Trishuli-Kathmandu highway. This farm has been substantially successful in trout production and selling the dishes of the trout for local tourists invading from Kathmandu. With the influence of the success of this farm, four other farmers have started cultivation of trout in small scale as one of the sustainable livelihood activities utilizing the local cold-water resources.

RESULTS

In Nuwakot District 5 farmers have adopted trout production activities in private sector. Besides that two more new farms in Kaski and Kathmandu Districts are expected to in begin near future. The present production of

trout from private sector is about 12 mt in year 2002, while the government production in the same year was 6 mt (Godwary and Trishuli fish farm). The present trend of trout production in Nepal is in increasing trend after it's introduction in Nepal form 1989 onwards (Figure 2).

Our data showed that the number of broods used for breeding activities in Trishuli Fisheries Research Center is increasing (Table 1). When we compared the productivity of trout in farmer' field highest productivity was that of Puran Bahadur who successfully achieved a production level of about 18 kg of trout per square meter area. This might be due to his increasing skill over the farming techniques. The lowest productivity was in the field of Kanchan Lama who has started the farming only in year 2001. Huet (1975) mentioned that trout productivity in well-managed system could be reached approximately 30 kg M-2 (Figure 3A). Comparing to that production level it seems that we need to improve technical and managerial skills to reach on that productivity.

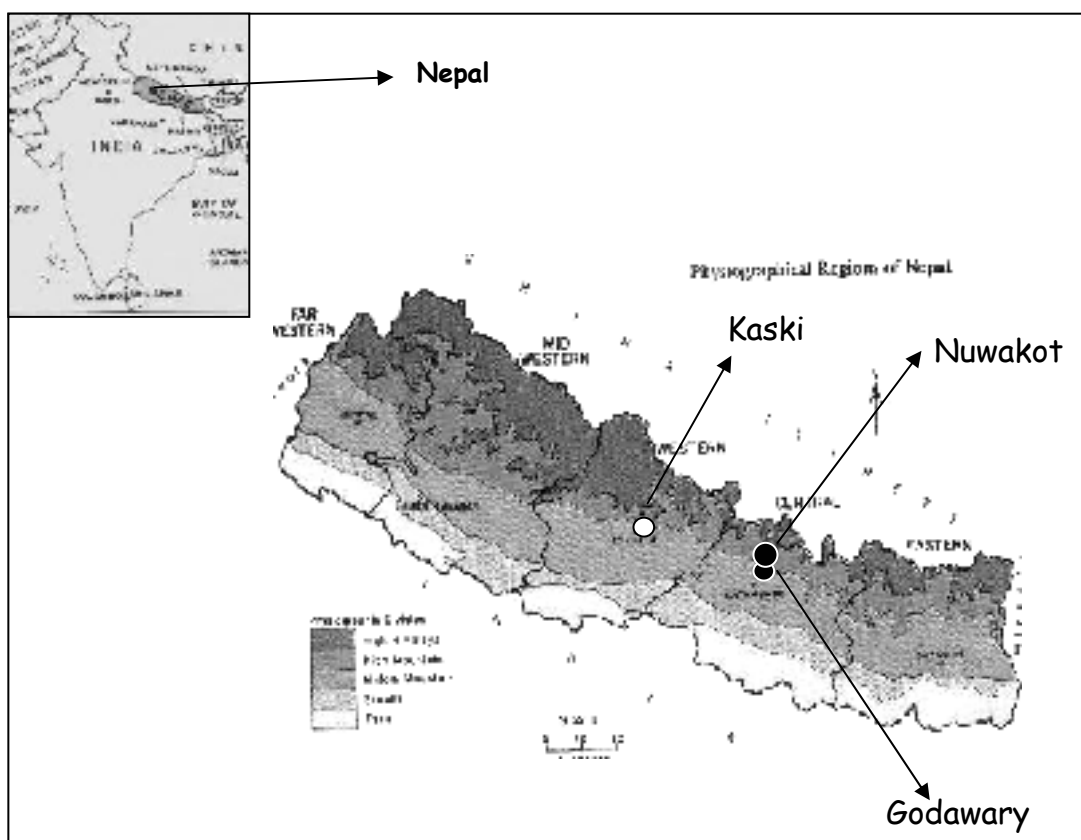


Figure 1. Map showing areas where trout farming were tested.

Table 1. Number of broods used for breeding of trout at Trishuli

SN	Year	Female	Male	Total
1	1990	20	15	35
2	1991	74	45	119
3	1992	174	98	272
4	1993	164	95	259
5	1994	33	20	53
6	1995	287	150	437
7	1996	688	225	913
8	1997	540	198	738
9	1998	353	156	509
10	1999	455	209	664
11	2000	448	205	653
12	2001	971	244	1215
13	2002	434	157	591
Total		4641	1817	6458

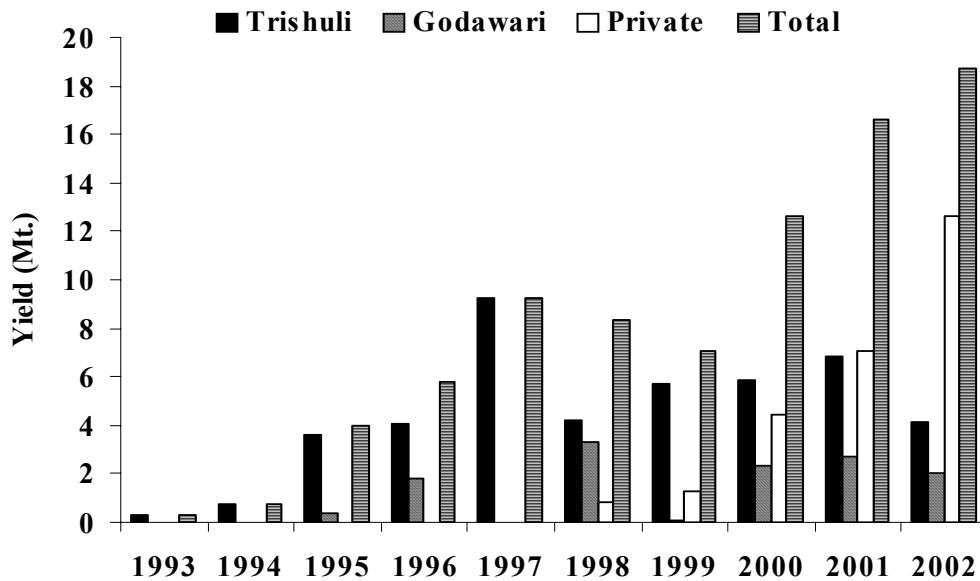


Figure 2. Yearly production of rainbow trout in Nepal.

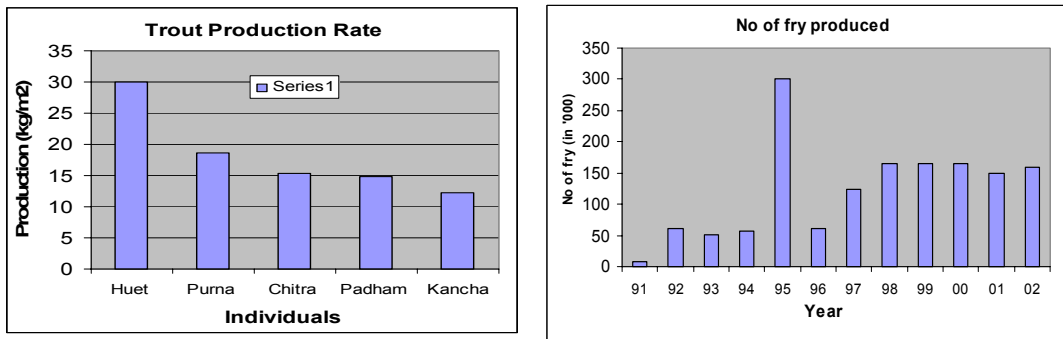


Figure 3. (A) Present level of trout productivity in private sector, (B) Number of fry produced in Nepal.

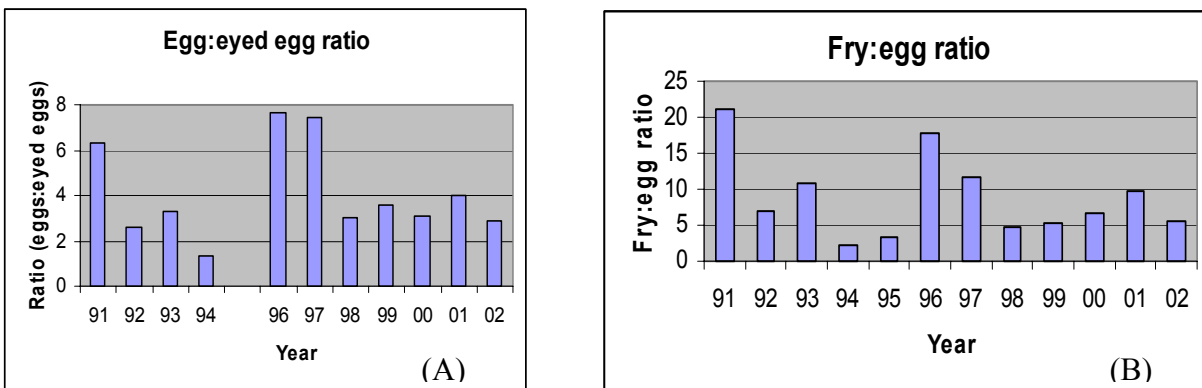


Figure 4: (A) Present level of trout egg: eyed egg production level. (B) Number of egg: fry produced in Nepal.

Godwary Breeding are performed only at Trishuli regularly and occasionally at Fish Farm. No private trout farms perform the trout breeding yet. The annual production of the fry is approximately 152 thousands in year 2002. In general it seems that fry production was increased from few thousand in 1991 to nearly 300 thousands in year 1995, then declined to nearly 150 thousands in 1997 and remain fluctuating within a short range till recently in 2002 (Figure 3B).

When fertilized eggs and number of eyed eggs were compared the result showed that the ratio was highly fluctuating from 1.7:1 to 7.67:1, while the fry: egg ratio ranged from 2:1 to 21:1. The lowest ratio was in 1994 while highest was in 1991 when 1 fry cost 21 eggs in 1991 (Figure 4). The number of trout farmers in private sector has been reached 5 (Figure 3) in Nuwakot District. Some other places where trout farmers are expected are Kaski and Kathmandu.



(A) A view of private trout farm in Nuwakot.



(B) Private trout farm



(C) Overview of a trout farm



(D) Use of terrace land for trout farming

Figure 7. A glimpse of privates trout farms in Nuwakot.

DISCUSSION

Rainbow trout was introduced in Nepal from Japan in 1989. It was only in 1996, the technology of trout farming has been adopted first time. It was anticipated that the adoption would be more rapid due to abundant cold water supply in mid hills of Nepal. However, this was not the truth. The reasons of low adoption of rainbow trout farming may be inadequate knowledge about the fish and its benefits in hills and mountains. Other constraints of low adoption are limited suitable areas for trout farming. Their might be several cold stream suitable for trout

farming, however, the lack of transportation is one of the important reasons that in all suitable cold water regions trout has not been adopted well.

The farming of trout in general requires absolute high protein containing artificial feeds. The extensive farming of trout without additional artificial feed has never been attempted in Nepal. Therefore, trout farming also requires the practices of packages of feed production technologies. The feed plants are in general costly and only a single farmer who begins the fish husbandry for livelihood cannot afford the expensive machine. On the contrary, formulated pellet diet in Nepal is only available in government farms. These are some of the vital reasons that trout farming in Nepal has not been well adopted on a large scale.

Farming technology of trout is a comprehensive task, where most of the farm activities need to be more synchronized. For this kind of task the skill level of workers is anticipated to be higher than normal. This might be one of the reasons that farmers may need much patience, training and skill to be successful with trout farming. For example the quality of brood and eggs in Trishuli are needed to improve. Similarly, quality of pellet feed also requires by which robust brood could be reared for 3-5 years interval. It is learnt that brood do not survive longer in Trishuli due to hepatoma disease. These problems directly need to be addressed in future research work.

The performance of private sector farms is satisfactory, producing about 12.3 to 18 kg/m²/year production of trout. However, the number of such farmer taking the advantage of trout farming is very limited. Therefore in future, efforts should be made for wider adoption of the technology for increasing fish production, generating income and job opportunities in hill and mountain areas of Nepal.

ACKNOWLEDGEMENT

We wish to extend our sincere thanks to many of our colleagues who worked to develop the cold water aquaculture in Nepal. Our sincere thanks to Mr. Uta Nakagawa and several other friends of Miyazaki Prefecture, Japan for providing us eyed eggs of rainbow trout for the introduction in Nepal. We also extend our sincere thanks to JICA and JOCV Nepal for conducting various field and laboratory works at Trishuli and Pokhara Fisheries Research Station.

REFERENCES

- Bardach JE, JH Ryther, WO McLaren. 1972. *Aquaculture: The farming and husbandry of freshwater and marine organisms*. John Wiley and Sons. Pp.1-867.
- Gurung TB. 2003. Fisheries and aquaculture activities in Nepal. *Aquaculture Asia*. Vol. VIII No. 1:14-19.
- Gurung TB. 2002. A glimpse of fishery and aquaculture in Nepal. Kathmandu Post. *Daily Newspaper*. Sunday 5.
- Gurung TB. 2001. A review on prospects and limitations of cage fish culture in Nepal. *Paper submitted to Hill Agriculture Research Program*, Kathmandu, Nepal.
- Huet M. 1972. Breeding and cultivation of salmonids. **In:** *Textbook of fish culture breeding and cultivation of fish*. Fishing News Book, 23 Rosemount Avenue, Surrey, England. Pp.59-110.
- Joshi PL. 1999. Growth of rainbow trout in different culture systems. **In:** *Proceedings of 3rd National workshop on livestock and fisheries research in Nepal* (SP Neopane and RC Khanal, eds). National Animal Science Research Institute. Pp.90-93.
- Martyshev FG. 1983. *Pond fisheries*. Amerind Publication, New Delhi.
- Nepal A. 2002. Economics of rainbow trout farming system in Nepal. **In:** *Cold water fisheries in the Trans-Himalayan countries* (T Petr and DB Swar, eds). *FAO Fisheries Technical Paper 431*.
- Rajbanshi KG. 2002. Zoogeographical distribution and the status of cold water fisheries of Nepal. **In:** *Cold water fisheries in the Trans-Himalayan countries* (T Petr and DB Swar, eds). *FAO Fisheries Technical Paper 431*.
- DoFD. 2001/02. *Country profile: Fisheries sector*. Directorate of Fisheries Development, Department of Agriculture, Ministry of Agriculture and Co-operatives, Kathmandu, Nepal.

Cryopreservation and its Implication for Fish Seed Production

Sadhu R Basnet, Gopal P Lamsal and Agni P Nepal

Fisheries Research Centre, Trishuli, Nowakot

ABSTRACT

The present study describes a method for cryopreservation of milt of carps, indigenous Sahar (*Tor putitora*) and rainbow trout (*Onchorynchus mykiss*) for a period of 2-4 days. For collection of milt healthy and robust male with best characteristic were selected, wiped with clean and soft cloth. The milt was collected by stripping the belly. The milt was diluted in the cold extender in a ratio of 1:4 (milt: extender) then transferred into 0.5 ml straws (French straw) in a beaker and kept into refrigerator. The preserved cryomilt was thawed after 2nd, 3rd and 4th day in warm water bath at a different temperature ranging from 15±1 °C to 38±1°C. The sperm motility ranged 35-60 %. There was no significant ($p<0.05$) difference among the media and sperm motility till 4 days. However, among the media "A" and "B" showed slightly better result than media "C" in the experiment. The main objective of cryopreservation is to develop the storage technique that could help the fish breeding by which selective breeding can be under taken for improvement of the indigenous stock.

Key words: Cryopreservation, fish seed production

INTRODUCTION

Cryopreservation is a storage technique of fish sperms, egg and embryos with practically no time limits in the way of liquid Nitrogen gas. Preservation of fish gametes has been tried with this technique. Cryopreservation of sperm is well-established procedure in animal husbandry of Nepal (Shrestha 1999). Now cryopreserved sperms are used successfully for inseminating of cattle. Efforts have also made to apply this technology for preservation of fish sperms, egg and embryos. Sperms, eggs and embryos can be preserved, but the preservation of egg and embryo are difficult because of unavailability of cryoprotectant to be absorbed sufficiently in their cells because of their large size in comparison to spermatozoa. The cryopreservation of spermatozoa in fish is successful in many species. These species are *Oncorhynchus mykiss*, salmon, *Labeo rohita*, *Catla catla*, *Cirrhinus mirgala*, *Cyprinus carpio*.

Cryopreservation can help selective breeding program for improvement of the indigenous stock, which helps to breed their indigenous species with special strains of superior stock. The technique of cryopreservation of gametes plays an important role in genetic variability caused by environmental disturbances. It can help in production of monosex stock. Moreover problem with non-coincidence maturation of female can be over come, if sperms are hold in storage. Cryopreseravation can make the fish husbandry more economical as it may reduce the cost of brood rearing and management for breeding.

METHODS AND MATERIALS

This study was performed at Trishuli Fisheries Research Center, Nuwakot for two consecutive years (2002-2003).

Milt collection

Healthy male of common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), grass carp (*Ctenophryngodon idella*), trout (*O. mykiss*), and sahar (*Tor putitora*) with best characteristic traits were selected in different months of the year. The genital region of all males were cleaned, washed and dried with the help of soft clean cloth. Milt was

collected from all males using the stripping method. The catheter may be used which is better alternative than stripping of unanaesthetized fish. The collection of milt was checked and recorded for color, volume, density, pH and motility. Care was taken not to mix with urine and faecal matter. Smear of the sample was examined under microscope to observe the abnormalities in sperms if any.

Sperm motility

This study was conducted in different months of the year in those seasons when a particular fish species begin to show the maturation. The general characteristic of milt of different fish species are given in Table 1. Spermatozoa are found immotile in the testis as well as seminal fluid. These immotile fish spermatozoa become highly activate and show vigorous movement when a droplet of water is added. In this study the activation of spermatozoa was evaluated and graded as shown in Table 2.

Table 1. General characteristics of milt of different fish species (2002-2003)

Species	Volume, ml	Colors	pH	Motility, %	Ratio (M:D)	Date of experiment
Labeo rohita	1.0	milky	7.0	80-90	1:4	15 Jun 02 and 03
Cyprinus carpio	1.5	„	7.0	70-80	1:4	15 May 02 and 03
Ctenophryngodon idella	1.5	white	7.0	70-90	1:4	15 Jun 02 and 03
O. mykiss	2	„	7.2	80-90	1:4	17 Jan 02 and 03
Tor putitora	1.2	„	7.1	70-90	1:4	15 Jun 02 and 03

Table 2. Symbol and grade of the milt quality according to the motility of fish sperm

SN	Motility, %	Symbol
1	0-10	+
2	11-30	++
3	31-50	+++
4	51-70	++++
5	71-90	+++++
6	91-100	++++++

Preparation of extender solution

Main constituents of the media for Cryopreservation were sodium chloride, sodium bicarbonate, potassium chloride, calcium chloride, magnesium sulphate, sodium phosphate and double distilled water in different concentrations. Glycerine and/or dimethyl sulphoxide (DMSO) act as cryoprotectants. The basic common extender solution was prepared at the given ratio (Table 3). Cryoprotectant and extender solution were taken into a fixed ratio, generally one part of cryoprotectant and nine part of extender solution is called a diluent. The milt was mixed into the diluents in 1:4 ratios and stored in the refrigerator at 4-5°C. The semen was pooled, diluted in the ice cold extender in a ratio 1:3 (semen:extender) transferred into 0.5 ml straws and frozen in an insulated box in the vapor of liquid nitrogen within 5 min. Three kinds of media were prepared for these experiments. The following chemical constituents were weighted accurately and dissolved in double distilled water (Table 3). The desirable pH of the extender solution was maintained at 7.2 to 7.3.

Table 3. Constituents for the preparation of media

Chemical	Media-A, mg	Media-B, mg	Media-C, mg
CaCl ₂	400	750	750
KCl ₂	23	23	20
NaHCO ₃	38	38	20
NaH ₂ PO ₄	41	41	-
MgSO ₄	23	23	-

Selection of cryoprotectant

Cryoprotectant plays a vital role to penetrate in spermatozoa cell and may help to tolerate freezing temperature. Dimethyl sulfoxide and glycerol was selected for the experiment.

Preparation of diluents

Cryoprotectant and extender solution are mixed in a fixed ratio, generally one part of cryoprotectant and nine part of extender solution is called diluents. Glycerol was used for cryoprotectant where, one part of glycerol and nine part of extender solution was mixed properly. The cryoprotectant solution was not mixed directly in the milt sample.

Table 4. The ratio of extender and cryoprotectant in different diluents

Constituent	A	B	C
Glycerol	10 ml	10 ml	-
DMSO	5 ml	8 ml	15 ml
Extender	90 ml	90 ml	65 ml

Thawing

In the present protocol, the cryomilt samples were thawed in warm water bath at a different temperature ranging from $15\pm 1^\circ\text{C}$ to $38\pm 1^\circ\text{C}$ with time variation as given below.

Water bath	Time	N
$15\pm 1^\circ\text{C}$	20 sec	3
$15\pm 1^\circ\text{C}$	30 sec	4
$15\pm 1^\circ\text{C}$	60 sec	3
$25\pm 1^\circ\text{C}$	30 sec	4
$25\pm 1^\circ\text{C}$	45 sec	3
$38\pm 1^\circ\text{C}$	7-8 sec	3

General procedure of cryopreservation

Milt from *Labeo rohita* (rohu), *Cyprinus carpio* (common carp), *Ctenophryngodon idella* (grass carp), *Tor putitora* (Sahar) and *O. mykiss* (rainbow trout) individuals were taken in different amounts. The equal volume of diluted milt was kept in beaker separately. The milt was diluted in the cold extender in a ratio of 1:4 (Milt: extender) transferred in to 0.5 ml straws (French straw). Both ends of straws were sealed by the sealing power and cotton. Sealed milt straws put in to the refrigerator. The frozen milt was checked daily at the same time according to thawing procedure.

RESULTS AND DISCUSSION**Media**

The following chemical constituents were weighted accurately and dissolved in 100 ml of double distilled water. Three groups of media were named media A, B and C and checked for pH color and temperature. After a month, fungus developed had been appearing in beaker. No significant different among desirable P^{H} and temperature of media ranged between 7.2-7.3 and between $4-5^\circ\text{C}$, respectively.

Thawing

Thawing is reverse event of freezing. Thawing was done in water bath at different temperature and time factor (Table 5). It is done in different temperature with different fish species.

Table 5. Thawing procedure of the preserved spermatozoa

SN	Thawing temp, $^\circ\text{C}$	Time, sec	Milt temperature, $^\circ\text{C}$	Frequency
1	15 ± 1	20	6-8	3
2	15 ± 1	30	10-11	4
3	15 ± 1	60	12-15	3
4	25 ± 1	30	20-23	4
5	25 ± 1	45	24-26	3
6	38 ± 1	7-8	25-26	3

Milt temperature (inside the straw).

Sperm motility

The sperm mobility was obtained 35-60 % in beaker and straw. Good sperm motility was slightly appeared in media "A" and "B" than media "C" but, there was no significant ($P<0.05$) difference among the species. The color, volume, pH, and motility of stored milt have been given in Table 6.

Table 6. Physico-chemical properties of milt

Species	Volume, ml	Colors	pH	Motility, % 2 nd day	Motility, % 3 rd day	Motility, % 4 th day
2002						
L. rohita	0.8	milky	7.0	>50	>45	>45
C. carpio	0.6	milky	7.2	>45	>40	>40
C. idella	1.0	white	7.3	>40	>35	>35
O. mykiss	1.5	white	7.2	>60	>55	>55
T. putitora	1.0	white	7.1	>55	>55	>55
2003						
L. rohita	1.0	milky	7.3	>45	>40	>40
C. carpio	1.0	milky	7.3	>50	>45	>45
C. idella	1.0	Milky white	7.2	>40	>30	>30
O. mykiss	2.0	Milky white	7.2	>60	>55	>55
T. putitora	1.4	Milky white	7.1	>50	>50	>50

In this experiment the cryopreservation experiment showed that milt of trout, sahar, common carp, and rohu can be preserved for 2-4 days. Previous studies have shown that the fish milt can be stored for several months using the most advance complex techniques. However, in the present study we only start the cryopreservation procedure for fish milt preservation.

REFERENCES

- Kumar K. 1989. Studies on cryogenic preservation of carp spermatozoa. **In:** *Fish genetic in India* (P Das and AG Jhingran, eds). Today and Tomorrow's Printers and Publisher New Dehi. Pp.199-206.
- Legendre PM and R Bill. 1980. Cryopreservation of rainbow trout sperm by deep-freezing. *Repord. Mutr. Develop* 6:1859-1868.
- Shrestha BM. 1999. An introduction to artifical insemination. Printer Shrestha Computer Center, Putali sadak. *Third country training program on fresh water aquaculture*. 11 June-11 Aug 2000. National Inland Fisheries Institute Department of Fisheries. Pp.149-156.

Study on Growth Performance and Quality of Meat in Relation to Nutrient Level of Rainbow Trout Fed on Different Protein Level Diets

Agni P Nepal¹, Gopal P Lamsal², Neeta Pradhan¹ and Santa K Shrestha²

¹Fisheries Research Division, Godawari, GPO Box 13342, Kathmandu, <agninepal@yahoo.com>

² Fisheries Research Centre, Trishuli, Bidur-9, Nuwakot, Nepal

ABSTRACT

A feeding trial was conducted to observe growth performance and the meat quality of rainbow trout using fry of initial average body weight of 3.9 ± 0.5 to 4.3 ± 0.6 g in first experiment and 9.4 ± 0.6 and 9.6 ± 0.5 g in second experiment. Fish were fed with 5 different types of diet containing 30%, 35%, 40%, 45% crude protein (CP) and control diet as existing feed (35% CP content) practiced in the Centre. All treatments were supplied with 10% soybean oil as the calorie source. The feed efficiency remained 44.8% to 53.5% in first experiment and 31.5% to 50.6% in second experiment showing highest efficiency, 53.5% in 30% CP containing diet in first experiment and 50.6% in 45% CP containing diet in second experiment. The highest specific growth rate was observed (2.2%/day) in fish fed with 45% CP containing diet in first experiment and lowest (1.3%) in fish fed with control diet and 30% CP containing diet in second experiment. Survival rate were >87.7% and >91.3% in all treatments in first and second experiments, respectively. The feed conversion ratio (FCR) remained 1.9 to 2.2 in first experiments and 2.0 to 3.2 in second experiment. The average body weight gain was the highest in 45% CP containing diet, but there was no significant difference ($p > 0.05$) on the growth of fish among the treatments in both experiments. Highest protein level (22.8%) in meat was found in treatment B (35% CP) in second experiment. But there was no significant difference ($p > 0.05$) in protein level of fish meat among treatments in both experiments.

Key words: Growth performance, nutrient levels, quality meat, rainbow trout

INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) is high oxygen demanding cold water fish. It is a carnivorous fish but can also be grown to all stages from fingerlings to adults, feeding upon quality artificial feed. Quality diet with nutritionally sound composition is essential for the growth and optimal health of this fish. Shrimp meal, fish meal and soybean meals are the main dietary components traditionally used in formulated fish diets as the main source of protein. The high cost of shrimp meal and fish meal, increases the cost of production compared to other cultured fish species. Many researchers have tried to replace the expensive fish meal and shrimp-meal component of fish diets with other less expensive plant proteins. Soybean meal as a protein supplement has been used widely in fish feed (Abel et al 1984) due to its nutritional value, low cost, and market availability. However, most feeding studies showed that substitution of fish meal and shrimp meal with soybean meal in fish diets result in reduced growth and feed performances (Pongmaneerat et al 1993). The degree of success for the replacement of fish meal and shrimp meal depend on the species of fish, the size of fish, and the types of ingredients used (Pongmaneerat and Watanabe 1993).

The main limitation in the use of soybean meal is attributed to the low level and of smaller availability energy (Abel et al 1984). Shrimp-meal and fish meal cannot be fully replaced by plant origin protein for trout feed, but it was pointed out that soybean meal could be included up to 50% in the high-energy diet (the so called soft-dry pellet) for rainbow trout (Watanabe et al 1991). The use of soybean meal as a replacement for fish meal has been practiced for many years (Watanabe and Pongmaneerat 1993).

Shrimp is more expensive than fish meal, and the shortage of quality fish meal has made it necessary to increase the use of alternative protein source in practical feed (Pongmaneerat et al 1993). Because of unavailability of fish meal, shrimp is the only one ingredient of animal protein source in trout diet, practicing in Nepal. The main objective of this study was to observe growth performance and the meat quality in relation to nutrient level of meat of rainbow trout fed upon different protein content diets.

MATERIALS AND METHODS

Two experiments were conducted in plastic tanks in cold water hatchery at Fisheries Research Centre (FRC), Trishuli. The duration was 60 days in each experiment. The first experiments carried out from 5 June 2000 to 5 August 2000 and second from 15 May 2001 to 15 July 2001. The difference between two experiments was only in the stocking number of fish. There were five treatments in each experiment with three replicates in each treatment.

Rainbow trout fry of average weight 3.9 ± 0.5 g in first experiment and 9.4 ± 0.6 g in second experiment were used for the study. They were stocked in plastic tank of 0.063 m^3 ($0.575 \times 0.365 \times 0.3$ -m) size. Nested plot design was used and the stocking density was 100 fish/tank in first and 50 fish/tank in second experiment. The stocking number was varied due to the size of fish in different periods. The fish were acclimated in aquaria for one week feeding with regular diet. The dead fish were replaced with same sized fish until 7 days after stocking. At the end of acclimation period, the fish were starved for 24 hrs and weighed individually, after which they were fed with the experimental diets. Trishuli River was the source of water and the flow rate of water was maintained 5 liter/minute in each tank. Water temperature and dissolved oxygen were recorded daily. The tanks were cleaned daily before feeding to remove fecal and unnecessary matters like silt as well as other deposited matter at the bottom.

Experimental diets

Five experimental diets including the control were prepared with shrimp meal, soybean meal, wheat flour, rice bran, oil cake, mineral premix and vitamin premix (Table 1). Four experimental diets, A, B, C, and D were formulated with 30%, 35%, 40% and 45% crude protein (CP) containing feed, respectively and control diet with 35% soybean meal contained, which is used as regular normal diet. The diets A, B, C, and D were designed to contain 18%, 32%, 42% and 48% soybean meal respectively, by replacing the corresponding level of shrimp meal to examine the effect of dietary soybean meal and feed performance in rainbow trout. In total composition 1% mineral and 1% vitamins are added to avoid the deficiency of minerals and vitamins. To balance between calories and protein, 10% soybean oil was supplied as the calorie source, because the excess protein will be wasted as stored fat or used for energy if the level of calorie is low. The fish were fed at the rate of 5% of their body weight four times a day.

Table 1. Composition (%) of experimental diets

Treatment	CP	Shrimp meal	Soybean meal	Wheat flour	Rice bran	Oil cake	Mineral premix	Vitamin premix
A	30	20	18	24	29	5	2	2
B	35	20	32	20	15	9	2	2
C	40	25	42	10	10	9	2	2
D	45	35	48	3	8	2	2	2
Control	35	20	35	22	12	9	2	2

Mineral premix (g/100 kg diet): Calcium lactate: 32.70; Calcium Dihydrozon phosphate 13.58; Magnesium Sulphate 13.70; Sodium Chloride: 4.35; Sodium Diphosphate Dibasic: 8.72; Potassium phosphate Monobasic: 23.98; Iron III Citrate unhydrate: 2.97. Vitamin premix (g/100 kg diet): Vitamin A: 220000 IU; Vitamin D3: 50000 IU; Vitamin E: 4.0; Vitamin K3: 0.4; Vitamin Biotin: 0.06; Folic Acid: 0.15; Colin Chloride: 80.0; Vitamin B: 0.6; Vitamin B6: 0.4; Vitamin B12: 0.0003; Niacin: 1.0; Pantothenic Acid: 2.8.

Table 2. Nutrient content (%) of test diets

Treatment	Crude protein		Crude fat		Crude ash		Moisture	
	1 st exp	2 nd exp	1 st exp	2 nd exp	1 st exp	2 nd exp	1 st exp	2 nd exp
A	31.6	31.0	7.5	4.0	12.1	13.6	6.0	5.8
B	37.3	36.4	5.4	4.6	12.1	14.1	5.8	6.0
C	43.6	40.7	4.8	4.4	13.4	15.0	5.2	6.3
D	48.6	47.2	3.6	3.5	15.2	16.4	7.2	5.4
Control	37.5	37.1	4.7	6.3	11.7	13.3	6.5	6.0

Proximate analysis of feed for crude protein (Micro- Kjeldahal methd), crude fat (Soxhlet extraction using diethyl ether at 40-60°C), crude ash (burning in a muffle furnace at 600°C) and moisture (oven drying at 105°C) was performed before starting the experiment (Table 2).

Growth up was measured by sampling 10% fish from each replication and also determined. The feed required feed efficiency and health condition were determined every 20 days intervals. Feeding was completely stopped one day before growth check up and harvesting. The data were used to calculate specific growth rate, feed conversion ratio (FCR), feed efficiency (FE), survival rate and specific growth rate by the following equations;

FE, %:	Increased wt /given feed *100
FCR:	Given feed / Increased wt
Recovery, %:	(No. of fish harvested /No. of initial fish stocked) *100
SGR, %/day:	[Ln (harvested wt)] – [Ln (initial wt)]/raising days *100

RESULTS AND DISCUSSION

The feed efficiency ranged from 44.8% to 53.5% in first experiment and 31.5% to 50.6% in second experiment showing the highest efficiency, 53.5% in 30% CP containing diet in first experiment (Table 3) and 50.6% in 45% CP containing diet in second experiment (Table 4). According to Tasiro et al (1974) feed efficiency should be >60% for good result in trout culture, but this result has shown <60% which means the feed efficiency need to be improved.

Table 3. Average weight, feed efficiency (FE), feed conversion ratio (FCR), recovery rate and specific growth rate (SGR) of young rainbow trout (first experiment, 5 June to 5 August 2000)

Detail	Treatments				
	A (30%)	B (35%)	C (40%)	D (45%)	Control
Fry stocked (100/repl), n	300	300	300	300	300
Number harvested, n	296	263	277	283	295
Survival rate, %	98.7	87.7	92.3	94.3	98.3
Initial individual wt, g $\pm$ SD	4.1 $\pm$ 0.3	4.3 $\pm$ 0.6	4.0 $\pm$ 0.5	4.1 $\pm$ 0.5	3.9 $\pm$ 0.5
Final individual wt, g $\pm$ SD	13.8 $\pm$ 2.5	13.4 $\pm$ 2.4	12.9 $\pm$ 2.6	14.2 $\pm$ 2.3	12.7 $\pm$ 2.0
Total weight gained, g	2871.2	2393.3	2465.3	2858.3	2596.0
Total feed consumed, g	5371.0	5344.0	5039.0	5416.0	5037.0
Feed efficiency, %	53.5	44.8	48.9	52.8	51.5
FCR	1.9	2.2	2.0	1.9	1.9
SGR, %/day	2.0	2.1	2.1	2.2	2.0

Table 4. Average weight, feed efficiency (FE), feed conversion ratio (FCR), recovery and specific growth rate (SGR) of young rainbow trout (second experiment, 15 May to 15 July 2001)

Detail	Treatments				
	A (30%)	B (35%)	C (40%)	D (45%)	Control
Fry stocked (100/repl), n	150	150	150	150	150
Number harvested, n	142	138	139	146	137
Survival rate, %	94.7	92.0	92.7	97.3	91.3
Initial individual wt, g $\pm$ SD	9.5 $\pm$ 0.6	9.5 $\pm$ 0.6	9.4 $\pm$ 0.6	9.6 $\pm$ 0.5	9.4 $\pm$ 0.6
Final individual wt, g $\pm$ SD	20.7 $\pm$ 3.3	19.3 $\pm$ 3.0	20.0 $\pm$ 3.7	26.6 $\pm$ 2.5	19.0 $\pm$ 3.2
Total weight gained, g	1590.4	1352.4	1473.4	2482.0	1315.2
Total feed consumed, g	3994.0	4128.0	4186.0	4901.0	4177.0
Feed efficiency, %	39.8	32.8	35.2	50.6	31.5
FCR	2.5	3.0	2.8	2.0	3.2
SGR, %/day	1.3	1.4	1.5	1.7	1.3

Specific growth rate was highest (2.2%/day) in fish fed with diet D contained 45% CP followed by 35% (2.1%/day) and 40% (2.1%/day) CP containing diet (Table 3). Though the specific growth tare of fish fed with 45% CP containing feed was better, but there was no significant different ($p>0.05$) in the growth of fish among the treatments in both experiments.

Survival rate remained >87.7% in first experiment (Table 3) and >91% in second experiment (Table 4). FCR was lowest (1.9) in fish fed with diet A, D and control followed by fish fed with diet C (2.0) and diet B (2.2) in

first experiments (Table 3). FCR was lowest in fish fed with diet D (2.0) followed by fish fed with diet A (2.5), C (2.8), B (3.0), and control diet (3.2) in second experiment (Table 4). After harvesting, proximate analysis (crude protein, crude fat, crude ash and moisture) of fish was done to observe the differences in quality of fish-meat, fed with different diets of different protein contents. The results of carcass analysis of trout fed with different diets in both experiments are presented in Table 5.

Table 5. Proximate analysis of experimented fish fed with different protein-level contained diets

Feed type	Crude protein, %		Crude fat, %		Crude ash, %		Moisture, %	
	1 st exp fish	2 nd exp fish	1 st exp fish	2 nd exp fish	1 st exp fish	2 nd exp fish	1 st exp fish	2 nd exp fish
A (30% CP)	20.0	20.7	5.1	4.7	1.1	1.3	86.7	84.5
B (35% CP)	19.5	22.8	4.2	3.2	1.2	1.3	88.5	84.3
C (40% CP)	20.8	21.1	5.1	4.6	1.3	1.2	86.5	83.9
D (45% CP)	22.4	21.6	5.9	4.9	1.3	1.2	87.3	86.6
Control (35% CP)	20.6	22.2	4.5	3.2	1.2	1.2	87.0	84.0

Highest protein level (22.4%) was found in treatment D in the first experiment and 22.8% in B in the second experiment (Table 5). But there was no significant difference ($p>0.05$) in nutrient level of meat among treatments (in respective nutrients) in both experiments. The water temperature was recorded 15.4°C to 19.3°C during June–August period and 16.8°C to 20.0°C during May–July period of experiment. Dissolved oxygen (DO) ranged from 7.0 to 7.3 mg/l. in outlet and average pH was 7.0 to 7.8 during the periods of both experiments.

Slow growth of fish during summer may be attributed to the highly turbid floodwater. Average visibility of the water used for experiment ranged from 3.9 to 4.6 cm during experiment (FRS 2001). This type of turbid water causes the adverse effect in the growth of rainbow trout, but the fish survival rates were >87% (Table 3 and 4). Prevailing feed efficiency of rainbow trout in Japan ranges 60-80% (Tasiro et al 1974), whereas the feed efficiency in these experiments remained <54% (Table 3 and 4). Generally feed efficiency varies with the size of rainbow trout. Bigger the fish size lower the rate of efficiencies and vice versa (Joshi 1999).

Prices of tested diets were calculated to find out the cost of feed. Diet A (30% CP) was the cheapest feed, which costs NRs49.21/kg and 6.7% lower than that of the control diet followed by B (35% CP), which costs NRs51.55/kg and was 1.9% lower than that of the control diet (Table 6).

Table 6. Feed cost of different protein level diets fed to rainbow trout in experiment, 2000/2001

Feed type	Feed price, NRs/kg	Remarks
A (30% CP)	49.21	6.7% lower than control diet
B (35% CP)	51.55	1.9% lower than control diet
C (40% CP)	58.45	11.3% higher than control diet
D (45% CP)	70.69	34.6% higher than control diet
Control (35% CP)	52.52	

Results of the study showed that the growth performance of the rainbow trout was higher in 45% CP containing diets but the price of feed increased by 34.6% in comparison with the control diet and 37.1% in comparison with diet 'B' (Table 6). The feed efficiency, specific growth rate and the level of protein in meat quality were not significantly different ($P>0.05$) (Table 3, 4 and 5). In this study diet 'A' was the cheapest feed but the growth performance should be confirmed. Thus, the regular feed used at research center and 35% CP containing test diet can be selected as the cost effective feeds for trout production. However, it is not a final recommendation, further studies should be conducted to confirm these results and study should be done on different size of fish from fry to adult to know the growth performance and their quality of meat in relation to the nutrients and other parameters.

REFERENCES

- Abel HJ, K Becker, CHR Meske and W Friedrich. 1984. Possibilities of using heat-treated full fat soybean in carp feeding. *Aquaculture* 42:97-108.
- FRS. 2001. *Annual technical report, 2000/01*. Nepal Agricultural Research Council, Fisheries Research Station, Trishuli.
- Joshi PL. 1999. Growth of rainbow trout in different culture systems. **In:** *Proceedings of Third National Workshop on Livestock and Fisheries Research in Nepal*. Nepal Agricultural Research Council, National Animal Science Research Institute, Khumaltar, Nepal. Pp.90-93.

- Pongmaneerat J, T Watanabe and T Takcuchi. 1993. Use of different protein meals as partial or total substitution for fish meal in carp diets. *Nippon Suisan Gakkaishi* 59(7):1249-1257.
- Tasiro F, W Tachikawa, T Kamata, E Tamur, H Aoe and Y Yabe. 1974. Rainbow trout. *Fish farming lecture series*, vol. 10. Midor Shobow Co. Ltd. Japan.
- Watanabe T and J Pongmaneerat. 1993. Potential of soybean meal as a protein source in extruded pellets for rainbow trout. *Nippon Suisan Gakkaishi* 59(8):1415-1423.
- Watanabe T, H Sakamoto, M Abiru and J Yamashita. 1991. Development of a new type of dry pellet for yellow tail. *Nippon Suisan Gakkaishi* 57:891-897.

Qualitative Analysis of Post Harvested Fish

Kusumabati Bajracharya and Nand K Roy

Fisheries Research Division, Godawari PO Box 13342, Kathmandu

ABSTRACT

A study was carried out to determine the quality of cultured fish species namely rohu (*Labeo rohita*), naini (*Cirrhina mrigala*) and silver carp (*Hypophthalmichthys molitrix*) which were transported from Fisheries Research Centre, Pokhara to Fisheries Research Division, Godawari in frozen and chilled (with ice) conditions as well as brought from Kathmandu market to Fisheries Research Division, Godawari. Fishes from FRC Pokhara were found good quality compared to Kathmandu market fishes in terms of bacterial load and by observing organoleptic test (appearance, colour of gills, texture of flesh and smell). But crude fat and crude protein level of fish species from Kathmandu market and FRC, Pokhara were not significantly different ($P>0.05$). The bacterial load of FRC's fish was found lower and ranged from 103×10^2 - 36×10^3 CFU/g in comparison to the market fish, which was, found 132×10^4 - 265×10^4 CFU/g in chilled condition in rohu, naini and silver carp. But the total number of bacteria was increased after transportation of fresh fish in chilled condition. There were no significant differences in the content of crude fat and crude protein in sun dried fish and smoked fish ($P>0.05$) but smoked fish was better than sun dried fish due to the presence of low number of bacteria. The bacterial numbers were found higher in sun-dried fish than in the smoked fish and ranged from 123×10^3 - 43×10^4 CFU/g than in the smoked fish and ranged from 99×10^2 - 84×10^3 CFU/g in the sun dried fish. The results showed that smoked fish can keep better quality than sun dried fish due to presence of low number of bacteria.

Key words: Fish, post harvest, qualitative analysis

INTRODUCTION

Fresh fish is an extremely perishable foodstuff and spoil very fast if adequate precautions are not taken while fishing, storage on fishing craft, icing, transportation and marketing (Govindan 1985). Spoilage of fish begins as soon as the fish dies due to a series of complicated changes brought in dead fish mainly by enzymes and bacteria (Clucas 1981). Three types of deteriorative changes have been observed in the landed fish. These changes are bacterial, enzymatic and oxidative. Bacterial spoilage proceeds quickly but autolytic and chemical changes are comparatively slow (Yadav 2002). Microorganisms are the most important agents of deterioration in raw, wet fish since they give rise to particularly undesirable flavours associated with spoilage. When the fish dies, bacteria present on the surface and in the guts multiply rapidly and invade the flesh, which provides an ideal medium for growth and multiplication. The bacteria can breakdown the muscle itself will also feed on the smaller units produced by autolytic action. The increase in number of bacteria results in a heavy slime on the skin gills and unpleasant ammoniacal, sour odour, eventually they cause the flesh to soften. In addition the gut wall may burst (Clucas 1981). During spoilage many of the nutritionally important compounds are destroyed and some toxic substances accumulate. Spoiled fish carries bacteria or their toxins or both. The nature of food poisoning depends on the species of the pathogens and quality of toxin. Some important food poisoning bacteria are *Salmonella sp*, *Shigella sp*, *Staphylococcus sp*, *Clostridium botulinum* etc (Yadav 1997).

Enzymes bring the stiffening of the muscle-taking place shortly after death (known as rigor mortis). The enzymes of the flesh also cause a complicated series of breakdown of other tissue components, a process known as autolysis. This breakdown of tissues affects the flavour, texture and sometimes the appearance of the fish. In addition, oxygen can attack on the chemically unsaturated fatty substances (lipids) contained in the flesh and other tissues and give rise to rancid flavor (rancidity) (Clucas 1981). Freshness is usually judged in the trade entirely by appearance, odour and texture of the raw fish. Since assessment depends upon the senses, these

factors are known as sensory or organoleptic (Biswas 1996). It is possible to determine the degree of freshness to a very satisfactory level based on sensory characteristics (Balachandran 2001).

Physically damaged fishes enhance the microbial contamination. The fish are gutted (eviscerated) and bled at the same time in one step operation during initial handling. Removal of fish's viscera eliminates the potential contamination of the edible flesh with various hydrolytic (digestive) enzymes found in these organs. It also prevents the inoculation of the flesh by the large microbial population found in the intestinal track (Regenstein 1997). Spoilage can be minimized or stopped by preservation and processing. Processing methods usually change the texture, taste, physical appearance etc of the fish so that deterioration is minimized or halted but the fish will change characteristics associated with the process used (Clucas 1981). The availability of better quality fish and fish products will help fish producer and traders to gain their income as well as consumers for their health. The objective of this study was to check quality of fish that collected from FRC, Pokhara and local market of Kathmandu after harvesting, processing and transporting for awareness of public in health. The purpose of this study was to measure the numbers or to indicate the presence or absence of organisms in a fixed quantity of product.

MATERIALS AND METHODS

Fish sample collection

Different fish species namely rohu (wt 413 g), naini (wt 420g) and silver carp (wt 480 g) each 20 samples were randomly collected in fresh condition and stored in defreeze and freeze for over night in 2000/01. These fish species were transported from Fisheries Research Center, Pokhara to Kathmandu/ Godawari by bus in chilled condition with ice. After bringing to Godawari, these fishes were examined for smell, gill color, eye color and texture of flesh. Similarly, rohu (wt 413 g), naini (wt 420g) and silver carp (wt 480 g) each 20 samples were randomly collected from Kathmandu market (Ranmukteshwar, Kalimati, Ason) to Godawari in chilled condition on ice. After bringing to Godawari, these fishes were examined for smell, gill colour, eye color and texture of flesh.

Bacteriological examination of fish

Total number of bacteria present in the fish flesh of both the samples collected from FRC, Pokhara and Kathmandu market were studied using pour plate method of serial dilution (Benson 1979). Bacterial loads in the fish were studied in fresh and storage condition (Frozen, ice, dried in sun and smoke). For the isolation and identification of *Salmonella*/*Shigella*, the sample was inoculated into Selenite F broth for enrichment and incubated at 37 °C for 24 hrs. A loopful of this enriched inoculum was streaked onto a S/S (*Salmonella*/*Shigella*) agar and incubated at 37°C for 24-48 hrs (Krieg et al 1986 and Sneath et al 1986) and results observed.

Proximate analysis of fish

Moisture, crude protein and crude fat of both the fish samples procured from FRC, Pokhara and Kathmandu market were analyzed by the following measurement methods (Watanabe 1988).

- Moisture measurement of fish flesh was done by vacuum drying oven method at temperature 110-135°C.
- Crude protein measurement of fish flesh was done by Semimicro-Kjeldahl method.
- Crude fat measurement was done by the Soxhlet's ether extraction method with the help of Diethyl ether.

RESULTS AND DISCUSSION

Organoleptic or sensory test

This test includes assessment of quality by appearance, colour of gills, firmness and texture of flesh, smell etc. Fish procured from FRC, Pokhara were found in good condition compared to market fish, which may be stored for longer period (Table 1). Fresh fish are bright, convex (bulging) eyes with a dark pupil but as spoilage progresses the eyes become duller and greyer and pass from being flat to concave (sunken). Fresh fish flesh is translucent; stale flesh tends to be opaque (Connell 1995).

Proximate analysis of fish

There were no significant differences ($P>0.05$) in crude protein level and crude fat level in sun dried fish and smoked fish (Table 4). Crude protein and crude fat were not significantly different ($P>0.05$) in fresh fish and transported fish in different conditions such as frozen and chilled in ice (Table 2). Similarly Crude protein and

crude fat were not significantly different ($P>0.05$) in chilled fish procured from FRC, Pokhara and brought from Katmandu market (Table 2, 3).

Table 1. Organoleptic tests of fishes obtained from FRC, Pokhara and Kathmandu market

Fish spp	Location	Organoleptic test					
		Eye	Gill	Odour	Surface slime	Scale	Flesh
Rohu	FRC, Pokhara	Glistening and bulging ie Convex and translucent cornea	Bright red, mucus and translucent	Fresh or fishy smell	Transparent or water white	Bright shining and no bleaching	Firmness or stiff ie faster the onset of flesh when pressure applied on the surface of the body and removed
Silver Naini	"	"	"	"	"	"	"
Rohu	KTM market	Slightly concave and opaque cornea	Faint red, mucus, opaque and thick	Musty (smelling or tasting old)	Milky	Dull, and slightly shrinkage	Little bit slower the onset of flesh when pressure applied on the surface of the body and removed
Silver Naini	"	"	"	"	"	"	"

Bacterial level analysis

The bacterial load of FRC, Pokhara fish was found lower and ranged from 103×10^2 - 36×10^3 CFU/g in comparison to the market fish, which was, found 132×10^4 - 265×10^4 CFU/g in chilled condition in rohu, naini and silver carp (Table 2, 3). But the total number of bacteria was increased after transportation of fresh fish in both chilled and frozen conditions. Bacterial load was greater in frozen condition ranged that from 145×10^2 - 42×10^3 CFU/g, than that in chilled condition that ranged from 103×10^2 - 36×10^3 CFU/g (Table 2). This might be due to contamination through utensils, exposed in air, water used for washing and ice used for preservation. *Salmonella* and *Shigella* spp. were not grown on S/S agar during the bacterial analysis of the samples. The result showed that these bacteria are absent in the collected samples.

Table 2. Proximate analysis and bacterial level of fish obtained from FRC, Pokhara in different conditions

Fish spp	Proximate level, %									Bacterial level (CFU/g)		
	Fish in fresh condition			After transportation						Fish in fresh condition	After transportation	
				Frozen condition			Chilled condition				Frozen condition	Chilled condition
	MS	CP	CF	MS	CP	CF	MS	CP	CF			
Rohu	7.8	76.6	4.3	7.8	76.6	4.4	7.8	76.5	4.5	63x10 ²	145x10 ²	132x10 ²
Naini	8.1	77.0	3.5	8.3	76.9	3.5	8.3	76.9	3.6	13x10 ²	157x10 ²	103x10 ²
Silver	7.0	75.1	4.7	7.0	75.1	4.7	7.0	75.1	4.7	220x10 ²	42x10 ³	36x10 ³

Table 3. Proximate analysis and bacterial level in fresh, sun dried and smoked fish obtained from the Kathmandu market

Fish spp	Condition	Proximate, %			Bacterial level (CFU/g)
		MS	CP	CF	
Rohu	Chilled in ice	7.0	73.1	4.8	132×10^4
Naini	Chilled in ice	8.3	76.8	2.6	157×10^4
Silver carp	Chilled in ice	6.9	75.1	4.6	265×10^4
Unknown	Sun dried fish	14.9	63.4	8.6	124×10^3
Unknown	Smoked fish	10.9	61.1	8.0	42×10^3

MS= Moisture, C P = Crude protein, C F = Crude fat, CFU= Colony forming unit, g= Gram.

The bacterial number was found higher in sun-dried fish, that ranged from 123×10^3 - 43×10^4 CFU/g, than that in the smoked fish, which ranged from 99×10^2 - 84×10^3 CFU/g (Table 4). This might be due to environmental contamination during sun drying. The results showed that smoked fish was of better quality than sun dried fish due to presence of low number of bacteria.

Less than 10^4 - 10^6 CFU/g for the total number of microorganisms that grow at 35° - 37° C and an absence of *Salmonella* in a given weight of sample (varying from 1 to 100 g) are safe working figures for fish and fish

products (Connell 1995). Fresh, cold, smoked and frozen fish has 5×10^5 total aerobic plate count per gram/cm² (Connell 1995). The total aerobic plate count per gram were found within the limit of International Commission on Microbiological Specifications for Food (1986) in case of FRC Pokhara fish in fresh/chilled condition and it was found with out of ICMS limit (1986) in case of Kathmandu market fishes in chilled condition (Connell 1995).

Table 4. Proximate analysis and bacterial levels of fish obtained from FRC Pokhara and Kathmandu market in different conditions

Fish spp	Sample collected site	Proximate level, %						Bacterial level (CFU/g)	
		After smoked at farm			After sun dried at farm			After smoked at farm Godawari	After sun dried at farm Godawari
		MS	CP	CF	MS	CP	CF		
Rohu	FRD	5.2	76.5	4.6	5.6	73.0	4.8	99×10^2	213×10^3
Naini	Pokhara	6.4	73.0	11.6	6.0	70.5	7.8	100×10^2	123×10^3
Silver carp		7.1	62.2	15.0	6.9	69.8	14.4	101×10^2	151×10^3
Rohu	KTM	7.0	61.3	8.6	8.0	66.3	8.0	38×10^3	38×10^4
Naini	market	6.5	75.5	4.2	8.6	71.1	7.4	84×10^3	37×10^4
Silver carp		7.5	60.3	12.4	15.5	65.1	16.7	17×10^3	43×10^4

Spoilage is the result of the whole series of complicated changes brought about in the dead fish tissue by its own enzymes, by bacteria and chemical action (Biswas 1996). Microorganisms are the most important agents of deterioration in raw, wet fish since they give rise to the particularly undesirable flavours associated with spoilage (Connell 1995). Bacterial spoilage essentially involves partial digestion of fish tissues by the bacteria in their growth and reproduction. During the digestion process varying amounts of volatile and non-volatile compounds are liberated from the fish (Balachandran 2001). Thus higher the bacterial load contained, higher the chances of deteriorating the quality of fish.

The bacteria and enzymes are responsible for causing quick spoilage of fish and are concentrated in the intestines and gills. Therefore it is preferable to remove them as early as possible after fish harvesting. However, care should be given to clean the eviscerated and degilled fish thoroughly with clean water to remove all blood, slime and viscera, otherwise the inherent as well as external bacteria get access easily into the flesh. Hygienic evisceration and degilling is the best method to be adopted when the fish is meant for further processing by filleting, canning or even by salting (Govindan 1985). Bacterial load was found in higher numbers in different fresh fish species of the market compared to the FRC's fish species (Table 2). Higher bacterial multiplication may be due to the time duration during transportation, physical damage and selling technique. This indicates that the fish kept in the market for selling is poor in quality than the fish sold from the centre (Table 2, 3). It is estimated that as much as 75% of the fresh fish supply in Kathmandu is of Indian origin specifically from Andhra Pradesh and in the bulk of all fish arrived from Andhra Pradesh to Kathmandu via Mozaffarpur/Raxaul altogether after some 6 days of fish harvesting. Immediately after arrival at Kalanki, fish trays are unloaded and distributed among wholesalers/retailers (Dahal 1998).

Present study showed that the quality of fish transported from FRC, Pokhara to Kathmandu is better than that of the fishes available in Kathmandu market in terms of bacterial load. Since fish is the most popular and highly perishable food item, people should be alert of health issues before buying it in the market. Although the *Salmonella* sp is not found in the fish that procured from FRC, Pokhara as well as from Kathmandu market, further research should be done to identify other food poisoning bacteria for assuring the fish quality.

REFERENCES

- Balachandran KK. 2001. *Post harvest technology of fish and fish products*. Daya publishing house, Delhi – 110035, India. 440pp.
- Benson HJ. 1979. *A laboratory manual in general microbiology*. Wm. C. Brown Company, Dubuque, Iowa.
- Biswas KP. 1996. *A text book of fish, fisheries and technology*. Narendra Publishing House, 1417, Kishan Dutt Street, Maliwara, Delhi-110 006, India. 578pp.

- Clucas IJ. 1981. *Fish handling, preservation and processing in the tropics: Part I*. Tropical development and research institute 127, Clerkenwell Road London EC 1R 5DB. 141pp.
- Connell JJ. 1995. Control of fish quality. 4th ed. *Fishing News Books*. Adivision of Blackwell Science Ltd, 54 Univ. Street, Carton, Victoria. 3053, Australia. 245pp.
- Dahal SP. 1998. An observation on fresh fish marketing in Kathmandu valley. *Proceedings of Present Status of Fisheries Research, Development and Education in Nepal*. Publ. Natural Water Fisheries Development Project, Nepal Agricultural Research Council (NARC), Japan International Cooperation Agency (JICA). Pp. 93-96.
- Govindan TK. 1985. *Fish processing technology*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi 110001, India. 252pp.
- Krieg NR, GJ Holt. 1984. *Bergey's manual of systemic bacteriology*. Vol. I.
- Regenstein JM and E Carrie. 1997. *Introduction to fish technology*. CBS Publishers and Distributors, 4596/1a, 11 Darya Ganj, New Delhi-110 002, India. 269pp.
- Sneath PHA, M Nicholas, SM Elisabeth and GJ Holt. 1986. *Bergey's manual of systemic bacteriology*. Vol. II.
- Watanabe T. 1988. *Fish nutrition and mariculture*. JICA Textbook, The general aquaculture course. Pp.179-191.
- Yadav BN. 1997. *Fish and fisheries*. Daya Publishing House, 1123/74, TriNagar, Delhi-110 035, India.366pp.
- Yadav BN. 2002. *Fish and fisheries*. Daya Publishing House, 1123/74, TriNagar, Delhi-110 035, India.366pp.

Diversity of Fodder and Grasses in Sankhuwasabha

Bal K Joshi¹ and Krishna B Karki²

¹ Agriculture Botany Division, NARC Khumaltar <joshibalak@rediffmail.com>

² Soil Science Division NARC Khumaltar

ABSTRACT

Diversity assessment is essential at species and variety level for sustainable use, conservation and improvement of fodder and grasses species. Survey is the preliminary method to assess status of species and varieties. Field observation, farmers' responses and literature review were applied in this study to measure the diversity of fodder and grasses in Hatiya, Num and Pawakhola VDCs of Sankhuwasabha, Arun valley. Existence of great diversity in both fodder and grasses are supported by geoclimatic variations. There are 22 kinds of bamboo species and subspecies, 69 different species of fodder and more than 25 species of grasses. Farmers collect fodder and grasses from two places 1. from their own farm and homestead and 2. from forest. Lack of cultivation practices of fodder and grasses raised issue of conservation. All fodder and grasses available in these areas are indigenous except Napier and clover. Common fodders are Amrisho, Khanayo, Badahar, Tanki, Koirala, Kavro and Nivaro in farm and Paiyun, Chuletro and Jhingane in forest. Some of these fodder and grasses are endangered due to many factors. Major factors reducing the diversity of fodder and grasses are extensive cultivation of cardamom, invasion of bambara, slash and burn agriculture and over grazing. Farmers reported lost of very few species from these areas. Livestock is affected negatively by decreasing availability of Kharka, fodder and grass species. Diversity of fodder and grass is directly linked to number and kinds of livestock, wealth categories of farmers, land holding sizes and altitude. For the better management of livestock, fodder and grasses and for controlling soil erosion, different agro forestry systems eg sloping agricultural land technology should be identified and implemented suitable to specific area.

Key words: Diversity, fodder, grasses, Sankhuwasabha,

INTRODUCTION

Diversity and distribution of fodder and grasses reflect the status of livestock. Mid and foothills of Nepal have greatest types and number of fodder and grasses species. Indigenous species are found more in mid and high hills than in Tarai. Use of agroforestry system in hilly areas help to conserve and use these species. Almost a total of 170 species of fodder trees and shrubs can be found in mid and foothill ranges. All farmers' areas have different types of fodder and grasses that can be used directly to livestock after cutting or can be made hay and used later.

Feeds and fodder play an important role in the development of livestock. The yield whether reflected in the form of milk, meat or wool depends on the quality of feeds the animals are fed with. In a food deficit area, feeding nutritive diets to the animals is beyond question. Whatever grasses and fodders are available in the field or forest are fed to the animals. Farmers meet their fodder requirements by lopping fodder trees available in community and private forests. There are many government offices for pasture development or grasses seed production located from Tarai to high hills. Different kinds of pasture, alpine, arid cold, forest, open pastures exist in Nepal.

Fodder is one of the main components of the farming system in Nepal. Animals derive an estimated 35% of their feed from trees (Amatya 1990). The preference of fodder trees varies from one ecological zone to another. Farmers preferred a total of 44 different fodder tree species. With respect to the Development Regions, Western Development Region has the highest number of preferred fodder trees (Amatya 1990). Although exposure and precipitation influences the distribution of species many of the fodder species have a wide geographical distribution mostly growing in acid soil.

The Arun River Valley, located in Eastern Development Region and for being the deepest valley of the world, is rich in biodiversity both in terms of wild as well as domesticated life forms. There are 11 globally endangered mammals, and numerous plant species listed as endangered or threatened elsewhere (Shrestha and Joshi 1996). These days, there has been a variety of disturbances in the bio-diversity of this region due to poverty, increased population pressure, lack of knowledge in sustainable use of natural resources, slash-and-burn agriculture, bush fires, excessive wood extraction, and poaching (Shrestha 1989). Improper introduction of exotic crop varieties and modern inputs have led to the disappearance of the native varieties of crops (Thapa 1996). Native species have resistance to diseases and pests, and they also survive in adverse conditions, therefore study on existence of native crop plants is necessary.

This study evaluates the diversity of fodder and grasses in the Arun River Valley covering three village development committees (VDCs) of Num, Hatiya and Pawakhola in the Sankhuwasabha district (Figure 1). The major objective of this study is to assess the status of fodder and grass diversity and to understand and analyse the traditional knowledge of the local communities regarding the conservation and sustainable use of fodder and grasses in one of the world's unique mountain ecosystems with globally significant bio-diversity.

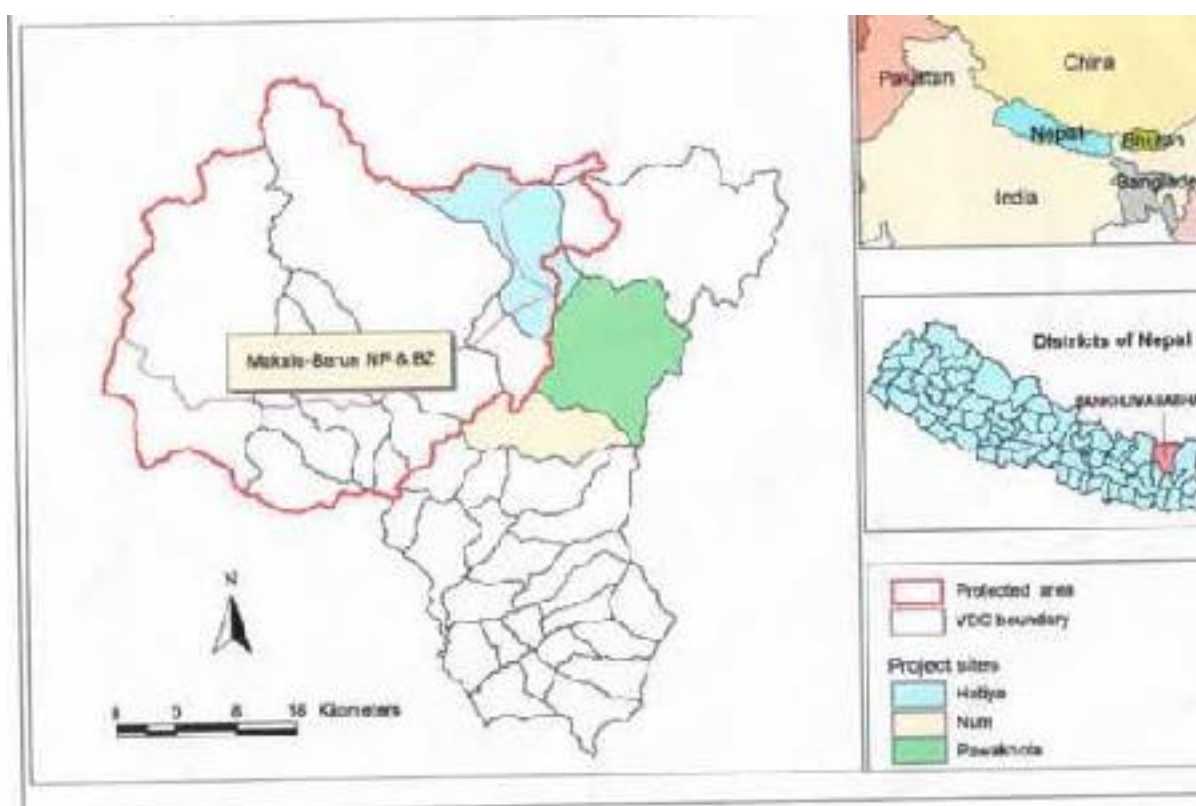


Figure 1. Location map of three VDCs of Sankhuwasabha district, where fodder and grass diversity was assessed.

METHODOLOGY

A desk study was conducted to collect and review relevant information regarding fodder and grasses in the study area. Libraries of The Mountain Institute (TMI), International Centre for Integrated Mountain Development (ICIMOD), World Conservation Union (IUCN), Nepal Agricultural Research Council (NARC) and King Mahendra Trust for Nature Conservation (KMTNC) were visited. Based on the gathered information, structured questionnaire and a checklist were developed for collecting relevant information from the field. The field visit itinerary is presented in Figure 2.

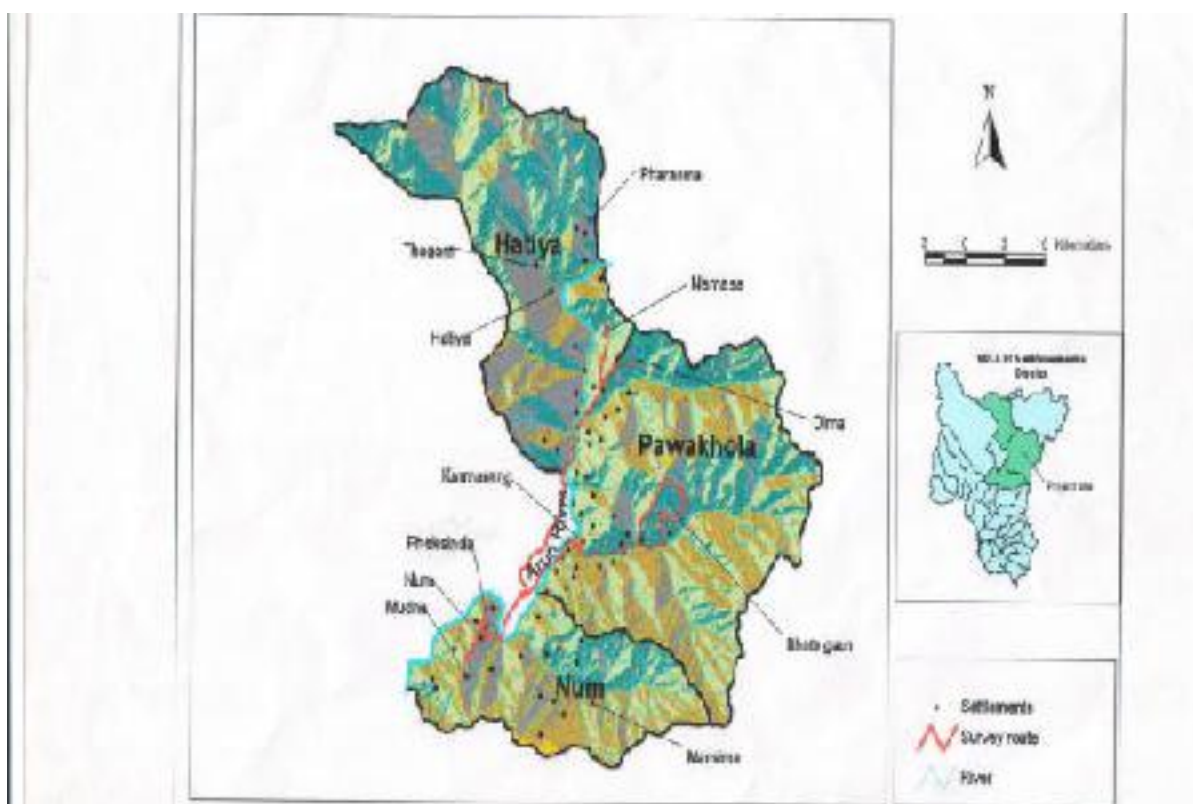


Figure 2. Survey route of agro biodiversity study in three VDCs of Sankhuwasabha district.

Groups of farmers were consulted for the purpose of holding discussion and collecting information by applying Rapid Rural Appraisal tools. Field observation, farmers' responses and literature review were applied in this study to measure the diversity of fodder and grasses in Hatiya, Num and Pawakhola VDCs of Sankhuwasabha, Arun valley. Additional information was collected from various agency officials working in Sankhuwasabha (Appendix I). Different plant species were listed related to livestock. Flora species richness was estimated at different land use systems.

FINDINGS

Study area

Num, Hatiya and Pawakhola are three VDCs of the Sankhuwasabha district of Koshi zone in the Eastern Development Region of Nepal. These VDCs lie between 27.30° to 27.40° North latitude and 87.15° to 87.27° East longitude (Figure 1). It takes 4 to 5 days of normal walking to reach these VDCs from Khandbari, the district headquarter. The altitude ranges from about 800 to 4,000 masl. The Bhotegaun settlement of Pawakhola lies at an altitude of 2472 m. The community forest of Jorkhabe Dada lies at an altitude of 4,192 masl. Because of the wide variation in altitude, this region has considerable biodiversity in agriculture.

Agro-climate

The study area lies in the high mountain physiographic region of Nepal (LRMP 1986). The vegetation line is below 5,000 m where biodiversity is very rich. The upper limit of agriculture goes to 3,000 m. This region enjoys a cool temperate type of climate with very high rainfall. It is said that this region is next to the Annapurna Region in terms of rainfall. The meteorological stations at Chepuwa at an altitude of 2,590 m and Num at an altitude of 1,497 m record an annual rainfall of 2,627 mm and 3,982 mm, respectively. There are instances when over 6,000 mm of rainfall has been recorded in these stations in some years (Kumar 2000). The rainy season lasts for four months (June-September). Clouds cover the sky most of the time with rare sunshine during the monsoon period.

Table 1. Bamboo species and subspecies found in Sankhuwasabha

SN	Nepali name	Common name	Scientific name
1.	Ban bans	-	-
2.	Bans	Bamboo	Dendrocalamus strictus
3.	Bet	-	Calamus acanthospathus Griff.
4.	Bhalu bans	-	-
5.	Bhedh bans	-	Calamus tenuis
6.	Bhude bans	-	
7.	Chitre bans	-	Dendrocalamus sp.
8.	Choyabans	-	Dendrocalamus sp.
9.	Deu nigalo	-	-
10.	Dhanu bans	-	Dendrocalamus strictus
11.	Ghode	-	-
12.	Ghove bans	-	-
13.	Kalo bans	-	-
14.	Kalo nigalo	-	-
15.	Mal bans	-	Bambusa nutans
16.	Malingo	-	Arundinaria maling
17.	Nigalo	Himalayan bamboo	Arundinaria falcate
18.	Nigalo	-	Arundinaria hookeriana Murno
19.	Singane bans	-	-
20.	Tama bans	Tufted bamboo	Dendrocalamus hamiltonii
21.	Thankre bans	-	-
22.	Tite nigalo	-	-

Table 2. Tree and shrub fodder species diversity in Num, Hatiya and Pawakhola, Sankhuwasabha

SN	Nepali name	Common name	Scientific name
1.		Calliandra	Calliandra calothyrsus
2.	Amriso	Broom grass	Thysanoleana maxima
3.	Anreli kanda	-	Mimosa rubicaulis
4.	Arkhaulo	-	Quercus fenestrata
5.	Badhar	Monkey jack	Artocarpus lakoocha
6.	Badhare	-	-
7.	Bainsh	-	Salix babylonica L.
8.	Ban kimbu	Mulberry	Morus sp
9.	Banjh	-	Quercus lanata Sm.
10.	Banmara	-	Eupatorium adenophorum
11.	Bar	-	Ficus bengalensis L.
12.	Bhate kaulo	-	Machilus odoratissima Nees
13.	Bhatmase	Flemengia	Flemengia congesta
14.	Bhimsen pati	-	Buddleja asiatica
15.	Bhorla	-	Bauhinia vahli
16.	Chulatro seto	-	Brassaopsis glomeulata
17.	Chulatro, kalo	-	Brassaopsis hainal
18.	Daar	-	Boehmeria rugulosa
19.	-	Desmodium	Desmodium intortum
20.	Dhalne katush	Chest nut	Castonopsis indica
21.	Dudhilo	-	Ficus nemoralis
22.	Ghayo	Cudaph almond	Bridelia retusa
23.	Ghurbisa	-	-
24.	Ghuyala	-	Callicarpa macrophylla
25.	Gogan	-	Saurana nepaulensis
26.	Guelo	-	Elaeagnus parviflora
27.	Jhingane, sano	-	Eurya japonica
28.	Jhingane, thulo	-	Eurya acuminata
29.	Kaulo	-	Machilus gamblei
30.	Kavro	-	Ficus lacor
31.	Khanyo	-	Ficus semicordata
32.	Khayer (Khair)	-	Acasia catechu

SN	Nepali name	Common name	Scientific name
33.	Khosreto	-	<i>Ficus hispida</i> L.
34.	Kimbu	Mulberry	<i>Morus</i> sp
35.	Koiralo	Mountain ebony	<i>Bauhinia veriatagata</i>
36.	Kunyel	-	-
37.	Kutmero	-	<i>Litsea polyantha</i>
38.	Malingo	-	-
39.	Mayal	Wild pear	<i>Pyrus pashia</i>
40.	Musure katush	-	<i>Castanopsis tribuloides</i> Sm. ADC
41.	Nibharo	-	<i>Ficus rosberghii</i>
42.	Nundaki	-	-
43.	Painyun	Cherry	<i>Prunus cerasoides</i>
44.	Pakhuri	-	<i>Ficus glaberrima</i>
45.	Patle katush	-	<i>Castanopsis hystrix</i>
46.	Phalat	-	<i>Quercus glauca</i> Thunb
47.	Phaledo	-	<i>Erythrina arborescens</i>
48.	Phaleto	Coral tree	<i>Erythrina variegata</i> L.
49.	Phirphire	-	<i>Acer oblongum</i>
50.	Pipal	-	<i>Ficus religiosa</i>
51.	Punwale	-	<i>Ilex doniana</i> DC
52.	Rapase	-	-
53.	Salime	-	-
54.	Sano bhatmase	<i>Campylotropis</i>	<i>Campylotropis speciosa</i>
55.	Saur	-	<i>Betula alnoides</i> Buch. Ham ex. D.Dam
56.	Seto khasru	-	<i>Quercus</i> sp
57.	Seto koiralo	Camel's foot	<i>Bauhinia variegata</i>
58.	Simal	-	-
59.	Simsime	-	-
60.	Sindure	-	<i>Mallotus philippinensis</i> Muell. Arg.
61.	Syal phorse	-	<i>Grewia tihialfolia</i>
62.	Tanki	Camel's foot	<i>Bauhinia purpuria</i>
63.	Thosne	-	<i>Ficus hispida</i> L
64.	Thotne	-	<i>Aconogum molle</i>
65.	Thulo bhalayo	-	<i>Rhus succedanea</i> L.
66.	Thulo Falant	-	<i>Quercus lamellosa</i> Sm.
67.	Tooni	-	<i>Cedrela toona</i>
68.	Tusare	-	-
69.	Utish	-	<i>Alnus nepalensis</i>

Natural vegetation

Altitude plays a major role in the temperature variation in this region. Since the study area ranges from about 800 m (Pheksinda of Num) to 4,200 m (Gorjura Danda of Pawakhola), the natural vegetation also exhibits a successive pattern of change along the slope. Based on the vegetation composition and climate, forest types are categorized into five different groups as follows:

1. Tropical belt gorge forest (<1,000 m)
2. Subtropical belt *Castanopsis* forest (1,000-2,000 m)
3. Temperate belt *Schima* and *Castanopsis* forest, oak forest (2,000-3,000 m)
4. Sub alpine fir forest (3,000-4,000 m)
5. Alpine belt juniper scrub (>4,000 m)

Fodder and grass diversity

All plant species related to livestock are grouped under seven categories. These are bamboo species, tree and shrub species, grasses, leguminous species, cultivated crop species and protected/endangered species. There are 22 bamboo species and sub species (Table 1). Nepal has more than 36 species of bamboos in twelve genera. Farmers reported all these are used for livestock. Variation on quality exists among these bamboo species. Most of the bamboo species have multipurpose value. These are adapted to different environments. Some of them are grown in private land and some species exist under forest. Farmers collect leaf of bamboo from forest as well as private land for livestock.

Table 3. Grass species diversity in Num, Hatiya and Pawakhola VDCs of Sankhuwasabha

SN	Nepali name	Common name	Scientific name
1.	Babiyo	-	Eulaliopsis binata
2.	Banso	-	Eragrostis tenella
3.	Berseem	-	Trifolium alexandrinum
4.	Bhote jhar	-	-
5.	Buki	-	-
6.	Dhude harkat	-	-
7.	Dubo	-	Cynodon dactylon
8.	Ghode banso	-	-
9.	Gongleto	-	-
10.	Halhale	-	-
11.	Harkat	-	-
12.	Khar	-	Themeda arudinaceae (Roxb.) Ridley
13.	Khar	-	Themeda vilosa (Poir.) A. Camus
14.	Khari	-	Celtis australis
15.	Kharuki	-	Capioedium assimile
16.	Kode jhar	-	-
17.	Kure jhar	-	-
18.	Kuro	-	-
19.	Lajmanti	-	Mimosa pudica
20.	Nepier	Elephant grass	Pennisetum purpureum
21.	Phurke	-	Arundouella nepalensis
22.	Pire	-	-
23.	Siru	-	Imperata cylindrical
24.	Titepati	-	Artemisia vulgaris
25.	Titre banso	-	-

Table 4. Grassland categories according to climatic zone

Zone	Remarks
Tropical	Grasslands grazed almost all the year round
Subtropical	Non- palatable species such as ferns, stinging nettle, and Eupatorium species are becoming dominant because of heavy grazing
Temperate	Winter grazing for cattle, sheep and goats. Burning to improve grasslands is a common practice, causing increased soil erosion.
Sub alpine	Seasonal grazing because of heavy snow covers in winter. Burning of grasslands at the end of the grazing season and in early spring is common.
Alpine	Grasslands are grazed only during the summer (June-September)

Table 5. Leguminous trees and shrubs at Num, Hatiya and Pawakhola

SN	Nepali name	Common name	Scientific name
1.	-	-	Campylotropis speciosa
2.	Bhatmase	Flemengia	Flemengia congesta
3.	Desmodium	Desmodium	Desmodium gyroides
4.	Kalo siris	-	Albizia lebbeck
5.	Koiralo	Mountain ebony	Bauhinia variegata
6.	Kure	Gliricidia	Gliricidia sp
7.	Phaledo	-	Erythrina arborescens
8.	Rato siris	-	Albizia julibrissin
9.	Seto siris	-	Albizia procera
10.	Siris	-	Albizia chinensis
11.	Tanki	Camel's food	Bauhinia purpuria

Bamboo is one of the most useful plants for the people of Nepal. Out of the 170 fodder trees, thirty are used extensively and *Dendrocalamus* spp seems to be one of the best species. Farmers of Baglung and Parbat districts pay upto Rs500 per clump per year for leaf fodder of *Dendrocalamus* and *Bambusa* spp (Shrestha and Tiwari 1992, cited by Paudyal 1993). Similarly farmers of these areas value bamboo species. In the higher altitudes, cattle are allowed to graze in the natural forest of bamboo species. Large diameter bamboos are adapted to lower altitudes and small diameter bamboos to higher altitudes.

Farmers reported 69 species of tree and shrub fodder in these VDCs (Table 2). Nepal has 170 species of tree and shrub fodder. A total of 75 species of tree and shrub fodder exists in Arun basin (Shrestha 1989). Diversity in fodder is found mainly due to variation in climate, and livestock species. There may be many more fodder and grasses species to be explored. Both trees and shrubs have been used for livestock in all areas. Farmers produce year round green fodder and grasses to their livestock. There is lack of cultivation practices of fodder and grasses. There are no private nursery on fodders and grasses. Every household has some kinds of fodders and grasses. Most important species are Kahniyo, Gogan, Amriso, Nivaro, and least important are Arkhauilo, Patle Katush.

There is a lack of information about the number of grasses species available in Nepal. Possibly greatest diversity may exist in grasses. Everywhere from Tarai to high mountains grasses grow well. More than 25 species of grasses are found in these areas (Table 3). Different types of grasses eg annual, perennials, creepers, climbers, scented, saprophytes with different colors have contributed especially to livestock management in these VDCs. Some species are adapted to grazing and some are to cut. Priority was given to leguminous grasses. Expansion of a single species eg clover and napier to large areas has reduced the grasses diversity. Initiation of cultivation and management practices at farmers level may be basic strategy to maintain indigenous species.

Table 6. Cultivated crop species used for livestock

SN	Nepali name	Common name	Scientific name
1.	Alu	Potato	<i>Solanum tuberosum</i>
2.	Bhatmans	Soybean	<i>Glycine max</i> L.
3.	Dhan	Rice	<i>Oryza sativa</i> L.
4.	Ghahat	Horse gram	<i>Dolichos biflorus</i>
5.	Ghau	Wheat	<i>Triticum aestivum</i>
6.	Jai	Oat	<i>Avena sativa</i>
7.	Jau	Barley	<i>Hordeum vulgare</i>
8.	Kaghuno	Italian millet	<i>Setaria italica</i>
9.	Kodo	Finger millet	<i>Elusine coracana</i>
10.	Makai	Maize	<i>Zea mays</i>
11.	Mans	Black gram	<i>Vigna mungo</i>
12.	Phapar	Common buckwheat	<i>Fagopyrum esculentum</i> Moench
13.	Philingo, Jhuse til	Niger	<i>Guizotia abyssinica</i>
14.	Tite Phapar	Tartary Buckwheat	<i>Fagopyrum tataricum</i>
15.	Tori	Rape seed	<i>Brassica campestris</i>
16.	Masyang	Rice bean	<i>Phaseolus radiatus</i>
17.	Pharsi	Pumpkin	<i>Cucurbita moschata</i>
18.	Rayo	Leaf mustard	<i>Brassica napus</i>
19.	Kera	Banana	<i>Musa paradisiaca</i>
20.	Kakro	Cucumber	<i>Cucumis pepo</i>
21.	Simi	Bean	<i>Phaseolus sp</i>
22.	Mula	Radish	<i>Raphanus sativus</i>
23.	Bodi	Cowpea	<i>Vigna sp</i>
24.	Banda	Cabbage	<i>Brassica oleracea</i> var capitata
25.	Cauli	Cauliflower	<i>Brassica oleracea</i>
26.	Uwa	Naket barley	<i>Hordeum nudum</i>

The grasses and fodder species can be grouped into two categories: those available in farms and homesteads, and the others available in the forest. Common fodder species available in the vicinity of the animal sheds are Amriso, Khanayo, Badahar, Tanki, Koiralo, Kavro and Nivaro. Other species like Paiyun, Kango, Chuletro, Jhingane etc are found in the forest. Some of the domesticated species are also available in the forest. Since the farmers extract fodder from forest trees heavily, plant population in the forest is also decreasing. Because of the limited availability of fodder, the livestock population in these villages is low.

Pastureland is found in Hatiya and Pawakhola. Different types of grassland from tropical to alpine support the livestock (Table 4). Cattle, sheep and goats are the major animals depend on these grasslands. In subtropical zones, grassland area (kharka) is increasingly going to cover by non-palatable species as ferns, stinging nettle and *Eupatorium*. Farmers believe that burning grassland help to grow grasses well in next seasons. There are no grassland management systems. The monsoon is the only season when plenty of local grasses are available in the pastureland of high hills. Popular local grasses in high hills are Sunbuki, Dhudhbuki, Danklabuki, Minodhuki, Brapang and Padang. Some farmers produce hay from these selected grasses. Many types of grasses are found in pastureland. Some grasses are cut and used in stall-feeding. Some are cut and dried and later used during lean

period. Grazing grasses are more in number than cut grasses. Similarly wild/natural grasses are significantly higher than cultivated species. Generally imported grasses are under cultivation practices.

Table 7. Plants species poisonous to livestock at Num, Hatiya and Pawakhola

SN	Nepali name	Common name	Scientific name
1.	Alaichi	Cardamom	Cardamom subulatum
2.	Angeri	-	Lynia oralifolia
3.	Balu	-	<i>Pieris formosa</i>
4.	Bikh	Aconitum	Aconitum napallus
5.	Chimal	-	<i>Rhododendron barbatum</i>
6.	Darsane	-	-
7.	Dudhe lahara	-	-
8.	Ghungring	-	-
9.	Ilame, Ghandhe	-	<i>Ageratum conyzoides</i>
10.	Kalo siris	-	<i>Albizzia odoratissima</i> Benth.
11.	Kosre	-	-
12.	Lalighuras	Rhododendron	Rhododendron sp
13.	Pahelo siris	-	-
14.	Simal tarul	-	<i>Manihot esculenta</i>
15.	Suktuk	-	-
16.	Unyu	-	<i>Pteridium</i> sp
17.	Utish	-	<i>Alnus nepalensis</i> D. don

Table 8. Nepal's protected, rare, endangered and endemic fodder and grass species found at Num, Hatiya and Pawakhola (Shrestha and Joshi 1996, Chaudhary 1998, M Siwakoti IUCN 2002, Pers. Comm.)

SN	Nepali name	Common name	Scientific name
1.	Arkhaulo*		<i>Quercus fenestrata</i>
2.	Kakro (Seto, Hariyo)**	Cucumber	<i>Cucumis pepo</i>
3.	Dudhilo*	-	<i>Ficus nemoralis</i>
4.	Gogan*	-	<i>Saurana nepalensis</i>
5.	Jau*	Barley	<i>Hordeum vulgare</i>
6.	Jinghane*	-	<i>Eury</i> sp
7.	Kaghuno**	Italian millet	<i>Setaria italica</i>
8.	Karunke ghans**	-	
9.	Kharuki*	-	<i>Capioedium assimile</i>
10.	Kodo (Bhojpure, Fyakure)**	Millet	<i>Eleusine coracana</i>
11.	Kurilo	Asparagus	<i>Asparagus racemosus</i>
12.	Lamche khursani*	Chilly	<i>Capsicum</i> sp
13.	Makai (Yangrupe, Thulo seti, Phalendo, Paheli makai)**	Maize	<i>Zey mays</i>
14.	Majitho	-	<i>Rubia manjith</i>
15.	Phaper*	Buckwheat	<i>Fagopyrum</i> sp
16.	Dhan (Marshi, Yanseere, Guture)**	Rice	<i>Oryza sativa</i>
17.	Utish*	-	<i>Aluns nepalensis</i>
18.	Uwa*	Naket barley	<i>Hordeum nudum</i>
19.	Khayer	Catch tree	<i>Acacia catechu</i>
20.	Okhar	Walnut	<i>Juglans regia</i>
21.	Simal	Silk cotton tree	<i>Bomex ceiba</i>
22.	Vyakur	Dioscorea	<i>Discorea deltoidea</i>

* Locally endangered, ** Locally extinct.

Different species of leguminous tree and shrub supported both soil fertility and livestock. Some of them are very useful for sloping agricultural land technology (SALT) (Table 5). Most of the residual or by product of cultivated crop plants are used to livestock (Table 6). Among cultivated species, dhan, kodo, makai and bhatmas are common for livestock use.

Some plants available in the forests are poisonous to grass eating animals (Table 7). When the tender leaves are eaten, they are poisonous. Angeri is poisonous to all animals, and ilame is deadly to sheep. By mistake, they eat these plants and fall sick. It causes shooting diarrhoea and death due to dehydration. If bhakimlo dust is available in time, it can be cured. Angeri causes stomach swollen for a day or two and the animal dies. Some poisonous

plants affect the throat. Animals cough and die with a breathing problem. The farmers report that they do not have remedy to cure their animals of these problems.

Based on status of species and literature review, 22 species and varieties of crop plants useful to livestock are categorized under protected/ endangered/ endemic (Table 8). Four protected flora, which are useful to livestock and found in this area are Khayar, Okhar, Simal and Vyakur. Few species and varieties were lost and some are locally endangered. Farmers reported that a Karunki grass was lost. Locally threatened species are Musure katush, Utish, Katush, Nigalo, Malta, Arkhaulo, Jhingae, Karauki, Gogan and Dhudilo.

Threats to fodder and grass diversity

- Cultivation of cardamom in forest area has decreased the diversity.
- Exotic plant species *Banmasa* (*Eupatorium odoratum*) in the lower areas and *Banmara* (*E. adenophorum*) in the higher are quickly invading the habitats and replacing the local species.
- Slash and burn agriculture system is the major threat to diversity loss.
- Fragmentation, encroachments of natural forestland by human activities cause heavy loss of diversity.
- Over grazing and over looping retard the species regeneration.
- Due to unconsciousness of the farmers for sustainable use of these species some of them has been under threat to extinct.
- Sweeping /uprooting of species due to landslides and floods cause the lands barren.
- Disease and insects are the natural factors in decreasing the agro biodiversity.
- Overgrazing change the grassland into unpalatable lands.
- Due to over exploitation of some species having multipurpose uses there are decreasing trend in the number of such species.
- Due to lack of cultivation practices of most commonly exploited species eg medicinal, and fodder plants, they are under threat to extinct

Slash and burn agriculture is common practices in these area. Khorias where slash and burn agriculture is practiced is also important source of fodder grasses. Due to the high species richness of khorias (Figure 3), farmers give importance of khorias to collect diverse form of fodder and grasses both in number and quantity as well as quality from khorias. Most of the lands of these areas are slopy. For better management of soil and livestock, agroforestry as well as SALT system should be applied. Agro forestry/ SALT should be initiated using locally available species in slopy area. Slash and decompose rather than slash and burn agriculture system should be developed. Special program for threatened species be designed. Occupation of large areas by a single spp is not a good way. Site specific/ farmer specific technology considering the species evenness may be good systems of crop plants conservation and utilization. Cultivation system of fodder and grasses and pastureland management systems also be initiated for fodder and grass genetic resources management.

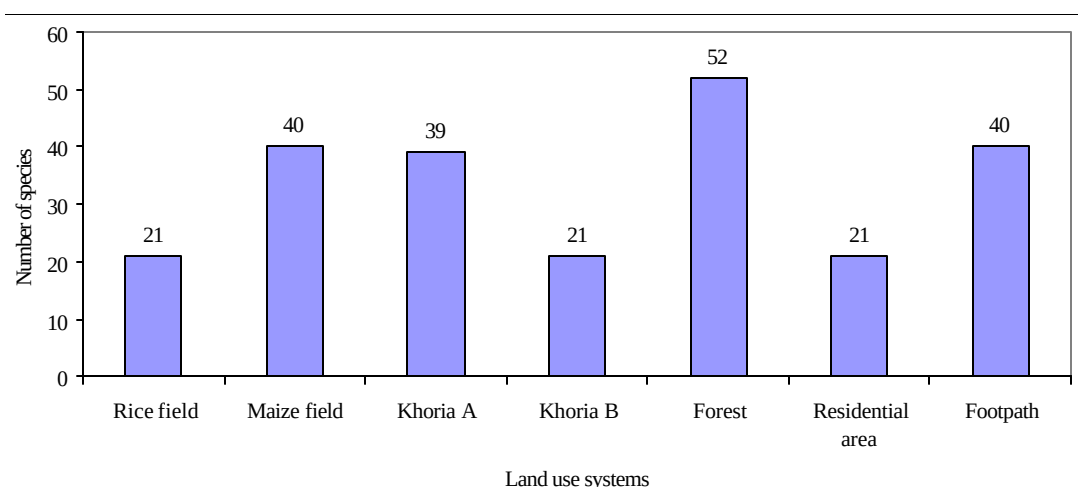


Figure 3. Species richness in different land use systems (Khorias A, with standing crops and Khorias B, after 2 years of crop harvest).

ACKNOWLEDGEMENTS

Farmers of Num, Hatiya and Pawakhola VDCs of Sankhuwasabha and SEEPORT, Kathmandu.

REFERENCES

- Amatya SM. 1990. *Fodder trees and their lopping cycle in Nepal*. BM Amatya Tahachal.
- Chaudhary RP. 1998. *Biodiversity in Nepal*. S Devi Saharanpur and Tecpress books.
- Kuwar N. 2000. Biodiversity strategies and its significance for sustainable agriculture. **In:** *Environment and Agriculture at the Cross Road of New Millennium* (PK Jha, SB Karmacharya, SR Baral and P Lacaul, eds).
- LRMP 1986. *Land resources mapping project*. Survey department, HMG and Kenting Earth Sciences, Kathmandu.
- Paudyal PP. 1993. Indigenous management of natural bamboo resources in Nepal. **In:** *Indigenous management of natural resources in Nepal* (D Tamang, GJ Gill and GB Thapa, eds). Winrock International, Kathmandu. Pp.197 –202.
- Shrestha TB and RM Joshi. 1996. *Rare, endemic and endangered plants of Nepal*. WWF Nepal program, Kathmandu.
- Shrestha TB. 1989. *Development ecology of the Arun River Basin in Nepal*. International Centre for Integrated Mountain Development, Kathmandu.
- Thapa GB. 1996. Land use, land management and environment in a subsistence mountain economy of Nepal. *Agriculture, Ecosystem and Environment* 57(1): 57-71.

Seed Production of Oat Varieties in Relation to Cutting Management under Rainfed Condition

Mukesh Karki¹ and Babu R Banstola²

¹ Regional Agriculture Research Station, NARC Parwanipur

² Pasture and Fodder Research Division, NARC Khumaltar Kathmandu

ABSTRACT

The experiment was conducted at RARS, Parwanipur during winter seasons of 2001/02 and 2002/03. The treatment comprised of six promising oat varieties with three cutting managements viz. no cut, one cut and two cut. It was laid out in a factorial randomized block design with three replications. Irrespective of varieties, higher green forage yield (14.02 t/h) was obtained from two cut management practice than one cut (4.79 t/h) and the green forage yield increased with increasing number of cuttings. Significant difference ($P < 0.01$) on seed yield was observed between varieties and cutting managements in both the year 2001 and 2002. Irrespective of variety, higher yield was obtained from zero cut (1.824 t/h), followed by one cut (1.375 t/h) and very poor production in two cuts (0.706 t/h). The experiment showed that Kent and Bundel-851 are high seed yielding varieties (2.213 t/h and 2.206 t/h, respectively) with zero cut management under rainfed condition. However, in case of Bundel-851 even after taking one cut (5.33 t/h green forage) seed yield was decreased only by 5% and quality of seed also remained normal. So, Bundel-851 for seed production with one cut practice under rainfed condition is more beneficial. Furthermore, there are high chance of lodging at maturity under zero cut management where as after taking one cut lodging chances could be minimized.

Kew words: Cutting management, oat, seed production

INTRODUCTION

Inadequate feed supply and poor nutrition during winter dry season is one of the major constraints on livestock production in Nepal. Though, importance of forage in overcoming feed shortage has long been recognized, the existing sources of fodder and pasture are not supplying adequate amount of feed for livestock and still there is feed deficit by 31%. Among different forage crops, the importance of oat cultivation is well known for its quick growth, palatability. Many farmers prefer to cultivate wheat rather than oat in irrigated land, due to which limits its production. However, a large proportion of *khet* land remains fallow during winter season due to lack of moisture. Utilizing this rainfed land for green forage production is only the best way for expansion and promotion of forage crops. Several reports are available on green forage production of oat under rainfed condition (Shrestha and Kshatri 1995, Aryal and Gurung 2000, Tiwari 2000).

It is reported that unavailability of seed of appropriate varieties on time is also one of the limiting factors for the adequate fodder production in Central Tarai region of Nepal (RARS 2001). As forage seeds are the pre-requisites to carry out fodder development activities, priority should be given to generate appropriate technology of seed production (Raut et al 2000). Screening of oat cultivars for seed production under rainfed condition is also necessary. There is limited experience on testing appropriate cutting management practices for both forage and quality seed production. This paper focuses on green mass and seed production of oat cultivars in relation to three cutting management practices under rainfed condition of Central Tarai region.

MATERIALS AND METHODS

The experiment was conducted at RARS, Parwanipur during winter seasons of 2001 and 2002. The treatment comprised of six promising oat cultivars with three cutting managements viz. no cut, one cut and two cut. It was laid out in a factorial randomized block design with three replications. Seeds were sown on 25 Nov 2001 and 4 Dec 2002 in 4 m² plot size in rows distance of 25 cm at the rate of 100 kg/ha. Chemical fertilizer was applied at the rate of 80:60:40 kg/ha N:P₂O₅:K₂O. Green forage harvesting was taken at 35 days after sowing for single cut treatment and further one cut was taken at 35 days after the first one for two cut treatment. The different growth and production parameters of oat cultivars under different treatments were recorded and analyzed using MSTATC computer program.

RESULTS AND DISCUSSION

Green forage yield

Green forage yield was significantly different ($P < 0.01$) among the tested varieties, cutting managements and their interaction. Irrespective of varieties, higher green forage yield (14.02 t/h) was obtained from two cut management practices than one cut (4.79 t/h). The overall higher green forage yields was obtained from Kent (17.32 t/h), followed by Canadian (15.21 t/h), Caraville (14.84 t/h) and Bundel-851 (Bundel) (14.34 t/h) under two cut management practices. However, irrespective of cutting Canadian produced higher green forage yield than Kent in 2001 but it was lowest 2002. This could be due to late sowing in 2002 and foggy and severe cold environment at Parwanipur during cropping season. These findings agree with findings of Tiwari (2002) that Canadian is very sensitive to sowing time. The details of green forage yield are given in Table 1. The green forage yield increased with increasing number of cutting management.

Table 1. Green forage yield (t/h) of various oat cultivars under different cutting practices in two years

Variety	Zero cut			One cut			Two cut			Mean	
	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03
Canadian	0.00	0.00	0.00	6.02	2.94	4.48	17.54	12.89	15.21	7.85 ^a	5.25 ^c
Bundel	0.00	0.00	0.00	5.46	5.21	5.33	14.5	14.19	14.34	6.65 ^{ab}	6.47 ^b
Taiko	0.00	0.00	0.00	4.31	3.46	3.88	11.83	11.63	11.73	5.38 ^b	5.03 ^c
Caravile	0.00	0.00	0.00	6.15	5.48	5.81	14.94	14.75	14.84	7.03 ^a	6.74 ^b
Omhi	0.00	0.00	0.00	1.68	4.36	3.02	7.75	13.62	10.68	3.14 ^c	5.99 ^{bc}
Kent	0.00	0.00	0.00	6.18	6.28	6.23	16.94	17.69	17.32	7.71 ^a	7.99 ^a
Mean	0.00	0.00	0.00	4.97	4.62	4.79	13.92	14.13	14.02	6.29	6.25
	2001/02			2002/03							
CV, %	26.3			18.28							
LSD (0.05)											
Variety (V)	1.586			1.095							
Cutting (C)	1.121			0.774							
V × C	2.747			1.896							

Value with same letter is not different at 0.05 level.

Plant height at maturity

Plant height of six oat varieties with three cutting management is given in Table 2. Significant different of plant height were observed between variety ($P < 0.01$), cutting ($P < 0.001$) and their interaction ($P < 0.05$) in both year. Table 2 reveals that irrespective of variety plant height at maturity decreases with increase in number of forage cutting viz 134 cm, 116 cm and 87 cm under zero cut, one cut and two cut management, respectively. The overall, taller plant height was observed in Canadian (153.5 cm) under zero cut management. However, sharp decrease in plant height was observed in Kent (41%), followed by Canadian (40%), Caraville (35%), Taiko (31%) and Bundel (26%) from zero cut to two cut management practices.

Days to maturity (75%)

Days to maturity were found significantly different ($P < 0.001$) between variety and cutting management in both consecutive years. Table-3 reveals that days to maturity was increased with increasing number of green forage cutting viz. 133 day, 135 day and 141 day with zero cut, one cut and two cut management, respectively. Under no cut management, Kent had significantly longer duration (137 day) to maturity at par with Canadian (136 days). The data revealed that the mean days to maturity was shorter with delay sowing (139 day and 133 day in 2001 and 2002 respectively). This might be due to forced maturity by dry wind under late sown condition.

However, Canadian and Kent had same duration of maturity in 2002 compared to 2001(141 Vs 140 day and 133 Vs 132 day) but in contrary, Taiko and Caraville had drastically shorter period (144 Vs 133 day and 145 Vs 131 day). This could be either due to light insensitive and sensitive nature of former and latter variety or any environmental factors, which were not considered during the experimental period. So, in future activities should be directed towards these aspects.

Table 2. Plant height (cm) of various oat cultivars under different cutting practices in two years

Variety	Zero cut			One cut			Two cut			Mean	
	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03
Canadian	152	155	153.5	135	125	130	103	81	92	130 ^a	121 ^a
Bundel	130	128	129	121	114	117.5	104	86	95	118 ^b	110 ^b
Taiko	138	135	136.5	114	122	118	100	87	93.5	118 ^b	115 ^{ab}
Caravile	129	130	129.5	108	111	109.5	81	85	83	105 ^d	109 ^b
Omhi	125	123	124	110	109	109.5	93	73	83	109 ^{cd}	102 ^c
Kent	131	130	130.5	118	112	115	90	64	77	113 ^{bc}	102 ^c
Mean	134	134	134	117	116	116	95	79	87	116	110
	2001/02			2002/03							
CV, %	5.21			5.8							
LSD (0.05)											
Variety	5.771			6.093							
Cutting	4.08			4.309							
V × C	9.996			10.55							

Table 3. Days to maturity (75%) of various oat cultivars under different cutting practices in two years

Variety	Zero cut			One cut			Two cut			Mean	
	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03
Canadian	135	137	136	137	139	138	152	146	149	141 ^{ab}	140 ^a
Bundel	133	127	130	134	127	131	133	138	136	134 ^c	130 ^c
Taiko	144	130	137	145	131	138	144	138	141	144 ^a	133 ^b
Caravile	140	128	134	147	130	139	147	136	142	145 ^a	131 ^c
Omhi	133	129	131	136	131	134	145	137	141	138 ^b	133 ^b
Kent	130	129	130	134	129	132	136	137	137	133 ^c	132 ^{bc}
Mean	136	130	133	139	131	135	143	139	141	139	133
	2001/02			2002/03							
CV, %	2.82			1.61							
LSD (0.5)											
Variety	3.764			1.418							
Cutting	2.662			1.003							
V × C	6.519			ns							

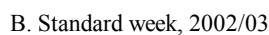
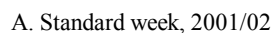
Seed yield

Significantly different ($P<0.01$) seed yields were observed between varieties and cuttings in both the years 2001 and 2002. The overall first year yield (1.669 t/h) was significantly ($P<0.01$) higher than second year average (0.943 t/h). This could be due to late sowing in 2002 and also because of heavy hail storm during cropping season in second year (Feb 19, March 13 and March 16). Irrespective of variety, significantly ($P<0.01$) higher yield was obtained from zero cut (1.824 t/h), followed by one cut (1.375 t/h) and very poor production in two cut (0.706 t/h).

Under zero cut management, higher yield was obtained from Kent (2.213 t/h), followed by Bundel (2.206 t/h), Canadian (1.838 t/h) and Omhi (1.819). Tiwari (2002) has reported seed yields of 2.613 t/h, 2.54 t/ha, 2.16 t/ha, 2.00 t/ha and 1.223 t/ha from Kent, Bundel, Caraville, Omhi and Canadian, respectively under rainfed condition under no cut management (20 Nov sowing). He also found decreasing trends of seed yield with delay sowing. However, Bundel produced significantly higher seed yield (2.079 t/h), followed by Omhi (1.59 t/h), Kent (1.343 t/h) and Canadian (1.163 t/h) from one cut management practices. Similarly, Bundel and Kent produced higher yield (1.13 t/ha and 0.921 t/h respectively) under two cuts management. The overall data of variety means revealed that seed yield decreased by 25% and 60% from that of zero cut after taking one cut and two cut respectively. Seed yield was decreased by 5%, 13%, 26%, 29%, 37% and 39% in One cut and similarly 49%, 57%, 68%, 69%, 72% and 58% in two cuts management from that of zero cut for varieties, Bundel, Omhi, Caraville, Taiko, Canadian and Kent respectively. This indicated that out of tested varieties Bundel and Omhi even after taking one cut produced more seed yield and green mass than that of zero cut.

Variety	Zero cut			One cut			Two cut			Mean		
	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03	Av	01/02	02/03	AV
Canadian	2.723	0.954	1.838	1.967	0.358	1.163	0.9	0.115	0.51	1.863 ^b	0.476 ^c	1.17
Bundel	2.517	1.895	2.206	2.35	1.809	2.079	1.883	0.382	1.13	2.25 ^a	1.362 ^a	1.806
Taiko	1.483	1.429	1.456	0.967	1.106	1.036	0.633	0.265	0.449	1.028 ^c	0.933 ^b	0.981
Caravile	1.55	1.272	1.411	0.883	1.194	1.038	0.567	0.325	0.446	1.00 ^c	0.93 ^b	0.965
Omhi	2.05	1.588	1.819	1.917	1.264	1.591	1.3	0.261	0.781	1.756 ^b	1.038 ^b	1.397
Kent	2.883	1.543	2.213	1.8	0.886	1.343	1.517	0.325	0.921	2.07 ^{ab}	0.918 ^b	1.492
Mean	2.201	1.447	1.824	1.647	1.103	1.375	1.133	0.279	0.706	1.669	0.943	1.302
	2001/02			2002/03								
CV, %	21.5			22.15								
LSD (0.5)												
Variety	0.341			0.201								
Cutting	0.214			0.142								
V × C	ns			0.348								

Except Canadian and Taiko variety, there is a high chance of lodging at maturity under zero cut management where as after taking one cut lodging tendency was reduced though it was slightly observed only in Kent variety.



445

CONCLUSION

Kent and Bundel-851 are higher seed yielder varieties (2.213 t/ha and 2.206 t/ha, respectively) under zero cut management practices under rainfed condition at Central Tarai. Seed yield considerably decreased with number of cuttings viz. 25% in one cut and 60% in two cut compared to zero cut management. However, in case of Bundel after taking one cut (5.33 t/h green forage) seed yield was decreased only by 5%. Although more seed yield was obtained from zero cutting management, one cutting management practices for seed production of Bundel seems beneficial even under rainfed condition for it provides additional benefits in terms of green forage. Furthermore, high risk of lodging and devoid of forage harvesting in Zero cut also forced to go for one cutting management practices for seed production. After taking two cut, not only seed yield was drastically decreased but quality of seed also seemed to be deteriorated. However, quality of seed is not found to be influenced in case of one cut management. So, Kent and Bundel can be used for seed production under rainfed condition with zero cutting management. However, Bundel for seed production with one cut practices under rainfed condition is more beneficial.

ACKNOWLEDGEMENTS

The authors express their sincere thanks to Mr. Raghawandra Mishra, Regional Agriculture Research Station, Parwanipur for his support to carry out this experiment. Thanks are due to Dilip Saha, Padam Lal Adhikari and Khem Pomu, Poultry Research Unit, Parwanipur for their active involvement throughout the trial period. Sincere thanks goes to Dinesh Pariyer, Pasture and Fodder Research Division, Khumaltar for providing the seed materials and other supports.

REFERENCES

- Aryal IK and HB Gurung. 2000. Effect of planting on fodder production of oats under rainfed condition. *Proceedings of the third National Animal Science Association*, 27-28 August 1997 Kathmandu.
- RARS. 2000. General assessment of major technology problems in the region. *Regional Agriculture Research Report*, RARS, Parwanipur. Pp.7.
- Raut Y, DR Pradhan and AS Ranjit. 1997. Pasture development situation and its constraints for livestock production in Nepal. *Proceedings of the third National Animal Science Association*, 27-28 August 1997 Kathmandu.
- Shrestha NP and BB Karki. 1995. Study of different cultivars of oat for green forage production under rainfed condition. *Proceedings of the third National Animal Science Convention*, 7-10 August 1995, Lalitpur, Nepal.
- Tiwari DN. 2002. Effect of sowing dates on the biomass and seed production of oat cultivars under rainfed condition at RARS, Nepalgunj. *Proceedings of the fourth national Workshop on Livestock and Fisheries Research in Nepal*.

A Review on Ten Years (1991-2000) Outreach Research Findings of Horticultural Crops in Research Command Area of ARS, Lumle

Amar B Pun and Yam R Pandey

Regional Agricultural Research Station, Lumle, Kaski

ABSTRACT

All the publications of outreach research findings of horticultural crops and some other related technical publications for the past ten years 1991 to 2000. were reviewed. The research findings of common vegetables under variety verification, diseases and insect-pest and agronomic practices that were expected to be relevant and useful to the extension workers, farmers and researchers are obstructed in this paper. The vegetable crops included in this paper are cucumbers, bitter gourd, sponge gourd, summer squash, cauliflower, cabbage, radish, onion, garlic and broad leaf mustard. Majorities of the studies were focussed on varietal and cultural management. The cucumber Bhaktapur Local was identified as the best variety for off-season production. Different staking practices were also studied for cucumber production. Under high management practice for commercial production where fruit are harvested even after the onset of monsoon and irrigation facility exists, staking with wooden stick was found beneficial. Similarly, Creeper, Baisakhi and Grey Coat were found promising varieties of bitter gourd, sponge gourd and summer squash respectively. Studies on varietal, boron application and disease management of cauliflower and cabbage were carried out. The cauliflower varieties; Snow Dome, Snow King and Snow Crown were found promising for their higher curd yield and suitability for off-season production. Cabbage varieties Copen Hegan Market, Green Challenger and Green Coronet were found promising for their yield, compact head and marketability. Minu Early was found important radish variety for normal season production and 40 days for early production in normal season. Tokinase was observed one of the best for late season production. Similarly, the farmers for their attractive root color and taste preferred Lumle Red and Pyuthane Red. Red Creole, Regel and Early Red were found to be good yield potential varieties of Onion, whereas Early Red has a better storing capacity. Some indigenous germplasms of Garlic were evaluated, in which Lamjung, Palpa, Lungdi and Panchkhal Local were found high yielding varieties. Similarly, under the TuMV resistance varietal screening studies, a large number of families of Manakamana BLM were found resistant to TuMV in comparison to Khumal and other local varieties.

Key words: Husbandry technology, outreach horticulture research, review, variety

INTRODUCTION

Various on-farm verification trials on vegetable crops cucurbits, cole crops, radish, onion, garlic and broad leaf mustard. have been conducted in the farmers' field at 10 different outreach sites in 9 mid hill districts of western region of Nepal. The objectives of these outreach programs were to verify and to disseminate the technology developed at elsewhere so as to identify suitable technologies for wider range of agro-climates and socio-economic conditions with farmers and extension's participation.

Research findings under the varietal research and agronomic practices of vegetable crops that have been carried out during the last decade 1991-2000., has been reviewed. This paper in the form of research highlights has been summarized and synthesized as a research conclusion and recommendations. It has believed that this paper will help to the extension workers, farmers and other line agencies as a guideline for increased production and productivity of vegetable crops. Most of the technologies those tested in the outreach programs on horticultural crops in the last decade 1991-2000. were in the form of FFTs, PPVTs, verification studies, seed production studies and so on.

MAJOR FINDINGS OF OUTREACH RESEARCH ON HORTICULTURAL CROPS DURING THE PERIOD OF LAST TEN YEARS 1991-2000

Cucurbits

Cucurbits are important vegetable crops especially for both subsistence and commercial production system in the western hills of Nepal. The common cucurbits grown in the western hills are Cucumber, bitter gourd, sponge gourd, zucchini and Chayote. The production of cucurbits in off-season was high potential for market value. During this decade, the priority was given on the identification of varieties and management practices suitable for the off-season production.

Cucumber

Cucumber is one of the important cucurbits crops in the western hills of Nepal. Normally, this crop is grown in April-September. Cucumber production before and beyond this period has high market value. Different experiments were conducted on varietal improvement and management practices for off-season production in this last decade.

The variety Bhaktapur local was found an appropriate variety for off-season production for low to mid hills 1500 masl. areas both in term of its good fruit yield, good quality fruits fruit shape, size, color and taste., early bearing and also in term of farmers and consumers preference. On an average the fruit yield of 22.4 t/ha was recorded of this variety and a day to first harvest was recorded 63 days. Seedling raising using poly pot in hot bed in early January and transplant in during Feb–March was concluded a suitable time and means for off-season cucumber production.

The technology of maintaining two plants /hill was found appropriate than one plant /hill in term of high fruit yield as well as safeguard against missing plants in the hills during dry season cultivation. The research results revealed that the effect of plant density on marketable fruit yield was significant where two plants /hill increased the marketable fruit yield by 15 % 44.7 t/ha vs 39.0 t/ha. over one plant /hill. The significant result plant density was observed on crop yield that two plants per hill was observed better than one plant per hill.

Table 1. Effect of plant density on crop period and fruit yield of cucumber during 1992 and 1994

Plant density	Days to first harvest			Mean	Marketable fruit yield, t/ha			Mean
	1992/92	1994/95	1993/94		1992/92	1994/94	1993/94	
Plant/hill	82.2	85	70	79.1	39.44	47.0	37.18	41.2
Plant/hill	82.4	85	70	79.1	44.23	52.53	42.38	46.4

Under high management practices for commercial production, where fruits are harvested even after the onset of monsoon and irrigation facility exists, the staking was found beneficial in term of quality fruit production that allow to apply various improved cultural practices including timely irrigation and pesticides application.

Table 2. Effect of staking system on crops period and marketable yield of cucumber Bhaktapur Local. in RCA, Lumle, 1992/92, 1995/96, 1996/97

Treatment	Days to first harvest			Mean	Marketable fruit yield, t/ha			Mean
	1996/97	1995/96	1992/93		1996/97	1995/96	1992/93	
Staking with plastic string	77	64	82	74.33	33.12	25.70	48.44	35.75
Farmers practice of staking	77	64		70.5	31.35	28.40		29.87
No staking	78	63	82	74.33	25.60	25.60	36.10	29.10

Whereas, no use of staking was found useful under poor to moderate management condition and even the fruits are harvested before monsoon starts. It is better not to use staking under dry season cultivation since spreading plants covers most part of the ground, which helps in conserving the soil moisture and also it minimizes the investment cost of staking. However, the unmarketable fruit yield was found higher in case of non-staking by 116% over farmers practice of staking and the problems of fruit curvature, whitish fruit color and poor taste that all causing fruit quality were also observed under non-staking.

Bitter gourd

Bitter gourd is an important cucurbit crop in Tarai to mid hills, especially for both traditional and commercial production systems. Normally bitter gourd is grown during July to September. The

production of this crop beyond this period as an off-season production gets high market value. Moreover, this crop has great potentiality for off-season production due to its long productive life, very less diseases and insect-pest attack and relative tolerant to moisture stress condition.

Under varietal trials, Creeper was found a suitable variety in term of high fruit yield, uniform fruit type and attractive fruit shape and moderate level of bitterness. On an average, this variety was ready for first harvest at 75 days found one week earlier than the varieties Green Long and White Long. Average fruit yield of 28.0 t/ha was reported of this variety that was higher than the yield of White Long 26.69 t/ha. and Green Long 23.15 t/ha.

Table 3. Days to first harvest and marketable fruit yield of bitter gourd

Character	Varieties					
	CO-1	Pusa Do Mausami	White Long	Green Long	Creeper	Jaunpur
Days to first harvest	90	89	70	71	75	77
Yield, t/ha	24.9	20.2	26.69	23.15	27.84	18.57

Gourd, particularly a vine species, requires staking for good production. It was found relatively long productive life compare to other gourds like cucumber and sponge gourd. The practice of staking was found better to minimize the fruit rot and to extend the productive life of the plant during rainy season.

Sponge gourd

Off-season production of Sponge gourd has a high market value. Normally it is grown in May to August, the production during this period receives very less market price. If it could be produced beyond this period, substantial high market value could fetch.

A total of five varieties of Sponge gourd including Local genotypes were tested to verify suitable varieties in term of earlier and yield potential for off-season production. The average yield and maturity period of the different Sponge gourd varieties tested at different locations are presented in the table. Among the tested varieties, Baisakhi was observed an appropriate variety for off-season production in term of yield potential and earlier maturity. This variety was mostly preferred to its attractive fruit color and tenderness. Farmers reported that variety Pusa Chickni developed fibers in fruits earlier than variety Baisakhi. The reported overall mean yield indicated that Baisakhi 30.92 t/ha. out yielded Pusa Chickni 29.49 t/ha. by 4.84%. However, Pusa Chickni was also equally preferable variety because of its attractive green skin color and smaller fruit size, which are affordable to all kind of consumers.

Table 4. Average yield and maturity period of sponge gourd varieties tested at different locations of RCA, Lumle

Observation	Varieties				
	Pusa Chickni	Baisakhi	Tanchock Local	Lumle Local	Paudhur Local
Days to first harvest	83	81	85	86	94
Marketable yield, t/ha	29.49	30.92	14.43	6.61	2.4

The practice of planting two plants/hill was observed better than one plant /hill for higher fruit yield as well as less chance of missing plant at hills. The effect of plant density on fruit yield and harvesting period was evident, where one plant /hill was found delayed harvesting by three days.

Summer squash

The variety Grey Coat was found superior than other tested varieties for off-season production in term of yield and quality of fruit ie color and shape.. The variety Black beauty was equally suitable for fruit yield and number of fruit per plant. The result showed that on an average marketable fruit yield of 23.2 t/ha and 21.2 t/ha were recorded of varieties Grey Coat and Black Beauty respectively.

Fresh vegetable production during the period of March to mid June is very difficult due to moisture deficit in the soil. Mostly poor farmers with low purchasing power are deprived of fresh vegetable consumption. To alleviate this problem, an attempt on early fruiting and easily cultivable cucurbitaceous vegetable i.e. Summer squash production was carried out to determine the possibility of producing fruits with minimum use of water during summer season.

The use of mulching and fertilizer application in recommended amount without irrigation was resulted a satisfactory effect on higher fruit yield of Summer Squash in summer season as compared to non-mulching. Similarly, the grass/ straw mulching was found better than the pit planting for higher fruit yield. The results of time of planting trials revealed that late January planting, as a safe and appropriate planting time for Summer Squash production since most of the crop life coincides to the unfavorable weather i.e. winter stress and foggy weather resulting poor set in early planting. Similarly, heavy fruit fly incidence was observed in late planting.

Cole crops

Cauliflower and cabbage are the two most popular and economically important Cole crop commercially grown for fresh market and seed production in the hills of Nepal. These crops in the Western Hills of Nepal are grown both in normal and off-season as well.

Cauliflower: With the development and introduction of new hybrid varieties of Cauliflower, it is possible year round production. The production of cauliflower either on early and late seasons has a great potential for market value. The early, mid and late maturing varieties for mid and upper hills were been identified under varietal selection experiments. The reported suitable growing season and marketable curd yield of Cauliflower varieties are as follow:

Under the varietal verification trial, Snow King was observed an appropriate variety for early season production in term of high curd yield and curd quality curd size, compact and uniformity.. Besides this, variety Snow Queen and Silver Cup were found also equally good varieties. Snow Dome and Snow Crown have performed well for mid season. Similarly, Kathmandu Local, Snow ball-16 and Snow Dome were observed good performance for mid season. Whereas, the Kibogaint was an appropriate variety of Cauliflower for late season production up to December planting. at the altitude around 1600 masl in term of its highest curd yield and curd quality curd color and compactness.. This variety was also found wider adaptability of wide range of temperature than other tested varieties, since it was found less problems of richness, buttoning and curd compactness even in late season. The taste of Kibogaint was better than Snow ball-16 and comparable with Kathmandu Local. On an average Kibogaint 14.78 t/ha. out yielded Snow Ball-16 12.45 t/ha. by18.7%.

The off-season production of Cauliflower on summer season March-May. has a lot of opportunity in the hills to get high market value. Considering the performance of different late season varieties of Cauliflower on two planting dates ie Mid December and Mid January, Kibogaint has been found suitable for growing in summer season at the altitude around 1600 masl. On an alternative to Kibogaint, Snow ball-16 was found suitable for summer season production at and around Lumle condition.

Among the tested varieties, Snow ball-16 was found earlier than Kibogaint and Kathmandu Local. Varieties planted on Mid January were found significantly earlier than planted in Mid December. The problem of richness, buttoning and loose curd were substantially occurred higher in varieties Snow ball-16 and Kathmandu Local than Kibogaint, possibly due to their poor adaptability of temperature. When comparing between two planting dates, the percentage of richness and buttoning occurred significantly higher on Mid January planting than Mid December planting in all varieties. Similarly, mean curd compactness was higher in Mid January planting than the Mid December planting of all varieties.

Table 5. Effect of planting dates on days to 50% curd harvest and marketable fruit yield of different varieties of Cauliflower at RCA of ARS, Lumle during 1991-2000

Date of planting	Days to 50% curd harvesting						Marketable curd yield, t/ha					
	1992/93			1994/95			1992/93			1994/95		
	Kibo gaint	Snow ball-16	Kath L	Kibo gaint	Snow ball-16	Kath. L	Kibo gaint	Snow ball-16	Kath. L	Kibo gaint	Snow ball-16	Kath. L
15 November	145	135	142	127	120	117	15.1	6.5	5.0	16.4	10.6	11.3
01 December	138	128	140	131	122	124	9.5	4.7	4.8	11.7	10.0	5.9
15 December	134	123	128	122	112	116	12.1	6.9	2.3	10.6	8.7	3.0
1 January	125	124	123	110	104	112	9.3	6.3	5.3	10.7	10.9	3.9
15 January	124	121	120	101	92	101	13.6	6.0	4.1	9.9	6.0	3.2
01 February	127	122	115	99	91	93	7.3	4.9	4.3	6.3	6.4	1.7
15 February	115	118	110	105	89	92	7.2	5.4	4.0	2.1	3.7	0.7

Damping-off disease caused by *Pythium* spp is one of the major biotic constraints of Cole crops in nursery beds. High rainfall and relative humidity during nursery raising period favors the disease development and poses a great threat for raising seedlings because unfortunately the rainy season coincides the nursery raising period.

From the results of the experiments on damping-off disease management in cauliflower, the following points could be concluded

- Soil sterilization and formalin soil treatment of nursery bed was found effective in reducing damping-off incidence in seedling raising.
- Partial tunneling in comparison to full tunneling for seedling raising during rainy season was seen effective to produce less affected seedling.
- Formalin soil treatment and use of agronomic field soil for nursery raising was equally effective to produce less affected seedling by damping-off.

The practice of seedling raising in nursery bed by partial tunneling in combination with either formalin drenching of soil or use of agronomic crop field soil was found effective in reducing damping-off incidence. The problem of dwarf seedlings in agronomic crop field could be corrected by applying chemical fertilizers and foliar application of nutrients. The performance of the compost extract was reported well in managing many diseases of various crops.

Table 6. Effect of soil sand mixture on seed germination, damping off and survivability of seedlings during 1991/92 and 1992/93

Soil and sand ratio	Seed germination				Seedling dead				Seedling survivability			
	1991		1992		1991		1992		1991		1992	
	%	Arcsine	%	Arcsine	%	Arcsine	%	Arcsine	%	Arcsine	%	Arcsine
1:0	-	-	55.1	46.8	29.1	28.6	10.7	17.7	70.9	60.9	9.4	8.8
3:1												
1:1												
1:3												

The cauliflower was found apparently responsive to the micronutrient, particularly to the boron. Under the boron deficit condition, a substantial loss in crop yield was occurred. The occurrence of micronutrient deficiency has been increasing in the farmer's field. The effect of boron application on marketable curd yield has been found significant that the results showed curd yield increased by 39% due to the application of boron. In study it was reported that the variety snow ball-16 was more prone to boron deficiency and more responsive to boron application than Kibogaint. Majority of the farmers has preferred the practice of boron application in cauliflower because it improved the quality of curd

Table 7. The fresh marketable curd yield t/ha. of two cauliflower varieties with and without the application of borax during 1993/94 season

Treatment	Sites								Mean
	Dhanubase	Khabara	Hemja	Mallaj	Kudule	Khurkot	L/Saliya	U/Saliya	
Snowball +Borax	14.2	14.9	12.7	12.5	4.0	6.6	15.6	18.8	12.4
Snowball + No Borax	18.8	11.2	15.5	11.8	3.1	4.9	15.3	12.7	11.7
Kath. Local +Borax	8.2	9.9	11.9	15.4	4.2	4.8	10.6	17.2	10.3
Kath. Local +No Borax	10.6	8.3	14.2	3.8	3.6	2.3	9.3	8.7	8.8

Cabbage: In general, Cabbage is a winter season crop. However, with the development of heat tolerant varieties, now it is possible to produce upto the mean temperature range of 38°C. The result of heat tolerant varieties indicated the possibility of off-season cabbage production during summer and rainy season December to August. in the hills of Nepal.

Among the tested varieties, the F₁ hybrid variety K.K. Cross, Green Cross and Green Coronet were found suitable for off-season production. These all varieties took around 67 to 111 days for maturity after transplanting. Comparatively variety Green Stone was earlier and Green coronet was late than other varieties. On an average, yield of K.K. Cross and Green Coronet were reported about 36.4 t/ha and 31.7 t/ha respectively. On account of consumer's preference, the varieties Green Stone, Green-621 and T-621 were

better for off-season production due to its compact and marketable head size. The research result revealed that KK cross out yielded Green coronet, Green stone and LEO F₁ by 16.7%, 18% and 62% respectively.

The Copen Hegan Market Nepal., since the seed of this variety is locally available in cheap price, was performed better for normal season. The performance of other open pollinated varieties like Copen Hegan Market H. and Drum Head were found inferior as compared to Copen Hegan Market N.. However, fresh cabbage production during summer and rainy season with the use of open pollinated varieties was observed difficult. It was because they produce the compact head only upon induction of the chilling requirement of 18-22o C for certain thermal cumulative hours.

Table 8. The performance of Cabbage varieties tested during 1991-2000

Variety	Observations			
	Days to harvesting	Marketable head yield, t/ha	Heading, %	Transplanting
K.K.Cross	78	18.6	93.9	Mid- May to mid August
Kaveri	76	18.7	89.7	Mid- May to mid August
Ganga	90	15.0	80	Mid-October to mid-December
Pride of India	101	19.9		
Green Coronet				
Copen Hegan Market	84	11.93		Mid-December to mid-February
Drum Head	108	9.6		

Radish

During summer, radish cultivation was reported scarce in the hills because of the pre-mature bolting problem in the Terai. From the experiments, Tokinashi was found suitable for growing in off-season summer season. without pre-mature bolting problem.

The experiments conducted during this period indicated that Minu Early not suitable for off-season except for normal season due to heavy pre-mature bolting, unmarketable root shape and size, high fiber content and very poor quality of roots. The overall result of root yield revealed that Tokinashi out yielded over all tested varieties.

Table 9. Crop period and yield performance of different Radish varieties tested during 1991-2000

Variety	Days to first harvest			Marketable root yield, t/ha		
	1990/91	1991/92	1995/96	1990/91	1991/92	1995/96
40 Days	77	51	52	3.55	6.8	4.5
Minu Early	101	86	95	17.95	29.4	2.9
Pyuthane Red	88	83	95	12.95	23.4	10.0
Tokinashi	100	93	101	32.50	33.5	23.5
Pusa Chetaki	92	60	81	18.30	8.6	23.5
Lumle Red	100	61	96	15.00	16.3	14.3

Table 10. Effect of organic and inorganic fertilizers on days to first harvest and marketable root yield of Radish varieties during off-season, 1995/96

Treatment	Days to first harvest	Marketable root yield, t/ha
Minu Early +Only compost	66	2.08
Minu Early + Compost and chemical fertilizer	65	4.23
Tokinashi + Only compost	92	18.4
Tokinashi + compost and chemical fertilizer	92	25.6

A study on seed production of radish was carried out to verify the suitable varieties and planting time. The Lumle Red, seeding on 22 September was found best for highest seed yield. Moreover, the seeding on 22 September was neither too late nor too early for seed production of this variety. The average crop duration for seed production was 138 days from transplanting and yield of 1.4 t/ha.

Onion

Different varietal trials on onion were carried out to identify the bolting resistance in 1991/92, 1992/93 and 1993/4. Rank analysis of yield for three years over locations resulted Equanex, Regel PVP, Rio Roji Red, Granoble and Early Red were appeared promising than the rest varieties. Similarly, the

varietal trial carried out in 1995/96 revealed that Regel was found better for normal season onion production followed by Early Red in term of both higher bulb yield 39.5 t/ha. and good quality bulb. All the varieties ie Regel PVP, Red Synthetic, Early Red, Red Creole, Mallaj Local and N-53. included under study took almost same number of days 138-147 days. from transplanting to maturity.

Table 11. Performance of different radish varieties in different seasons in the hills

Region, masl	Activity	Varieties			
		40 days	Minu Early	Pyuthane Red	Tokinashi
Low hill 300-900.	Planting time	Mid Mar- October	October-Mid Nov	Mid Aug - November	Dec – Feb
	Harvesting time, days	35-45	60	83	75-90
	Yield, t/ha	12-18	30-46	34-38	10-16
Mid hill 901-1400.	Planting time	July – Oct.	Mid Mar–May Aug– Oct	Mid Aug– Oct	Dec –Feb
	Harvesting time, days	40-50	65	70	80-100
	Yield, t/ha	20-30	40-50	30-40	20-40
Upper mid hill 1401-2200.	Planting time	Aug. – Sep.	Mid Mar– May Mid Jul– Mid Sep	Aug– Mid Sep	Dec – Feb
	Harvesting time, days	40-50	60	70	80-120
	Yield, t/ha	20-30	50-76	34-60	34-76

Off-season onion cultivation during the monsoon season has number of advantage over the normal season. Various studies conducted at LARC had shown good result with the off-season set planting of N-53, Nasik Red, Mallaj Local and Red Creole Budathoki et al 1990.. Therefore, these varieties were further verified in different agro-ecological domain. Under the varietal study carried out in 1992/93 for off-season production, Agrifound Dark Red produced 31% and 15 folds more bulb yield than Red Creole and dN-53 respectively. Similarly, an onion varietal trial in 1995/96 for off-season production through the use of set revealed a good potential for green onion production because of severe non-bulbing, bolting and bulb splitting problems and high demand of green onion during this period September–November.. The storability is very crucial criteria for variety selection in onion, where Early Red was found a better storable than Granoble, Equanex, Rio Roja Red and Regal PVP in spite of its lower marketable bulb yield. Bulb of Early Red could be stored for up to four months after harvest Bhattarai 1993, Budathoki and Subedi 1996.. One more trial, on determination of critical weed competition stages and management aspects on onion production was carried out in 1993/94. In the results, Isoproturan 2 g/l. of water was found suitable for weed control in onion when applied at 15 days after transplanting. Weed competition in the early stage was found very critical to yield, survival and economic return. Mulching was equally effective as frequent weeding. Study also revealed that not only the number of weeding but also the timing of weeding was found very important in onion weed management. Weeding during the early crop growth was very crucial than late weeding.

The overall treatments mean averaged over locations indicated that the variety Early Red 46.11 t/ha. was the highest bulb yielder and produced 8.9% and 11% more bulb than Red Creole and Mallaj Local respectively. Farmers preferred the variety Early Red for its less splitting and less bolting properties and producing big size and good quality bulbs ie attractive, big and uniform bulb shape and size..

Table 12. Days to harvest and marketable bulb yield of onion varieties tested under FFT, 1996/97

Location	Varieties					
	Early Red		Red Creole		Mallajh local	
	Days to harvest	Bulb yield, t/ha	Days to harvest	Bulb yield, t/ha	Days to harvest	Bulb yield, t/ha
Dhanubase	133	33.10	133	28.23	133	28.38
Kholakheth						
Kudule	153	42.11	153	57.48	155	55.08
	131	63.13	131	41.27	131	41.0
Mean	139	46.11	139	42.33	13	41.49

Out of the six varieties, Regal PVP and Early Red were found to be most promising varieties at most of the locations across low to high hills. The overall treatments mean across the locations also indicated that Regal PVP was found promising for normal season followed by Early Red in term of both highest bulb yield and farmers' preference. Early Red was also preferred by farmers for its higher marketable bulb yield and good quality bulbs. All the varieties included under study took almost same number of days 138-147 days. from transplanting to maturity.

Agrifound Dark Red was observed to be the best variety for green onion production in off-season. Farmers preferred green onion production during off-season rather than keeping the plants for bulb production because green onion has high demand in market and fetched a good market price. The mean days to green onion harvest ranged from 121 days Agrifound Dark Red. and Nasik Red. to 125 days Mallajh local..

Table 13. Marketable bulb yield and days to harvesting of onion varieties under FFT in 1995/96

Variety	Normal season		Off-season monsoon season through the use of set.	
	Marketable bulb yield, t/ha	Days to harvesting	Marketable bulb yield, t/ha green onion	Days to harvesting
Regal PVP	39.5	138	22.10 Nasik Red.	121
Red	25.4	139	30.14 Agrifound dark red.	121
Synthetic	35.4	138	24.94 Agrifound light red.	123
Early Red	28.8	140	20.46	123
Red Creole	29.8	140	16.90	125
Mallajh local	23.3	139	-	-
N-53				

Garlic

Garlic is one of the important spice crops. It has a wide use from green vegetable to medicinal purpose besides spices. Garlic has a wide range of agro-ecological and socio-economic cultural adaptability and can be grown from Terai to high hills 300 masl 3500 masl. across the diverse range of farming system.

The indigenous germplasms have reported wide genetic variations for yield and earliness. Taking this into account, an initial evaluation trial on local and exotic Garlic germplasms was carried out at Lumle Centre 1600 masl. in 1991/92. Out of 16 genotypes tested, early group varieties matured in 203 days 10 Sept 1991 to 1 April 1992, these were Panchkhal, Kathmendu, Palpa, Lamjung, Lungdi and Khurkot. Among these early matured varieties, Lamjung, Palpa, Lungdi and Panchkhal produced higher yield of 33.9 t/ha, 26.9 t/ha, 26.2 t/ha and 25.57 t/ha respectively. These early matured and higher yielder varieties were found suitable for maize-garlic cropping system Bari land. for mid hill region. The highest yield was observed on variety Bhote but it could not fit on maize based cropping system due to late maturity attribute.

Later in 1993/94, an evaluation of local and exotic Garlic germplasms by including 45 genotypes for maize-garlic and rice-garlic cropping system was carried out. The higher yield and early crop period were observed on the varieties: Kholakheth, Lungdi, Keware II, Keware III Bandipur II, Lamjung I and Lamjung II. They were also found suitable for Maize- Garlic system.

Broad leaf mustard

Broad leaf mustard is most important winter leafy vegetable in Nepal. Although, a large number of local varieties are available, the cultivar Marpha and Khumal are recommended due to their good foliage characteristic. But in recent years, turnip mosaic virus has seen a severe problem in its commercial production. This disease caused dwarfing, mild to severe mosaic and distortion of leaf blades, resulting in inedible leaves. If the infection occurs early, plant dies prematurely. Taking this fact, a study on progeny test of turnip mosaic virus TuMV. resistant BLM cv Manakamana and Epidemiology of TuMV was carried out in 1993 and 1994 to examine the segregation pattern of S2 progenies and to develop TuMV control method with altered planting date and resistant varieties.

The results showed that out of the 32 tested families of cv Manakamana, the progenies of 10 families produced 100% immune plants. This means that frequencies of resistance gene were found increasing through the selfing cycle. Whereas, different dates of planting was observed some effect on apparent rate of infection. The results suggest earlier dates of planting had lower rate of infection and vice versa. The four years

studies on varieties screening resulted into a variety Manakamana resistant to TuMV. In the beginning, resistant was heterogeneous but after screening of 3 selfing generations, uniformly resistance progenies were produced.

Transmission studies showed that aphids *Myzus persicae*. were the most important vectors. Moreover, flea beetle was also established as a TuMV vector. The research study on screening in Natural condition at ARS, Lumle Pokhara was carried out in 1991 and the results revealed that intensity of infection cv. Manakamana was appreciably lower in comparison to other varieties. Besides Manakamana, test plants of Tankhuwa and Paran Chaur Local under artificial condition at Lumle showed low intensity of the disease. In comparison to the results of susceptible cv Khumal, resistance genes appeared to be accumulating in the advancing selfing generation of Manakamana families. Test of transmission of turnip mosaic virus of broad leaf mustard through seed revealed that none of the test plants produced symptoms of TuMV, indicating that this disease was not seed transmitted in BLM as in other hosts Stobbs and Stirling 1990.. Generally viruses were transmitted via seeds.

Survey done for monitoring turnip mosaic virus at Lumle and Pokhara showed only 3.2% of the Manakamana population was infected by TuMV, whereas 98.2% of cv Khumal planted close with Manakamana seed plots were affected by TuMV under natural conditions. This showed that inoculum pressure was high in Pokhara, and also that cv Manakamana was field resistance to TuMV. It also confirms the potential for genetic improvement of Manakamana populations against TuMV, so that this variety could be a gene donor for future crossing programs to develop a good quality BLM variety resistant to TuMV.

CONCLUSION

The review of research findings of outreach Horticultural crops in last ten years has carried out with the objective of refreshing the information to the researchers, extensions and farmers. The vegetable crops included in this paper are cucurbits, cauliflower, cabbage, radish, onion, garlic and broad leaf mustard. Varietal verification, cultural management and disease controls are the major aspects of research studies done in the last decade.

ACKNOWLEDGEMENTS

The authors are indebted to all the researchers, who had involved in research on outreach horticulture during the last decade and grateful to Dr DN Sah for his encouragement for bringing out this paper. The author expresses also the heart-felt thanks to Mr IP Gautam, reviewer of this paper for his critical review and guidelines, so we able to come up with paper successful.

REFERENCES

- Amatya RK, JP Jaiswal and KJ Gurung. 1994.. Summer and off-season vegetable demonstration conducted at LARC's ECA during 1991/92. *LARC Working Paper No. 94/17*. Lumle Agricultural Research Centre, Kaski Nepal.
- Bhattarai SP and PP Subedi. 1994. Normal and off-season variety, nutrition and management trial at outreach sites. *Working Paper No. 94/36*. Lumle Agriculture Research Centre.
- Bhattarai SP and PP Subedi. 1995. Varietal and staking trial on cucumber and bitter gourd at outreach research sites. *Working Paper No. 95/35*. Lumle Agriculture Research Centre.
- Bhattarai SP and PP Subedi. 1996. Varietal and boron trials on cauliflower and evaluation of heat tolerant cabbage at outreach research during 1993/94 season. *LARC Working Paper No. 96/34*. Lumle Agricultural Research Centre, Kaski Nepal.
- Bhattarai SP and PP Subedi. 1996.. Varietal and boron trials on cauliflower and heat tolerant cabbage at outreach research during 1993/94 season. Working Paper No. 96/34. Kaski, Nepal: Lumle Agriculture Research Centre.
- Bhattarai SP, B Adhikari and LK Amatya. 1995. Varietal and time of planting research on normal season onion at Lumle and off-station sites conducted during 1992/93 season. *Working Paper No. 95/74*. Lumle Agriculture Research Centre.
- Bhattarai SP, B Adhikari and TB Gurung. 1994. Set size standardization and time of planting trial on off-season onion, 1993/94. *Working Paper No. 94/45*. Lumle Agriculture Research Centre.
- Bhattarai SP. 1993. Garlic Research at Lumle during 1991/92. *Working Paper No. 1993/34*. Lumle Agriculture Research Centre.
- Bhattarai SP. 1993. Off-season onion *Allium cepa* L Research at Lumle, 1991/92. *Working Paper No. 93/38*. Lumle Agriculture Research Centre.

- Bhattarai SP. 1995. Evaluation of local and exotic garlic germplasm for maize-garlic and rice-garlic cropping systems in the western hills of Nepal during 1993/94 season. *Working Paper No. 95/75*. Lumle Agriculture Research Centre.
- Budathiki K, G Gurung, DP Lohar, SP Bhattarai, HM Gurung, BD Thapa and G Rana. 1992. Summary of the research outreach results on vegetable crops. *Working Paper No. 95/28*. Lumle Agriculture Research Centre.
- Ghemire SR and S Sharma. 1996. Performance of S₄ and S₅ progenies of broad leaf mustard cv Manakamana against turnip mosaic virus. *Working Paper No. 97/4*. Lumle Agriculture Research Centre.
- Ghemire SR, RM Pradhanang and RR Pandey. 1993. Damping-off disease management of cauliflower. *Working Paper No. 93/21*. Lumle Regional Agricultural Research Centre, Kaski Nepal.
- Ghemire SR. 1994. Damping-off disease management of cauliflower. *Working Paper No. 94/31*. Lumle Agricultural Research Centre, Kaski Nepal.
- Jaisawal JP and PP Subedi. 1996. Outreach Research Report on cucurbits crops for off-season production, 1994/95. *LARC Working Paper No. 96/20*. Lumle Agricultural Research Centre, Kaski Nepal.
- Jaisawal JP and PP Subedi. 1996. Varietal cum boron trial on late season cabbage conducted at outreach sites during 1994/95. *Working Paper No. 96/36*. Lumle Agriculture Research Centre.
- Jaisawal JP and PP Subedi. 1996. Varietal trial on cabbage and varietal cum boron application trial on cauliflower conducted at outreach sites during 1995/96. *Working Paper No. 97/3*. Lumle Agriculture Research Centre.
- Jaisawal JP, PP Subedi and SP Bhattarai. 1996. Summary Findings of on-farm verification trials on vegetable crops conducted at Outreach Research Sites, 1992-95. *LARC Seminar Paper No. 96/20*. Lumle Agricultural Research Centre, Kaski Nepal.
- Jaisawal JP, PP Subedi and SP Bhattarai. 1997. Mulching trial on carrot, fertilizer trial on radish and top dressing trial on chinese cabbage conducted during 1995/96. *LARC Working Paper No. 97/27*. Lumle Agricultural Research Centre, Kaski Nepal.
- Jaisawal JP, PP Subedi PP and SP Bhattarai. 1991. Outreach research report on cucurbit crops for off-season production, 1993/94. *Working Paper No. 95/60*. Lumle Agriculture Research Centre.
- Jaisawal JP, SP Bhattarai and PP Subedi. 1997. Effect of different staking system in cucumber var. Bhaktapur Local for off-season production, 1995/96. *Working Paper No. 97/18*. Lumle Agriculture Research Centre.
- Jaisawal JP, SP Bhattarai and PP Subedi. 1997. Findings of staking trial on cucumber var Bhaktapur Local for off-season production, 1995/96. *Working Paper No. 97/48*. Lumle Agriculture Research Centre.
- Pradhanang PM. 1991. Collection and evaluation of broad leaf mustard varieties against Turnip Mosaic Virus. *Working Paper No. 91/8*. Lumle Agriculture Research Centre.
- Pradhanang RM. 1994. Progeny test on broad leaf mustard cv Manakamana against Turnip Mosaic Virus (TuMV) and epidemiology and transmission of TuMV. *LARC Working Paper No. 94/41*. Lumle Agricultural Research Centre, Kaski Nepal.
- Prasad RB and TB Karki. 2000. Summary report of outreach research in the western hills. *Lumle Seminar Paper No. 2000/16*. Agriculture Research Station, Lumle Kaski Nepal.
- Prasad RB. 2000. Outreach research report on vegetable crops in the western hills of Nepal. *Lumle Seminar Paper No. 2000/14*. Agriculture Research Station, Lumle Kaski Nepal.
- Subedi PP, SP Bhattarai and TB Gurung. 1997. Varietal trial on cauliflower for off-season summer for the hills, 1994/95. *LARC Working Paper No. 97/13*. Lumle Agricultural Research Centre, Kaski Nepal.
- Subedi PP. 1994. Causes of short productive life and mishappen fruit of cucumber for off-season production. *Working Paper No. 94/47*. Lumle Agriculture Research Centre.
- Subedi PP. 1994. Cole crop research during 1992. *Working Paper No. 94/6*. Lumle Agriculture Research Centre.

A Socio-economic Survey on Evaluation of Technology Transfer on Soil Fertility from Farmers to Farmers in the Western Hills of Nepal

Megh B Nepali, Kiran R Joshi and Buddhi B Pant

Agriculture Research Station, Lumle, Kaski

ABSTRACT

Socio – economic survey on proven soil fertility technology transfer from farmers to farmers was carried out on four agro- ecological research sites of Lumle command area on October 2002. The objective of the study was to evaluate the transfer of soil fertility management technologies to the farmers. The proven technologies, are “Plastic cover manure in a ditch for fast decaying, gives high percentage of nitrogen”, “the use of 50% manure and 50% chemical fertilizer gives better yield as well as low cost of production in comparison to the use of chemical fertilizer” and “roots left of leguminous crops in the fields by using stem cutting method at the harvesting time gives better nutrient to the next crops”, were evaluated in terms of technologies transfer from farmers to farmers. Next-door farmers who had not received the technologies, trial materials and methods were included in the interview for the evaluation of the technologies. Most of the interviewed farmers grow leguminous crops either on rice bund or in the Bari land (upland). In the study area at Chambas farmers grow upland rice – black gram, rice -cow pea and rice- soybean. In other sites, in general farmers grow maize + soybean, maize + beans, maize + cowpea as mixed crop. At lower Pakuwa and upper Pakuwa as well as Bhakimli agro ecological research sites farmers cultivate winter pea either in Bariland or in Khetland. Besides this farmers expressed their view that, leguminous crops make the soil soft and help in getting animal fodder and legume source of cash income.

INTRODUCTION

Most of the farmers grow leguminous crops either on rice bund or in the Bari land (upland). In the study area at Chambas farmers grow upland rice –black gram, rice -cow pea, rice- soybean. In other sites, in general farmers grow maize soybean and maize- beans, maize cowpea as mixed crop. At lower Pakuwa and upper Pakuwa as well as Bhakimli agro- ecological research (AER) sites farmers cultivate winter pea either in Bariland or in Khetland.

The proven technologies were “plastic cover manure in a ditch for fast decaying gives high percentage of nitrogen,” “the use of 50% manure and 50% chemical fertilizer gives better yield as well as low cost of production in comparison to the use of chemical fertilizer” and “roots left of leguminous crops in the fields by using stem cutting method at the harvesting time gives better nutrient to the next crops. These technologies were implemented in different trials in the farmers’ field in different AER sites for the purpose of transfer of technologies from farmers to farmers. Lower Pakuwa and Upper Pakuwa were based on rice – wheat, Bhakimli was Maize-millet and Chambas was based on Upland rice and blackgram cropping patterns. In maize finger millet cropping pattern farmers practices of inorganic fertilizer alone produced the highest grain yield followed by the same rate of nutrient supplied by organic and inorganic fertilizer combination (Tripathi and Shrestha 2000). Similarly in rice wheat system, application of farmers practice of 50% organic fertilizer and 50% through inorganic fertilizer produced the better yield (Tripathi and Shrestha 2000). In each AER sites each ten farmers were given the technologies, trial materials and methods. This study had evaluated the transfer of technologies from farmers to farmers. Objective of this study is to evaluate the transfer of proven soil fertility management technologies to the farmers in the western hills of Nepal.

METHODOLOGY

Discussions were made regarding the evaluation of soil fertility management technologies with Project leader and questionnaires were developed to evaluate the transfer of proven technologies. Socio – economic survey was carried out to the next-door farmers of four AER sites ie Chambas (river basin), lower Pakuwa (low hill), Upper Pakuwa (mid hill) and Bhakimli (high hill) of Lumle command area in western hills of Nepal for evaluation of soil fertility technology transfer from farmers to farmers on October 2002. In the survey gender farmers were also included in the interview. The purposive survey was conducted to the next-door ten farmers in each AER sites who had not received technologies, materials and methods. In each side ten farmers were interviewed and collected necessary information for analysis of the data.

RESULTS AND DISCUSSION

Use of plastic cover

The next-door farmers of lower Pakuwa and upper Pakuwa site adopted the use of plastic cover technology 100% for decaying manure where as the farmers of Chambas and Bhakimli adopted 80% and 40% respectively. Some next-door farmers of Chambas AER site were not adopting the technology because they were not fully convinced that the plastic cover manure contains high nitrogen. Besides that some other farmers could not respond the effect of organic fertilizer, they indicated that the yield of crop was low due to drought on that year. In the case of Bhakimli most of the household size was small and household members were away from their home to abroad to earn money. The detail illustration has explained in Table 1.

Benefits from plastic cover manure technology

The farmers were received different types of benefits from the plastic cover manure technology in different AER sites among interviewed farmers, 60% at lower Pakuwa, at Chambas and upper Pakuwa 100% and 40% at Bhakimli responded that the plastic cover manure contains high nitrogen. Similarly 100% farmers of lower and upper pakuwa, 70% farmers from Chambas and 40% farmers from Bhakimli mentioned that the plastic cover manure gives better yield. 60% farmers from lower Pakuwa and Chambas, 80% from upper Pakuwa and 40% farmers from Bhakimli said that plastic cover manure is cost effective. 60% farmers of Bhakimli said that they have a few animals due to the youths in abroad, however they explained the plastic cover manure gives effective response to the plants. 60% farmers from lower Pakuwa, 90% from upper Pakuwa, 40% farmers from Chambas and Bhakimli said that the plastic cover manure gives effective response to the plants growth. Similarly farmers gave response that the plastic cover manure is fast decaying and makes easy to plough land.

Table 1. A survey on use of plastic cover technology for decaying manure during 2002

Site	Respondents	Frequency (fi)	Percentage
Lower Pakuw	10	10	100
Upper pakuwa	10	10	100
Chambas	10	8	80
Bhakimli	10	4	40

Table 2. Benefits from plastic cover manure technology at different AER sites during 2002

Parameter	Lower Pakuwa			Upper Pakuwa			Chambas			Bhakimli		
	Respondent	fi	%	Respondent	fi	%	Respondent	fi	%	Respondent	fi	%
Nitrogen	10	6	60	10	10	100	10	6	60	10	4	40
Contain												
Yield increase	10	10	100	10	10	100	10	7	70	10	4	40
Low cost	10	6	60	10	8	80	10	6	60	10	4	40
Easy to plough	10	2	20	10	9	90	10	5	50	10	4	40
Effective	10	6	60	10	9	90	10	4	40	10	4	40
response												
Fast decay	10	9	90	10	10	100	10	7	70	10	4	40

Table 3. Use of proven technology (50% manure and 50% chemical fertilizer practices) at different AER sites, 2002

Cropping patterns	Lower Pakuwa			Upper Pakuwa			Chambas			Bhakimli		
	Respondent	fi	%	Respondent	fi	%	Respondent	fi	%	Respondent	fi	%
Maize millet										10	3	30
Rice wheat	10	8	80	10	2	20	10	4	40			
Upland rice blackgram							10	4	40			

Use of manure and chemical fertilizer

The proven technology of using 50% nutrient from organic manure and 50% inorganic chemical fertilizer gives the better yield of maize and millet. Only 30% farmers of Bhakimli were using the proven technology ie 50% manure and 50% chemical fertilizer on maize millet cropping pattern. In Rice wheat system at lower Pakuwa 80% neighbouring farmers were using the technology where as at upper Pakuwa only 20% farmers were adopting. At Chambas OR site where the cropping pattern was upland rice and blackgram, 40% neighboring farmers were adopting this technology. In general, most of the farmers rear animals so that the manure is easily available in their home yard and the use of manure in the field is common practices in the villages.

Table 4. Use of proven technology on 50% manure and 50% chemical fertilizer in different AER sites

Cropping patterns	Lower Pakuwa			Upper Pakuwa			Chambas			Bhakimli		
	Respondents	Frequency	%	Respondents	Frequency	%	Respondents	Frequency	%	Respondents	Frequency	%
Yield increased	10	5	50	10	2	20	10	4	40	10	5	50
Soil soft	10	6	60	10	9	90	10	5	50	10	5	50
Black soil	10	7	70	10	9	90	10	5	50	10	5	50
Better plant growth	10	6	60	10	9	90	10	5	50	10	4	40
Cost effective	10	6	60	10	9	90	10	5	50	10	5	50

Table 5. Leguminous crop root left technology adoption

Site	Respondents	Frequency	Percentage
Lower Pakuwa	10	6	60
Upper Pakuwa	10	8	80
Chambas	10	9	90
Bhakimli	10	4	40

Application of nutrients through 50% manure and 50% chemical fertilizer at different AER sites

The neighbouring farmers were benefited from the use of proven technology ie 50% manure and 50% chemical fertilizer. Farmers at lower Pakuwa were benefited by 50% yield increase whereas at AER side upper Pakuwa benefited by 20% yield increase. In case of Chambas AER site 40% farmers reported that the yield was increased in rice wheat system. At Bhakimli AER site, under maize millet cropping pattern 50% farmers said that the yield was increased. 50% farmers from Chambas and Bhakimli and 90% farmers from upper Pakuwa said that use of this technology makes soil soft and black. 60% farmers from lower Pakuwa, 90% farmers from upper Pakuwa, 50% farmers from Chambas and 40% farmers from Bhakimli said that the technology gave the effective response of the plant growth. Regarding the cost effectiveness 60%, 90% and 50% farmers of lower Pakuwa, upper Pakuwa, Chambas and Bhakimli respectively responded positively.

Nutrients addition through the leguminous crop roots

The roots left technology of leguminous crop was adopted by 60% farmers at AER site lower Pakuwa, 80% farmers from upper Pakuwa, 90% at AER site Chambas and 40% at AER site Bhakimli. The farmers were benefited by the use of the technology explained in Table 5.

Farmers were benefited by the use of leguminous crop roots left technology adoption at different OR sites. A total of 40% farmers from Bhakimli, 60% farmers from lower Pakuwa, 70% farmers from upper Pakuwa and 100% farmers from Chambas told that the use of leguminous crop root left technology helps to increase the yield

of next crop. The roots of leguminous crop also make soil soft. Farmers get nutrient food for their livelihoods from leguminous crops.

Table 6. Effect of black gram root left in different parameters on different OR sites

Parameters	Lower Pakuwa			Upper Pakuwa			Chambas			Bhakiimli		
	Respon- dents	Frequency	%	Respon- dents	Frequency	%	Respon- dents	Frequency	%	Respon- dents	Frequency	%
Yield increased	10	6	60	10	7	70	10	10	100	10	4	40
Soft soil	10	8	80	10	7	70	10	9	90	10	4	40
Fodder available	10	6	60	10	7	70	10	10	100	10	4	40
Cash crop	10	3	30	10	8	80	10	10	100	10	4	40
Nutrient food	10	2	20	10	6	60	10	7	70	10	3	30

Table 7. Benefits of the cultivation of leguminous crops

Parameters	Lower Pakuwa			Upper Pakuwa			Chambas			Bhakiimli		
	Respon- dents	Frequency	%	Respon- dents	Frequency	%	Respon- dents	Frequency	%	Respon- dents	Frequency	%
Leguminous crop available	10	6	60	10	8	80	10	10	100	10	4	40
Soft soil	10	5	50	10	9	90	10	10	100	10	4	40
Fodder available	10	1	10	10	2	20	10	9	90	10	4	40
Cash crop	10	2	20	10	2	20	10	9	90	10	3	30
Yield increase in next crop	10	2	20	10	3	30	10	10	100	10	5	50
Legume as a nutrient balance	10	1	10	10	1	10	10	6	60	10	2	20

Effect of black gram root left

Leguminous crops are the most important cash crops in the western hills of Nepal specially, where the cropping pattern is upland rice-black gram and maize -black gram. Among the leguminous crops black gram is one of the most important cash crop. Table 6 gives the detail information on view of benefits expressed by the different AER site farmers.

Leguminous crops growing farmers

60% farmers from lower Pakuwa expressed their positive view on availability of leguminous crops whereas at Upper Pakuwa 80%. In case of Chambas 100% farmers grow leguminous crops but at Bhakiimli only 40%. Besides this farmers expressed their view that leguminous crop makes the soil soft. From the leguminous crops, farmers were getting animal fodder and legume itself as a cash crop. Average 50% farmers told that leguminous crop gives better yield to the next crop. Similarly average 25% farmers told that leguminous crop is one of the nutrient foods for their lively hoods. The detail illustration of the benefit from the leguminous crop is given in Table 7.

CONCLUSION

Plastic cover manure has potential value for high nitrogen content and plant gives better response. By the application of plastic cover technology farmers could reduce the cost of chemical fertilizer. The use of nutrient value of 50% manure and 50% chemical fertilizer technology gives better yield in comparison of sole chemical fertilizer. The acidity of the soil caused by the excess use of chemical fertilizer will reduce by applying 50% organic manure, which is available. The Third technology roots of leguminous crops left in the soil after harvesting give better yield to the next crops. The above-mentioned technologies must be disseminated through other stakeholders so that many farmers could be benefited in future.

ACKNOWLEDGEMENTS

Farmers who provided their valuable time for answering the different questionnaire regarding the adoption of proven soil fertility technologies are acknowledged. Dr BP Tripathi who had given all ideas and support to conduct this survey is entitled to get thanks. Similarly Dr RP Sah who inspired us to prepare this working paper is the main person to be thanked.

REFERENCE

Tripathi BP and SP Shrestha. 2000. Review of soil research in the Western hills of Nepal. Biophysical and socioeconomic tools for assessing soil fertility. *Initiation Workshop Proceedings*. Agriculture Research Station, NARC, Lumle – Silsoe Research Institute Collaborative Research. Pp.8-19.

Addressing Poverty Reduction through Agricultural Research

Yuga N Ghimire, Thaneswar P Pokhrel, Hari K Shrestha and Ram B Bhujel

Nepal Agricultural Research Council, Kathmandu

ABSTRACT

Success of poverty reduction lies in the generation of poverty oriented agricultural research output in Nepal and its delivery to the target population. Agricultural research must be reoriented towards meeting the needs of small and marginal farmers who constitute the majority of rural poor in Nepal. This paper analyses the effects of uneven adoption of agricultural technologies on different categories of Nepalese farmers and explains importance of agricultural research that enhances the demand for labor and labor productivity. Uneven adoption of the technologies invites unsustainable food supply in the country and affects the whole economy. Strategies have been recommended for uniform adoption among different strata of farm households. Equal access to the resources irrespective of the wealth status is an important factor toward meeting this goal. To take a leap in poverty reduction, enough research resources should be invested on the research, which increases the returns and volume of employment for rural occupations, promotes changes in occupational structure that increases total remuneration and creates new occupational options.

INTRODUCTION

Recently Human Development Report (HDR 2003) has mentioned that Nepal is still struggling to reduce poverty, hunger and maternal mortality rate. According to the report, the country is at 143rd position on the basis of human development index with GDP per capita (PPP US\$) of 1310 in 2001. Household Living Standard Survey, 2033 had reported that 33 % of the people were below poverty line. At the end of ninth plan we have 38% people below the line majority of which is in the farming sector. Therefore, our efforts towards alleviating poverty were rather inappropriate or not enough (CBS 2002).

The 10th plan has set two targets, the normal growth (4.3%) and high growth (6.2%). Under the normal growth scenario the 10th plan has targeted to bring down poverty to 33% from the present 38 per cent, whereas, high growth rate is estimated to bring down the population below poverty line to 30%. Similarly, UN, in its millennium summit 2000, declared Millennium Development Goals (MDG). The numerical target of MDG in relation to reducing poverty in Nepal is to bring down 1990 level of poverty (42%) to 21% by 2015.

No doubt, the importance of staple food crops, rice, maize and wheat cannot be underestimated as the growth of these crops is crucial to feed the increasing population. However, expanding poverty in the country should also be properly addressed. We have the long experience that only the yield increase in certain cereal crops is quite inadequate to reduce poverty. Therefore, important responsibility of generating appropriate agricultural and natural resource technologies for poverty reduction has come on the shoulder of research institutes.

Agricultural research must be reoriented towards meeting the needs of small and marginal farmers who constitute the majority of rural poor in Nepal. Success of poverty reduction lies in the generation of poverty oriented agricultural research output in Nepal and its delivery to the target population. However, MoAC has experienced that most of the farmers visualize the DoA extension services as possible sources of subsidized inputs, rather than as a source of knowledge (Sharma 2003). Nepal Irrigation Sector Project experienced that the main constraints faced by majority of farmers were, among others, unavailability of quality seeds fertilizers, and plant protection chemicals in time and at a reasonable price. Important factor here are improving the delivery mechanism of agricultural inputs, generating suitable agricultural and natural resource technologies and updating the farmers' knowledge base.

Agriculture research institutes should play the key role to reduce poverty without which 10th plan as well as Millennium Development goal with respect to poverty cannot be attained. It has already been late to make appropriate agricultural and natural resource research policies strategies, and institutional mechanism to address rampant poverty we do have at present. This paper is an attempt towards this objective.

BASIC CHARACTERISTICS OF NEPALESE FARMERS

Most of the Nepalese farmers are small and marginal. Out of 2.6 million farm households in the country, 89 per cent of them have land-holding size of less than 2 hectares, covering only about 59% of the total agricultural land. The average land holding size is 0.96 ha, while the average family size is 5.25. In addition to this, the social system of dividing the parental land among the heirs is aggravating the situation. It is causing average land holding size to decrease and land fragmentation to increase with increase in population. The population of the country is estimated to be about 23 million with an annual growth rate of 2.2 per cent per annum (CBS 2002).

Furthermore, farming community is facing the problem of disguised unemployment. Given the estimated population growth of 2.2% per annum, more than 300 thousand of labor force enters into the labor market for employment each year. Of the total labor force, 32.3% was found to be underemployed with majority of it being dependent on agriculture. The situation of underemployment is widespread mainly due to the absence of alternative fulltime employment opportunity for agricultural labor force at local level. Five per cent, on the other hand are fully unemployed. Including these both, the total estimated unemployment goes up to 17.4% (CBS 2002).

Since the Nepalese farm households are almost subsistent in nature, there is no clear-cut demarcation between producer, consumer and labor. The same player, household unit, plays all the roles of these players in the ground of economics. In such situation, producer, consumer and labor supply decisions are made simultaneously. A large part of Nepalese agriculture is made up of semi commercial farms in which some outputs are sold and some inputs are purchased.

The analysis of agricultural development in this scenario is very complex due to the multiple characteristics of Nepalese farm households. A number of variables work simultaneously at varying degrees for each household. Higher aggregate output lowers price in closed economy. If our poor farmers are the net buyers of foods, lowering of food price will benefit them, if they are the net seller of foods, lower food prices will make them worse off. Similarly, lower wages benefits to net buyer of labor force and higher wages benefits to the net seller of labor force. Various positive and negative effects counteract each other to determine the overall net effect. Thus there is the complexity of the impact of increased productivity on different categories of households. Thus, it is possible that yield and output increasing technologies may increase poverty, if i) poor people are the non-adopter and net seller of the produce and iii) supply schedule shifts to the right due to the adoption of the technologies at a large area.

Since a high percentage of farm produce is consumed in the farm, cash requirement for non-food items is generally met from the sale of small animals such as he-goat, ghee, from remittance money, etc. Saving is virtually absent in rural economy. In the absence of saving, there is no investment. Ultimately, there is no economic growth and development in rural economy.

IMPACT OF UNEVEN/NON ADOPTION OF AGRICULTURAL AND NATURAL RESOURCE TECHNOLOGY

In a country like Nepal, economic impact on the society mainly comes through the adoption of improved agricultural technologies. The positive impact may arise either by expanding output with same cost, or reducing cost for the same level of output, or combination of both. This procedure will have effect on poor peoples' income by increasing income, decreasing prices of foods, stimulating economic growth with additional employment and wages. However, uneven/non adoption of the technology invites serious consequences in poor farmers' economy.

If a small number of farmers adopt the new technology, supply of output will increase but there will not have much effect on aggregate production. Price remains almost the same. In this situation adopting farmers earn more because of the expansion of output and selling it at the same rate.

If a large number of farmers adopt the new technology, while a smaller number of farmers do not, then the price may go down and non-adopting farmers may actually become worse off. Thus there is the tendency of non-adopters to suffer by losing price by P_0P_1 when supply reaches to S_2 from original position S_1 , demand (D) assuming to remain the same (Figure 1).

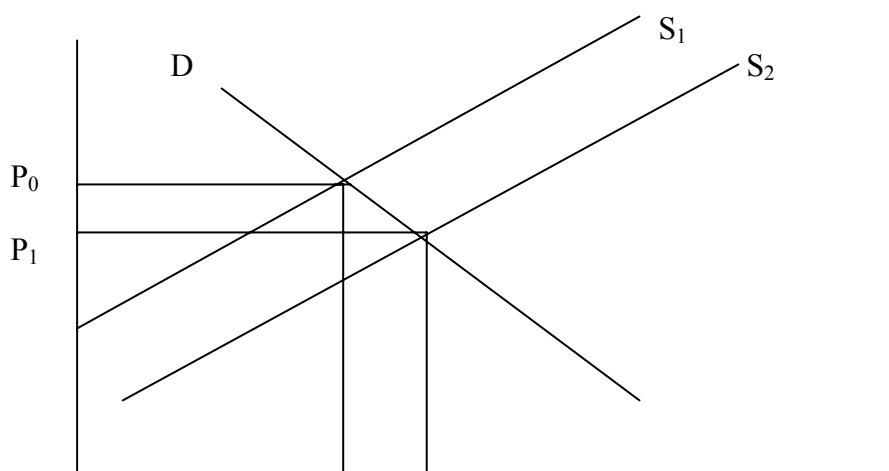


Figure 1. Effect of shift in the aggregate supply of output on non-adopter (Adapted from John and Shashi 1999).

In this situation, poor farmers lose assets, degradation of natural resources occurs which ultimately makes food supply unsustainable.

Avenues

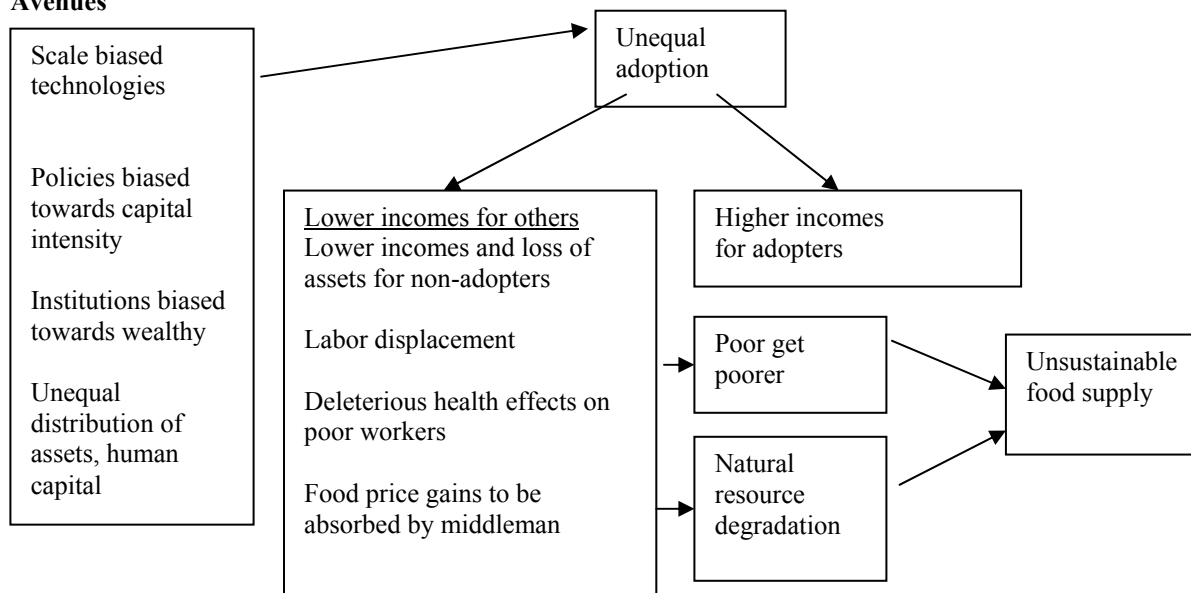


Figure 2. Effects of uneven/non-adoption of technology on sustainability of food supply (Adapted from John and Shashi 1999)

REASONS FOR UNEVEN/NON-ADOPTION OF TECHNOLOGIES

1. Poor farmers generally have weak access to information about new technology. Development agencies generally reach better off people nearby high way areas where access and dealings are easier.
2. Risk bearing capacity of such farmers is low. Since income is barely adequate, or in many cases inadequate, they need a regular and reliable source of income to meet the requirement of non-food items. They take external invasion as a risky game; rather believe on their own traditional system of farming using their own inputs.
3. Production credit is not reaching poor farmers. Borrowing from informal sources is 80% of the total credit in Nepal, which is the main source credit for resource poor farmers. Rate of interest in such loan is generally very high. In one of the study conducted at Dukuchhap VDC of Lalitpur in 2001, it is found that village money lenders charged 5 Pathi paddy per annum as the interest of Rs100 which at the then market price came to be Rs250.
4. Though poor farmers possess sufficient experiences of farming (as being a regular farm worker), they donot have chance of applying own decision due to the lack of enough land holding power.
5. Women farmers are socially least encouraged by community to come forward that contribute substantially to agricultural production.
6. Poors are socially docile, they hesitate to come forward and share experiences and other innovative ideas with development agents.
7. Low/no development of markets for agricultural inputs and outputs.
8. Technologies not suitable to farmers socioeconomic set up: Food habit, market demand, culture, etc.
9. Low level of education and exposure to outer world: If the people are unaware of relative economic standing, they may not be motivated to improve their standard of living. In the locality of poors, nobody may be feeling to be poor and deprived. They take their situation as a way of living.
10. Vicious circle of poverty- poverty, the reason of poverty
11. Farming, the responsibility of rural olds
12. Socio-cultural condition: The society is influenced by Buddhism and Jainism, which glorify poverty, peace and patient suffering (S Radhakrishnan).

Also influential is the saying of Aadishankaracharya who wrote:

अर्थमनर्थ भावयं नित्यं (भज गोविन्दम्)

निरातङ्को रङ्को विहरति चिरं कोटिकनकै (rags to riches with blessings from god) देव्यपराध क्षमापन स्तोत्रम्)

Similarly, Laxmi Prasad Devkota, one of the greatest poets of Nepali literature of 20th century, viewed poverty as a kind blessing:

गरीव भन्छौं सुखको म भै धनी
मिल्दैन संसार भरी कतै पनि
विलासको लालस दास छैन म
मिठो छ मेरो रसिलो परिश्रम

पंखा छ मेरो वर वृक्ष सुन्दर
समीर हम्कि कन चल्छ सरसर

HOW MANY PEOPLE ARE POOR IN NEPAL? WHERE DO THEY LIVE IN THE COUNTRY?

Internationally, the poverty line is "one US dollar per person per day". Income and consumption are important components of well being, and they are highly correlated to many other aspects of well-being. Consumption standards are preferred over income standards for measuring poverty, because among other reasons consumption is more stable from year to year. National Planning Commission, Nepal has set the poverty level based on the consumption requirement of food and non-food items.

Minimum consumption requirement for Nepalese has been fixed to be 2124 calories per capita per day. It costs Rs2627 per capita per year at 1996. Non-food item has been fixed to be Rs1767 per capita per year. Poverty

level income thus stands at Rs4404 per capita per year at 1996 prices. After price adjustment for 2000-01, it comes to be Rs954 per capita per year (Ghimire 2002). Poverty situation in Nepal is shown in Table 1. Poverty has been found extreme in mountains followed by tarai and hills.

Table 1. Extent and spread of poverty in Nepal

Region	Total	Poor	Ultra poor
Mountain	56.0	29.3	26.7
Hills	41.4	21.3	19.7
Tarai	42.0	28.7	13.3
Urban Nepal	23.0	13.2	9.8
Rural Nepal	44.0	26.4	17.6
Nepal	42.0	24.9	17.1

Source: Upadhyay 2001.

INVESTMENT SCENARIO IN AGRICULTURAL RESEARCH

The progress of agricultural research in Nepal is constrained by inadequate resources. During 1981-85, Nepal's total agricultural research expenditure (incurred both within and outside NARC) was only 0.79% of its AGDP, while it was more than 1% in Bangladesh, and Sri Lanka. World Bank has recommended it to be 2% of AGDP (Upadhyaya 2001). Despite the importance of agricultural research in Nepal, the investment in the same is not judicious (Table 2) which needs to be reviewed. It is too below than other SAARC countries, in spite of which poverty is too high in comparison to other SAARC countries. How can a poor national research institute help other poor of the country? The degree of seriousness of our policy makers towards the investment scenario in agricultural research should certainly reflect their determination to reduce country's poverty.

Table 2. Government budget in agricultural research

Year	AGDP as a % of total GDP	Research expenditure as a % of AGDP
1990/91	46	-
1991/92	44	0.18
1992/93	41	0.18
1993/94	40	0.20
1994/95	39	0.23
1995/96	39	0.20
1996/97	39	0.19
1997/98	37	0.29
1998/99	39	0.24
1999/00	39	0.26
2000/01	36	-

SLOPE AGDP: 0.095958579. GR: 10.07134705.

HIGH VALUE COMMODITY RESEARCH AND DEVELOPMENT IN NEPAL

APP (1995) prioritized high value commodities are livestock (dairy particularly buffalo), citrus, apples, vegetables, vegetable seed, apiculture and sericulture. These enterprises use land less extensively and, therefore, suitable for small and marginal farmers with high net benefit compared to other ventures of agriculture.

Although more than 40 varieties of different vegetables have been released by NARC, research focus is mainly on introduction, selection and storage (NARC 1995). It has been reported that vegetable seed production program was launched successfully in 24 VDCs in Kaski, Myagdi and Parbat, which benefited 710 farm households in the area. Vegetable research component in NARC should get priority, which can serve the poor sections of the society in income generation and employment.

Among the enterprise that does not use land extensively is mushroom cultivation. Along with the economy of space, the cultivation of this crop makes the use of locally available, cost effective materials like paddy straw and wheat straw and do not require heavy investment and is mostly scale neutral. Generally, small-scale

mushroom farms are concentrated in Kathmandu valley such as Balambu, Thankot, Kirtipur, etc. Out of the valley mushroom farms are located in Pokhara, Narayanaghat, and Gorkha (NARC 1995) and in tarai regions too.

The main problems farmers are facing are the forward and backward linkages of such ventures. We have experiences that farmers change the decision after adopting certain technologies. For instance, Gulmi farmers were attracted towards planting coffee initially. However, when production started to come, market had not developed. Limited monopsony market could not solve their problem and they started to clear the plantation. Farmers reported that much coffee area was then converted into rice area. Case of milk holidays in the country like ours where lots of foreign currency is invested to import milk and milk products are another area needing research focus.

REQUIRED RESEARCH POLICY AND STRATEGY FOR POVERTY REDUCTION

Agricultural research should carefully assess whether it can raise farmers' income sufficiently from the existing production system to provide an exit from poverty. Since the supply of arable land is limited in Nepal, farmers should be equipped with additional complementary assets such as education and other capital in the form of technology, easy loan and borrowing procedure. Since we are talking about the role of research in this context, the research focus should be on increasing returns to labor and labor productivity. Agriculture research should not only seek to improve the returns from farming, but also to increase the demand for labor and labor productivity. The potentiality of high value crops across different climatic regimes may prove boon to the poor farmers. But for this to be successful, integrated efforts of other agencies and development institutions should go hand in hand. The relevant institutions in this regard are public and private research institutions, infrastructure development and marketing related institutions.

RESEARCH POLICIES

- Emphasis on research, which increases the returns and volume of employment for rural occupations, promotes changes in occupational structure that increases total remuneration and creates new occupational options
- Strengthening agricultural research based on land suitability classification.
- Technologies, which do not use land extensively be given priority in agricultural research.
- Research focus in forward and backward linkages of high value crops/commodities to exploit its high marginal value productivity. For example, research for production efficiency should go together with marketing and post harvest research.

RESEARCH STRATEGIES

- Domestic and foreign market demand analysis of different high value commodities
- Prioritizing these commodities based on income and employment generation
- Preparing suitability map of these prioritized crops at the national level
- Identification of production constraints and other constraints associated
- Implementation of participatory research with poor/marginal farmers on these prioritized high value crops/commodities.
- Establishing Social Science and Policy Research Division in NARC to deal with poverty reduction, along with others

SPECIFIC RESEARCH AREAS

- Research on production and processing of medicinal plants, different preparations and processing of fruits, spices, etc.
- Herd improvement with animal nutrition, milk processing, marketing, etc

REFERENCES

- CBS. 2002. *Statistical pocket book Nepal*. CBS, NPC.
- Ghimire YN. 2001. Economic viability of farm households in central Nepal. *Master Thesis*, GB Pant University of Agriculture and Technology.
- John K and S Kolavalli. 1999. Impact of agricultural research on poverty alleviation: Conceptual framework with illustrations from the literature. *Impact Assessment and Evaluation Group*, Consultative Group on International Agricultural Research
- MoF. 2002. *Economic survey*. Ministry of Finance, His Majesty of Government of Nepal.
- NARC. 1995. *NARC research highlights 1989/90-1994/95*. NARC, Kathmandu.
- Sharma KC. 2003. MoAC: Experience in social mobilization. *Paper presented at the national workshop on Social Mobilization in Agriculture*. Nepal Agriculture Association in Lalitpur, Nepal.
- Upadhyay HK. 2001. Poverty, food security and agricultural research in Nepal: **In:** *Proceedings of the First SAS/N Convention*, 29-31 March 200 Kathmandu, Nepal. Society of Agricultural Scientists-Nepal.

Biological and Socio-Economic Verification of Crossbred Pakhribas Pig for Wider Adoption and Adaptation in the Eastern Hills

Madav P Aryal and Prenil KC

ARS, Pakhribas, Dhankuta, Nepal

ABSTRACT

A study was conducted for three years (1998 to 2001) to assess the productive and reproductive performance of crossbred Pakhribas Pig under on-farm condition so that the low adoption of pure breed Pakhribas pig in the rural area due to their poor adaptation in farmers feeding and management conditions could be tackled. At the same time, it was necessary to authenticate the farmers experience as “the crosses of Pakhribas Pig are better than pure breed in terms of their adaptability to on-farm condition” so as to make the wider adoption of crossbred possible. Irrespective of study sites, altitude and categories of farmers, the average birth weight of male and female piglets were found (0.87 ± 0.019 kg) and (0.81 ± 0.017 kg) respectively. Birth weight was found not related with sex but it was in decreasing trend with decreased socio-economic category of farming households. Average litter size was found (8.0 ± 0.31 piglet), but male to female ratio at birth was found higher for male piglet (4.68 ± 0.22) as compared with the female (3.32 ± 0.19). Average stillbirth was observed 1.25 ± 0.16 piglet, being higher in Dingla and Mudhesanischare sites. Most of the farmers (45 %) practice weaning even before the age of 45 days. However, some farmers (10%) did not wean their piglet up to the age of two months. Pre-weaning mortality of piglet was found higher for male as compared with the female, which was also reflected by the average litter size of male (4.02 ± 0.20) and female (2.95 ± 0.18) piglets at the time of weaning. Weaning weight of male and female piglets was observed (5.27 ± 0.02 Kg) and (5.11 ± 0.19 kg) respectively but it was found higher in low and high altitude as compared with the mid. Age at first service and farrowing of female crossbred pig was higher in mid altitude followed by low and high. Farrowing interval (226.5 ± 2.7 days) was found more or less similar with respect to site, altitude and category of participatory farmers. Male were observed attaining their sexual maturity earlier (335.6 ± 4.02 days) than female pig (448.7 ± 4.00 days) which might be the cause behind lower body weight of male pig (32.6 ± 0.93 Kg) as compared with the female (36.2 ± 0.83 kg) at puberty. An increasing trend was found in market price fetched by the farmers on sales of male and female piglet with respect to their decreasing socio-economic category. However, market price of pork was found related with geographical location of the study sites rather than any other parameters. Most of these parameters were found better than local pig, which was also reflected by the perception of participatory farmers as “the crossbred Pakhribas pig were better than local in terms of growth rate, body size, appearance and managerial requirement. But considerable number of participatory farmers (45%), experienced difficulties due to higher feed requirement of crossbred Pakhribas pig as compared with the local. Therefore, study on alternative feeding regimes that could develop a cost-effective method of raising crossbred Pakhribas pig through the use of conventional and non-conventional feeding resources is of critical importance.

INTRODUCTION

The lack of suitable technology for the different biophysical and socioeconomic domains in the hills is one of the main causes for the low adoption of recommended technology by the hill farmers. Verification of technology under location specific conditions will provide an opportunity for farmers to make an assessment on the economics of the technology as well as its acceptance. In other words, this allows farm households to identify the most appropriate technology based upon their needs. Some of the locally adapted indigenous technologies can also be verified and disseminated through technology verification trials in areas where these are not known. This would not only allow the verification of indigenous technologies, but it will also help to gather information for the scientific basis of the technology. The verification of technologies under specific biophysical and socioeconomic situations will be a more effective way to identify farmers' problems.

Generally, local breeds of farm animals are less productive than crossbred. Therefore, crossbreeding the local genotype with improved one might be a solution to upgrade the genetic makeup of local breeds and improve their productivity. At the same time testing and verifying the crossbred animals under farmers feeding and management condition provides information on farmers perception and reaction to them. On the other hand, it will have a demonstration effect amongst the farmers in the study area and encourage wider adoption of technology under test, if it is found better. Verification should not be limited to biological parameters. Socioeconomic verification of technology is as important as biological verification for the generation of appropriate technology. However, researchers in the past were not much concerned about the farmers' real situation, and technology development was based on research station environments. Farming environments are very different when compared to a research station.

Pakhribas pig is highly prolific and well adopted in the eastern hills. Although it is widely demanded by the pig raising communities in the eastern hills, there are still some extreme rural areas where farmers are not confident to raise this pig. Despite of its high demand, some farmers who have adopted Pakhribas pig have experienced that the pure breed Pakhribas pig is difficult to feed and manage under farmers feeding and management conditions. At the same time, some farmers have reported that the crosses of Pakhribas pig are better than the pure breed in terms of their adaptability to the farmer's local feeding and management situation. However, there is no report explaining the farmer's perception and experiences on the crosses of Pakhribas pig under farmers feeding and management conditions.

Therefore, emphasis in this study has been given to develop technology by testing and verifying it under various farming environments so that generated technology will be more appropriate and meet the biological and socio-economical requirements of farmers. This study has therefore been planned to demonstrate a group of farmer's experiences to others and verify some of the biological and social parameters of crosses of Pakhribas Pig under farmers feeding and management conditions. The study was undertaken to assess the productive and reproductive performance of crossbred Pakhribas pig under on-farm condition and to increase in the adoption of crossbred Pakhribas pig through on-farm verification and demonstration.

MATERIALS AND METHODS

Study was conducted under farmers feeding and management conditions within the outreach sites of ARS Pakhribas. The crosses of Pakhribas pig for verification testing were obtained by crossbreeding the local sows with pure breed Pakhribas boar. For that purpose, three farmers each of six outreach sites namely Basantpur, Beltar, Dingla, Hasanpur, Fakchamara and Mudhesanischare were provided one male piglet of pure breed Pakhribas pig. Those piglets were maintained on local feeding and management regime by the farmers. Upon maturity, those boars were used for crossbreeding the local sows. Ten farmers of different categories from each site having local sows were selected as participatory farmers for the trial. At least ten crossbred F-1 piglets from each site composed of five males and five females were monitored for their productive and reproductive performance under farmers feeding and management condition. They were monitored for Age at first service (weeks), Age at first farrowing (days), Farrowing intervals (days), Litter size at birth (number), Weaning age (days), Litter size at weaning (number), Pre-weaning mortality (%), Body weight at puberty (kg), Appropriate marketable age (as per farmers practice), Appropriate marketable age (as per farmers practice), Market price, problems observed and farmers reaction regarding feeding, management, behavior and performance of crossbreeds.

Week long farmers tour was organized for the participatory farmers involved in verification trial on Pakhribas Pig. A total of ten farmers were included in that tour and they visited various farming households of the trial implemented sites. Two such tours were organized during the study period. Literatures available at ARS Pakhribas related with pigs were reviewed; collected data were analyzed using SPSS computer program and reported.

RESULTS AND DISCUSSION

In case of trials on crossbred Pakhribas Pig, highest percentage (33.3 %) of participatory farmers was of category E (land less) followed by C (food deficit less than 6 months) 31.7 %, D (food deficit more than 6 months) 26.7 % and B (food balance) (8.3 %) respectively. None of the farmers were of category A (food surplus), which

indicates that pig raising is not a common practice among them. The ethnicity of farmers was higher (30 %) for Rai followed by Limbu (16.7 %), Kasai (16.7 %), Darji (8.3%) and other lower and occupational cast. Brahmins were not found as a participatory farmer because they usually do not raise pig in this region. Irrespective of study sites, altitude and categories of farmers, the average birth weight of male and female piglet was found (0.87 ± 0.019 kg) and (0.81 ± 0.017 kg) respectively. Birth weight was not found related with sex but was observed in decreasing trend with the category of farming households. The average litter size was found as (8.0 ± 0.31 piglets) but the male to female ratio at birth was found higher for male piglets (4.68 ± 0.22) as compared with the female (3.32 ± 0.19). Gatenby et al (1990) reported 7.9 piglets per litter for local sows. The average stillbirth was observed (1.25 ± 0.16 piglets) being higher in Dingla and Mudhesanischare sites.

Most of the farmers (45%) practiced weaning of their piglet before the age of 45 days. However, some farmers (10%) did not wean the piglet even after two months of age. Pre-weaning mortality of piglet was found higher for male as compared with the female, which was reflected by the average litter size of male (4.02 ± 0.20) and female (2.95 ± 0.18) piglet at the time of weaning. Gatenby et al (1990) reported 21.5 percent mortality in local piglets, which is higher than our observation for crossbred. Weaning weight of male and female piglet was observed (5.27 ± 0.02 kg) and (5.11 ± 0.19 kg) respectively but it was found higher in low and high altitude as compared to the mid altitude.

Age at first service and first farrowing of female crossbred pig was higher in mid altitude followed by low and high altitudes. Farrowing interval (226.5 ± 2.7 days) was found more or less similar with respect to site, altitude and category of participatory farmers. Gatenby et al (1990) reported the farrowing interval of local sows as 7.4 ± 2.14 months, which is higher than our observation. Male were observed attaining their sexual maturity earlier (335.6 ± 4.02 days) than female pig (448.7 ± 4.00 days) which might be the cause behind lower body weight of male pig (32.6 ± 0.93 kg) as compared to the female (36.2 ± 0.83 kg) at the age of puberty. Gatenby et al (1990) observed 10.7 ± 1.64 months of age at first farrowing for local sows. An increasing trend was found in market price fetched by the farmers on sales of male and female piglets with respect to their decreasing socio-economic category. Which was not the case with market price of pork, which was found related with geographical location of the study, sites rather than any other parameters.

Most of these parameters were found better than local pigs, which is also reflected in the farmers perception as "the crossbred Pakhribas Pig are better than local" in terms of growth rate, body size, appearance and managerial need. But considerable number of farmers (45%), experienced difficulties due to higher feed requirement of crossbred Pakhribas Pig as compared to the local. Therefore, research into alternative feeding regimes, which can develop a cost-effective method of raising crossbred Pakhribas pig by the use of conventional and non-conventional feed resources, is of critical importance.

CONCLUSION

Crossbred Pakhribas pig was found better than local in terms genetic and phenotypic parameters together with productive and reproductive performance. Therefore, it can be used extensively to upgrade the local pigs in the locality where black coloured pigs are preferred for religious or cultural reasons. However, higher feeding requirements and un-stabilized gene are still posing problem over wider adoption of crossbred Pakhribas pig. Further study to develop a cost-effective method of raising crossbred Pakhribas pig by the use of conventional and non-conventional feed resources need to be initiated. Extension stakeholders and developmental organizations should come up with crossbreeding or upgrading program of local pig by using the germplasm of pure breed Pakhribas pig. The unestablished gene in pure breed Pakhribas pig need to be stabilize and maintained through the intervention of appropriate breeding program.

REFERENCES

- Gurung HB. 1989. A study on the growth rare of local, crossbred and exotic breeds of pigs and carcass evaluation of local pigs. *PAC Technical Paper No. 116*, Pakhribas Agricultural Center, Dhankuta, Nepal.
- Gurung HB, RM Gatenby, SP Neupane et al. 1989. Number of Animals on Farms in the Koshi Hills. *PAC Technical Paper No. 109*, Pakhribas Agricultural Center, Dhankuta.
- Oli KP. 1986. Comparative study of carcass yields of different breeds of pigs in the eastern hills of Nepal. *PAC Technical Paper No. 90*, Pakhribas Agricultural Center, Dhankuta.27.

Appendix 1. On-farm performance of crossbred Pakhribas Pig in the eastern hills

SN	Parameter	Mean	SEM	Minimum	Maximum	N
1	Average birth weight of male piglet, kg	0.870	0.019	0.460	1.110	60
2	Average birth weight of female Piglet, g	0.810	0.017	0.487	1.060	60
3	Litter size of male piglet at birth, n	4.68	0.220	1	10	60
4	Litter size of female piglet at birth, n	3.32	0.190	1	7	60
5	Total litter size of piglet at birth, n	8.00	0.31	2	14	60
6	Number of dead birth of male piglet, n	1.27	0.120	1	2	60
7	Number of dead birth of female piglet, n	1.06	0.083	1	2	60
8	Total number of dead birth of piglet, n	1.52	0.160	1	3	60
9	Litter size of male piglet at weaning, n	4.02	0.200	1	10	60
10	Litter size of female piglet at weaning, n	2.95	0.180	1	7	60
11	Weaning weight of male piglet, kg	5.273	0.204	2.280	9.350	60
12	Weaning weight of female piglet, kg	5.118	0.199	2.330	9.250	60
13	Age of female pig at first service days	335.67	4.02	275	430	60
14	Age of female pig at first farrowing days	448.70	4.00	391	547	60
15	Farrowing interval days	226.52	2.70	160	285	60
16	Body weight of male pig at puberty, kg	32.66	0.933	22.70	47.10	60
17	Body weight of female pig at puberty, kg	36.20	0.835	22.70	48.47	60
18	Market price of male piglet, Rs	675.00	9.691	500.00	800.00	60
19	Market price of female piglet, Rs	510.00	7.775	400	600	60
20	Market price of pork, Rs	56.95	0.633	45.00	65.00	60

Appendix 2. On-farm performance of crossbred Pakhribas Pig in different outreach sites of ARS Pakhribas

SN	Parameter	Outreach sites of ARS Pakhribas				
		Fakchamara	Mundhe	Beltar	Dingla	Hasanpur
		Mean $\pm$ SEM	Mean $\pm$ SEM	Mean $\pm$ SEM	Mean $\pm$ SEM	Mean $\pm$ SEM
1	Average birth weight of male piglet, kg	0.997 $\pm$ 0.021	0.947 $\pm$ 0.055	0.632 $\pm$ 0.044	0.86 $\pm$ 0.026	0.875 $\pm$ 0.029
2	Average birth weight of female Piglet, kg	0.919 $\pm$ 0.033	0.957 $\pm$ 0.019	0.623 $\pm$ 0.027	0.78 $\pm$ 0.022	0.801 $\pm$ 0.035
3	Litter size of male piglet at birth, n	4.00 $\pm$ 0.39	3.83 $\pm$ 0.83	6.00 $\pm$ 0.76	4.35 $\pm$ 0.27	5.73 $\pm$ 0.59
4	Litter size of female piglet at birth, n	3.40 $\pm$ 0.31	3.67 $\pm$ 0.71	3.43 $\pm$ 0.57	2.73 $\pm$ 0.20	4.36 $\pm$ 0.64
5	Total litter size of piglet at birth, n	7.40 $\pm$ 0.62	7.50 $\pm$ 1.43	9.43 $\pm$ 0.65	7.08 $\pm$ 0.38	10.09 $\pm$ 0.61
6	Number of dead birth of male piglet, n	1.25 $\pm$ 0.25	1.50 $\pm$ 0.50	1.00 $\pm$ 0.00	1.40 $\pm$ 0.24	1.00 $\pm$ 0.00
7	Number of dead birth of female piglet, n	1.00 $\pm$ 0.00	1.00 $\pm$ 0.00	1.00 $\pm$ 0.00	1.20 $\pm$ 0.20	1.00 $\pm$ 0.00
8	Total number of dead birth of piglet, n	1.20 $\pm$ 0.20	1.67 $\pm$ 0.33	1.00 $\pm$ 0.00	2.17 $\pm$ 0.40	1.33 $\pm$ 0.33
9	Litter size of male piglet at weaning, n	3.00 $\pm$ 0.30	3.17 $\pm$ 0.48	4.43 $\pm$ 0.48	3.92 $\pm$ 0.28	5.36 $\pm$ 0.59
10	Litter size of female piglet at weaning, n	3.40 $\pm$ 0.31	3.17 $\pm$ 0.48	2.43 $\pm$ 0.43	2.42 $\pm$ 0.22	4.00 $\pm$ 0.59
11	Weaning weight of male piglet, kg	6.239 $\pm$ 0.39	5.173 $\pm$ 0.21	5.105 $\pm$ 0.18	4.436 $\pm$ 0.35	6.536 $\pm$ 0.149
12	Weaning weight of female piglet, kg	5.943 $\pm$ 0.47	4.923 $\pm$ 0.15	5.020 $\pm$ 0.19	4.346 $\pm$ 0.34	6.363 $\pm$ 0.17
13	Age of female pig at first service (days)	373.5 $\pm$ 8.06	315.8 $\pm$ 11.50	335.71 $\pm$ 12.9	329.23 $\pm$ 5.1	327.27 $\pm$ 6.41
14	Age of female pig at first farrowing (days)	477.00 $\pm$ 11.8	430.8 $\pm$ 11.63	448.4 $\pm$ 12.68	444.5 $\pm$ 5.19	442.6 $\pm$ 6.55
15	Farrowing interval (days)	214.8 $\pm$ 8.76	238.3 $\pm$ 7.46	224.0 $\pm$ 2.91	231.3 $\pm$ 4.58	221.0 $\pm$ 0.84
16	Body weight of male pig at puberty, kg	32.12 $\pm$ 1.30	31.31 $\pm$ 3.67	29.71 $\pm$ 2.96	33.65 $\pm$ 1.60	33.45 $\pm$ 1.86
17	Body weight of female pig at puberty, kg	37.78 $\pm$ 2.26	36.02 $\pm$ 3.03	34.57 $\pm$ 1.68	35.04 $\pm$ 1.30	38.66 $\pm$ 1.81
18	Market price of male piglet, Rs	605.0 $\pm$ 21.6	716.6 $\pm$ 16.6	714.2 $\pm$ 21.0	713.4 $\pm$ 10.2	600.0 $\pm$ 15.07
19	Market price of female piglet, Rs	445.0 $\pm$ 15.7	541.6 $\pm$ 8.33	542.8 $\pm$ 17.0	542.3 $\pm$ 8.63	454.5 $\pm$ 10.56
20	Market price of pork, Rs	54.5 $\pm$ 1.16	63.33 $\pm$ 1.05	47.85 $\pm$ 1.01	57.57 $\pm$ 0.59	60.0 $\pm$ 0.00

Diagnosis of Yield Stagnation Problem in Rice in Sunsari and Morang Irrigation Project Area

Hari K Shrestha, Yuga N Ghimire, Pitamber Thakur, Dev K Chaudhary and Ek M Bhattarai

NARC, Khumaltar Nepal

ABSTRACT

Despite the availability of irrigation facility and endeavors of GO and NGO sectors, rice yield has not been increased in Sunsari and Morang districts for last ten years. To determine the actual yield trend of rice and factors contributing to it, a survey was carried out in three purposively selected sites in each district. In the initial years of irrigation project, rice yield was substantially increased, later on remained stagnant in most parts but declined in some parts. Low dose and imbalanced use of fertilizer with 32:17:2 kg of NPK and very low rate of seed replacement were found as some of responsible factors for yield stagnation. Silt accumulation problem having detrimental effect on crop was severe near the head of canal and was spreading to adjoining portions. There is large disparity in water distribution as the area near tail portion usually receives less supply lately. About 10% of area was turned into waterlogged lowland since topsoil was removed from both sides for constructing the canal and road. In the tail area, SMIP covered only 40% of total area and remaining 60% of area was still rainfed. About 90% of farmers were growing Kanchhi Masuli variety of rice although it was prone to blast disease and not recommended by the research. Insect and disease in rice caused about 20% yield loss every year. Concerted effort on R&D for nutrient management, pest control, and genetic improvement on widely grown variety are imperative to increase the rice productivity.

Key words: Rice, Sunsari, yield stagnation

INTRODUCTION

There is a consensus built among the veterans of agriculture development that green revolution in rice cultivation was most successful in irrigated ecosystems. With nearly two-thirds of the world's rice and wheat produced on irrigated land, irrigation must remain a prime engine of agricultural growth, despite the likelihood that water will be shifted from agriculture to urban and industrial uses (Rosegrant 1998). However, growth in rice production, particularly in the irrigated system has declined sharply over the last decade (Hossain and Pingali 1998). The analysis of yield trends of long term experiment in Bangladesh, China, India and Nepal suggest that although significant yield decline is not widespread, yields of both rice and wheat are stagnant (Ladha et al 2003). The same study revealed that in the rice-wheat system, particularly in the Indo Gangetic Plains, rice yields are declining more rapidly than wheat.

It has become an issue that despite the availability of irrigation facility through Sunsari Morang Irrigation Project (SMIP), average rice yield has not increased for last ten years in its command districts viz Morang and Sunsari. The crop cut survey of SMIP on rice showed that the average yield of improved variety of rice was 3.7 mt/ha in FY 2001/02 as compared to 3.5 mt/ha in FY 1992/93. The SMIP officials reported referring to the feasibility study of the project that the average rice yield was 1.7 mt/ha in 1979. It is becoming difficult to sustain earlier rates of growth in rice production because most farmers have already planted modern varieties and farmers' yields are approaching the potential that scientists themselves attain from those varieties (Hossain 1997). The stagnation in rice yield in the area has become a serious concern for agriculture related authorities and stakeholders. Therefore, a diagnostic study was conducted in order to determine the responsible factors contributing to yield stagnation in rice. The survey was carried out in March 2003 at six representative sites of the SMIP area.

METHODOLOGIES

The study was based on review of various reports (secondary information) published by SMIP and field survey (primary information) conducted in the project area. A discussion program was organized with the field staff of SMIP in order to orient them on study purpose and select the survey sites. After the discussion, a representative site was purposively selected in each of head middle and tail portion of irrigation canal in each district. Thus altogether six sites including three in Morang and other three in Sunsari were surveyed. The survey team followed PRA approach, which included interview with farmers' group by administering semi-structured questionnaire, transect walk and field observation. The team was comprised of different disciplines viz. plant breeding, soil science, entomology and socioeconomics. Field survey was conducted in Aurabani (head), Sitagunj (middle), and Chhitah (tail) of Sunsari and Tetariya (head), Jhorhat (middle) and Nocha (tail) of Morang. At the end of survey, a discussion program was held with foreign experts and consultants of SMIP in the project office to deliver and validate the major findings of the study.

RESULTS AND DISCUSSION

Irrigation facility and fertilizer application

Although the Project aimed to cover the whole area of Morang and Sunsari, about 95% of the area is irrigated in mid of canal whereas the coverage is 75% in head and 40% in tail of the canal as reported by the local farmers. The irrigation facility was less in the tail area as the construction of watercourse was still underway in the area. Tail area receives water lately during transplanting, which ultimately causes adverse effect in rice yield. The study revealed that farmers apply chemical fertilizer @ 32:17:2 kg (NPK) which was a bit higher as compared to the rate of 25:9:2 kg (NPK) reported by SMIP itself (SMIP 2002). In the tail area particularly in Nocha VDC of Morang, poor soil type was found with low organic matter and high sand content consequently with high infiltration rate and inefficient water management.

Unreliability and untimely availability of chemical fertilizer was a common problem for the study area. Application of farmyard manure was negligible as dung cake was used as fuel for cooking food. Continuous nutrient mining had resulted in declined soil fertility. Despite the high potentiality of green manuring in irrigated area it was not found in practice. About 10% of area had turned into waterlogged wetland after construction of water canals. Farmers reported that the construction of canal was not properly done. Topsoil was removed from both sides during the construction of canal and road. This waterlogged area was no more suitable for rice as well as winter crops.

Cropping pattern

The cropping pattern of SMIP area shows that rice-wheat was the most important pattern adopted in more than half of the total cultivated area. The legumes, which comprised mainly lentil crop, was grown after rice in one-fifth of the area. The oilseed comprising mainly linseed was grown after rice in one-tenth of the area. About the same area was left fallow in winter. It is noteworthy among the cropping patterns that no vegetable except potato was grown in the whole area. It may be an issue that why vegetables is not grown in the area although irrigation facility is available. A few farmers in middle of the canal have started to grow spring rice taking three crops a year (rice-rice-wheat).

Rice area and productivity

Of the total cropped area in summer, improved rice was 95%, local rice was 2%, and sugarcane was 1.4% (SMIP 2002). The other crops grown in the minimal area were pulses, jute, maize and vegetables. The survey data shows that Kancchi Masuli covered about two third of the total rice area whereas each of Masuli, Radha 17 and local rice was grown in about one tenth of the area. Kancchi Masuli was grown in most of the irrigated area whereas local rice was mostly grown in less irrigated area. Most of the high yielding varieties recommended by the research had not been introduced in Sunsari Morang area.

The survey data shows that Makwanpur –1 was the highest yielder with 3.6 mt/ha followed by Radha –12 with 3.5 mt/ha. However, Makwanpur-1 was grown in only one percent of head area and Radha-12 was grown in only four percent of the total area. Local rice, which comprised several kinds of aromatic rice, was the lowest yielder with 1.2 mt/ha. About 90 percent of the total farmers were found to grow Kancchi Masuli although it was prone to blast disease and not recommended by the research. The reasons why farmers preferred to grow the same

variety from year to year were high milling recovery (70%), good cooking quality, higher demand in market and high straw yield.

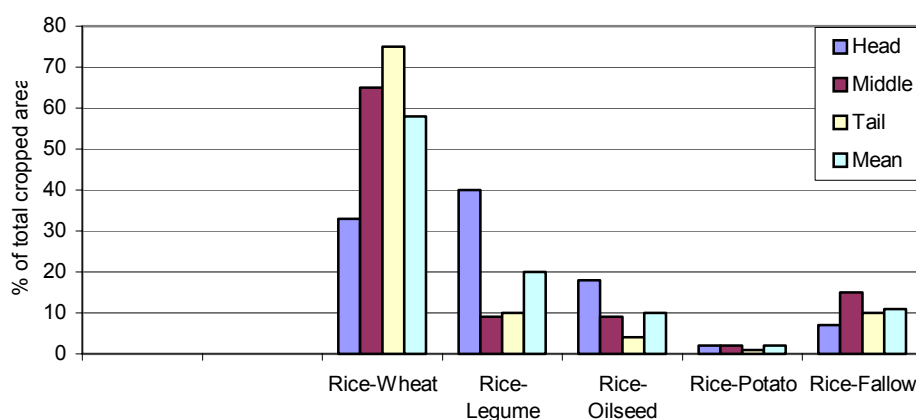


Figure 1. Cropping patterns in Sunsari, Morang.

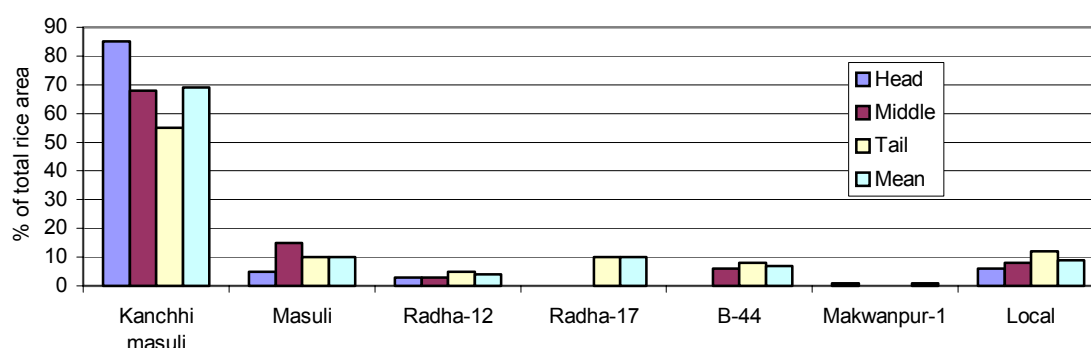


Figure 2. Area under different rice cultivars.

Farmers reported that rice yield was increased in the initial years of water supply through the irrigation project, later on remained stagnant in most parts but declined in some parts of the project area.

At present the average rice yield is higher in middle area of the canal where irrigation facility is less as compared to head of the canal. The reason behind this may be silt accumulation problem at the head, which resulted degradation of the land. The silting problem was increasing gradually in other fields too as reported by farmers. However, new construction of settling basin at the mouth reduced silting problem to some extent. The lowest rice yield was found in tail area of the canal mainly due to less and late availability of irrigation facility.

The average yield of improved rice and that of local rice found in survey were 2.8 mt/ha and 1.2 mt/ha, which were lower than the yield data presented in SMIP report 2002 (Table 1-6). One of the major reasons of low productivity was found as use of old generation seed from year after year. Seeds of farmers' preferred varieties like Kanchhi Masuli, Masuli and B44 had not been replaced since they came into practice.

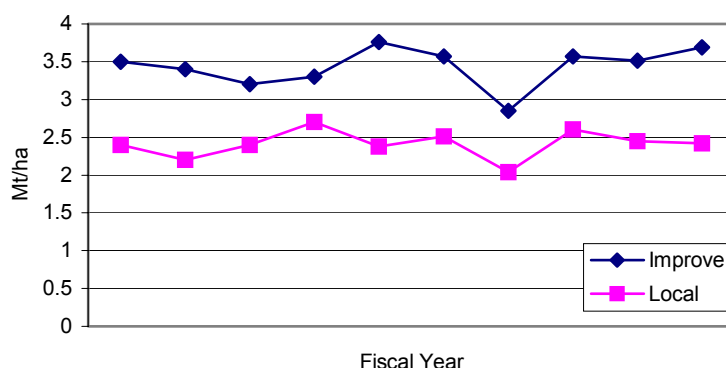
Table 1. Rice yield in Sunsari Morang from FY 1992/93 to 2001/02

Variety	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
Improve	3.50	3.40	3.20	3.30	3.76	3.57	2.85	3.57	3.51	3.69
Local	2.40	2.20	2.40	2.70	2.38	2.51	2.04	2.60	2.45	2.42

Source: SMIP 2002.

Table 2. Major cropping patterns

SN	Cropping patterns	Head (% area)	Middle (% area)	Tail (% area)	SMIP (% area)
1	Rice-Wheat	33	65	75	58
2	Rice-Legume	40	9	10	20
3	Rice-Oilseed	18	9	4	10
4	Rice-Potato	2	2	1	2
5	Rice-Fallow	7	15	10	11

**Figure 3. Trend of rice yield from 1992/93 to 2001/02****Table 3. Area under different rice varieties**

SN	Variety	Area, %			
		Head	Middle	Tail	Mean
1	Kanchhi masuli	85	68	55	69
2	Masuli	5	15	10	10
3	Radha-12	3	3	5	4
4	Radha-17	-	-	10	10
5	B-44	-	6	8	7
6	Makwanpur-1	1	-	-	1
7	Local	6	8	12	9

Table 4. Yield of different varieties of rice

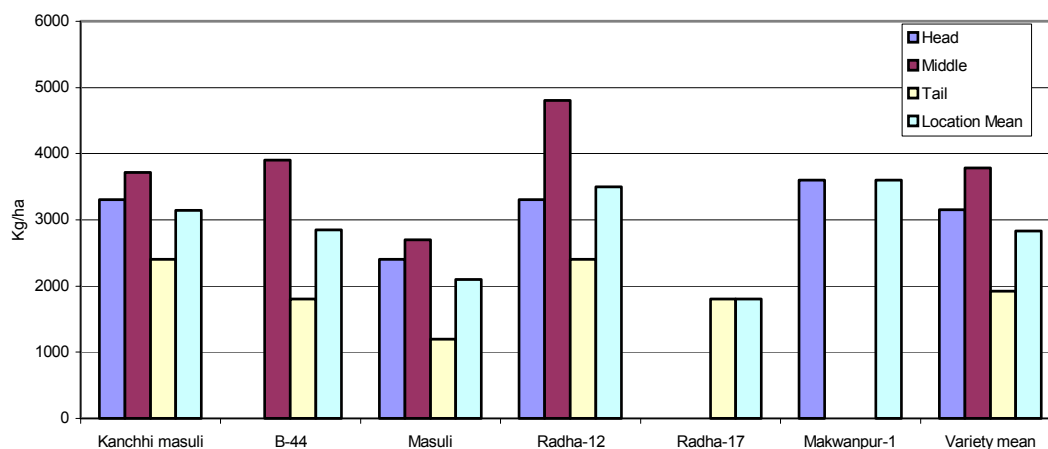
SN	Variety	Yield, kg/ha			
		Head	Middle	Tail	Mean
1.	Kanchhi masuli	3300	3720	2400	3140
2.	B-44	-	3900	1800	2850
3.	Masuli	2400	2700	1200	2100
4.	Radha-12	3300	4800	2400	3500
5.	Radha-17	-	-	1800	1800
6.	Makwanpur-1	3600	-	-	3600
	Mean of improved rice	3150	3780	1920	2832
7.	Local	1200	1200	1200	1200

Table 5. Yield loss due to insect

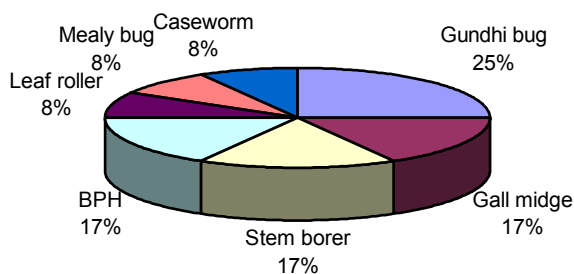
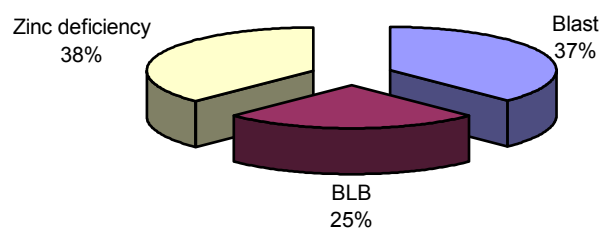
SN	Insect	Estimated yield loss, %			
		Head	Middle	Tail	Mean
1.	Gundhi bug	3	3	3	3
2.	Gall midge	1	3	4	2
3.	Stem borer	2	3	2	2
4.	BPH	2	4	0	2
5.	Leaf roller	2	0	1	1
6.	Mealy bug	2	0	1	1
7.	Caseworm	0	0	2	1
	Total loss, %	12	13	13	12

Table 6. Yield loss due to disease

SN	Insect	Estimated yield loss, %			
		Head	Middle	Tail	Mean
1.	Blast	4	2	3	3
2.	BLB	1	3	2	2
3.	Zinc deficiency	3	4	2	3
	Total loss, %	8	9	7	8

**Figure 4. Yield of rice cultivars****Yield loss due to insect and disease**

Gundhi bug, gall midge, stem borer and BPH were the major insects for yield loss in rice. The other insects viz. leaf roller, mealy bug and caseworm caused the yield loss by 2 or less than 2 percent. The estimated average yield loss in overall area of SMIP was 12 percent.

**Figure 5. Yield loss by insects (12%)****Figure 6. Yield loss by disease (8%)**

Total yield loss caused by major diseases viz blast, BLB and zinc deficiency was 8 percent. As the diseases were sporadic in nature the farmers' estimate was based on their memory.

CONCLUSION

The major causes of low rice yield in Sunsari and Morang were found as follows

- Low dose and imbalanced use of fertilizer
- Very low rate of seed replacement
- Silt accumulation problem in the crop field
- Large disparity in water distribution for irrigation
- About 10% of area was turned into waterlogged lowland
- In the tail area, SMIP covered only 40% of total area and remaining 60% of area was still rainfed.
- About 90% of farmers grow Kanchhi Masuli, a blast susceptible, not recommended by the research
- Insect and disease in rice caused about 20% yield loss every year

RECOMMENDATION

- The commonly grown rice cultivars such as Kanchhi Masuli were blast susceptible and low yielding. High yielding, disease resistant rice varieties should be introduced into existing farming system.
- Commercialization of improved varieties by introducing and familiarizing them among rice traders is imperative. The marketing intermediaries such as rice millers, traders should be involved in variety development program.
- To replace the old generation seed intermittently, seed multiplication program should be launched at farmers' level. The private participation in seed production and marketing through seed merchants/traders and entrepreneurs should be encouraged for attaining self-sufficiency in seed production.
- Soil sampling and testing are required to recommend fertilizer dose of NPK, micronutrients and to detect soil related problems.
- Genetic improvement in Kanchhi Masuli is imperative for higher yield as well as for blast resistance.

REFERENCES

- Hossain M. 1997. Nature and impact of green revolution in Bangladesh. *Research Report No. 67*. International Food Policy Research Institute, Washington DC.
- Hossain M and PL Pingali. 1998. Rice research technological progress and impact on productivity and poverty: an overview. Impact of rice research. *Proceedings of the international conference on the impact of rice research*. 3-5 June 1996. Bangkok. Thailand Development Research Institute, Bangkok, Thailand and International Rice research Institute. 428p.
- Ladha JK, D Dawe, H Pathak, AT Padre, RL Yadav, B Singh, Y Singh, Y Singh, P Singh, AL Kundu, R Sakal, N Ram, SK Gami, AL Bhandari, R Amin, CR Yadav, EM Bhattarai, S Das, HP Aggarwal, RK Gupta, PR Hobbs. 2003. How extensive are yield declines in long term rice-wheat experiments in Asia? *Field Crops Research* 81:159-180.
- Rosegrant MW. 1998. Water and irrigation policy: prospects for the future and implications for rice production. Impact of rice research. *Proceedings of the international conference on the impact of rice research*. 3-5 June 1996. Bangkok. Thailand Development Research Institute, Bangkok, Thailand and International Rice research Institute. 428p.
- SMIP. 2002. *Annual report III, progress report*. NEDECO-DHV-SILT-CMS-MASINA.

Farmer to Farmer Diffusion: Technology Dissemination Approach in Diverse Environments

Chabi L Paudel, Bijaya Bajracharya and Bhava P Tripathi

HELVATAS, Kathmandu

ABSTRACT

Demand-driven community led farmer to farmer diffusion approach was developed with farmers and other stakeholders by Sustainable Soil Management Programme (SSMP). This alternative diffusion model was tested in year 2001 and year 2002 in 8 mid hill districts of Nepal. District level farmer to farmer diffusion committee was formed and operationalised for smooth functioning of the farmer to farmer program. Fifty six experienced leader farmers provided services to 9000 farm households in FYM/compost management, groundnut cultivation, ginger cultivation, citrus orchard management, legume cultivation, organic pest management and vegetable cultivation. The service provided by the experienced leader farmers was found very effective and low cost. Farmers, extension workers, planners and policy makers have positively responded to this approach. Therefore, adoption of farmer- to-farmer diffusion approach in mainstream extension systems is suggested for quick and wider diffusion. FTF diffusion also complements decentralized extension.

Key words: Dissemination approach, diverse environments, farmer to farmer

INTRODUCTION

SSMP is implementing its diffusion activities through farmer organizations, governmental (GO) and non-governmental (NGO) partners. These Collaborating Institutions (CI) are working closely with leader farmers in training and technology testing. The leader farmers in turn are supposed to diffuse their farm practices to other farmers. Figure 1 shows the pilot success case development in the SSMP supported area and wider diffusion of successful technologies through experienced leader farmers in outside command area.

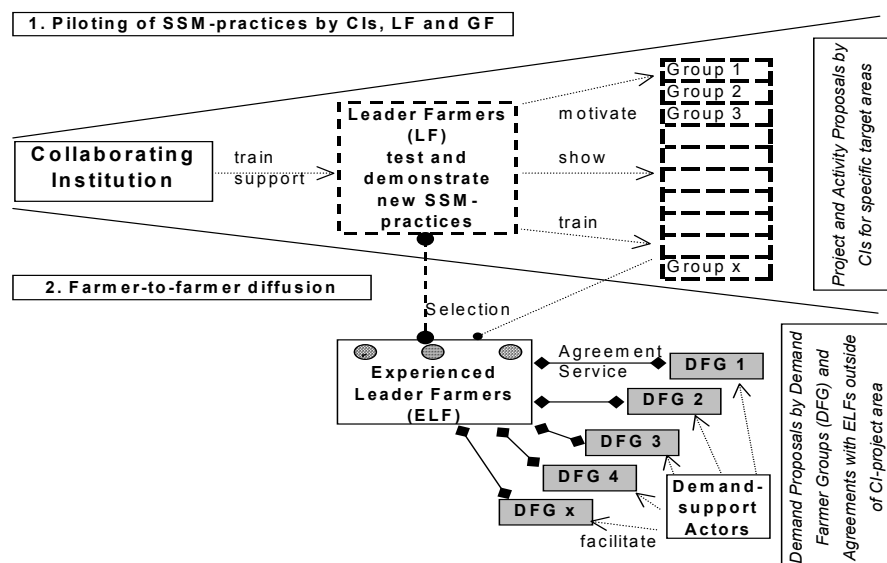


Figure 1. The mechanism of success case development and wider diffusion of verified technology through farmer- to- farmer .

The piloting and demonstrating of new technologies by leader farmers have resulted in the confirmation of a number of successfully confirmed technologies for wider dissemination. This is measured in the response of group farmers, who are in close contact with the leader farmers and the CI. Thus, the diffusion from leader to group farmers is found to be effective to influence near-by farmers, but there is still problem of diffusion of SSM technologies to wider communities.

PROCESS OF FARMER-TO-FARMER DIFFUSION

Based on the above-mentioned experience, the importance of farmer-to-farmer diffusion (FTF) has been realized. A pilot testing of the FTF process was initiated in 8 mid hill districts within the project area in April 2001. The districts are Baitadi, Doti, Surkhet, Dailekh, Parbat, Syangja, Baglung, Kavre and Sindhupalchowk. Critical observation and piloting is necessary before adopting it in large scale. Therefore, the programme is at a small scale in different districts for testing and learning in different environments. Preliminary guidelines for implementation of FTF have been developed, which explain the farmer-to-farmer diffusion approach.

Farmer- to- farmer extension committee in the districts

Farmer- to farmer extension committee was formed in eight districts to operationalize the farmer- to- farmer diffusion process in the district. The detail farmer- to- farmer diffusion implementation process is described in the operational guideline (Paudel et al 2002). The committee consists of 5 members. DADO works as a chairperson, one of the SSMP CI as a member secretary, Programme officer, District Development Committee (DDC) member and one male and one female-reputed farmers as a members in the committee. The major function of committee is the selection and training of ELF, demand group identification, Agreement facilitation among ELF and DFG, agreement assessment, financing the accepted demand proposals and monitoring and evaluation of the ELF services.

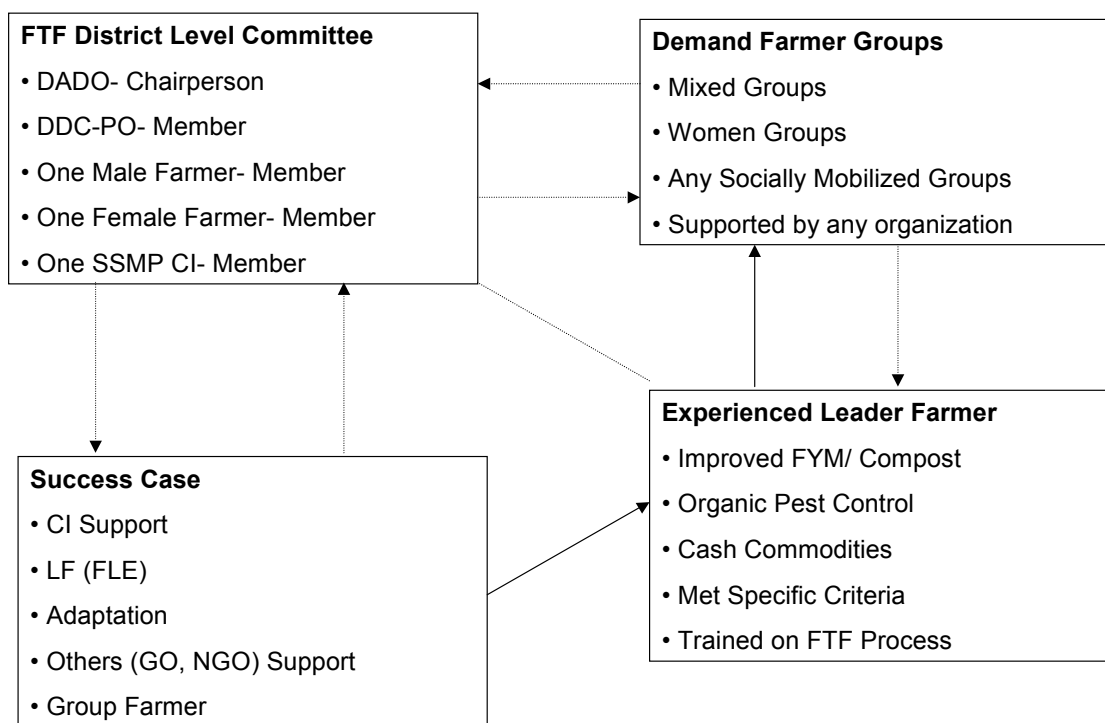


Figure 2. District level FTF committee, ELF and demand farmer groups (DFGs).

FTF is based on activating experienced leader farmer (ELF) for the diffusion process. Some innovative leader farmers are fully applying SSM technologies and successfully taking advantages from farming. These progressive farmers of long farming experience who have good leadership ability, communication skills, committed to social service, motivated to change and interested to serve the disadvantaged farmers groups are selected and trained for short capacity building aspects. After training, they can provide services to the farmers groups. ELF is the key actor in this diffusion process.

The capacity building of ELF is done in workshops for 3 days, containing communication skills, leadership development, technology synthesis and FTF-process implementation methods. Five workshops of ELF capability building training have been conducted to experienced leader farmers in 2001 and 4 workshops of ELF capacity building have been conducted in 2002. Table 1 gives the list of male and female experienced leader farmers available in pilot districts with their topic of specialization. More than 32% ELF were women.

Table 1. Trained service provider male and female experienced leader farmer in 2001 and 2002

District	2001		2002		Total	Success case/ technology to deliver
	M	F	M	F		
Kavre	7	3	11	-	21	Coffee, Vegetable, FYM/Compost, OPM and Legume
Sindhuraj	-	4	6	4	14	Vegetable, Legume, OPM and FYM/ Compost
Syangja	11	5	-	-	16	Coffee, Vegetable, Legume, OPM and FYM/ Compost
Parbat	6	4	-	-	10	Vegetable, Legume, OPM and FYM/ Compost
Baglung	-	-	6	8	14	Vegetable, Legume, OPM and FYM/ Compost
Surkhet	-	-	8	6	14	Ginger, Vegetable, OPM and FYM/Compost
Dailekh	11	1	-	-	12	Legume and FYM/ Compost
Doti	6	-	2	-	8	Legume, Vegetable, Ginger and FYM/ Compost
Baitadi	3	3	10	3	19	Ginger, Groundnut, Citrus, OPM and FYM/ Compost
Total	44	20	43	21	128	

The ELF were selected from the command area of selected collaborating institutions, which are termed as supply actors and whose responsibility is primarily to support the ELF. The supply actor (CI) had developed some experienced leader farmer from pilot testing and demonstrations of SSM technologies. They had demonstrated successful cases of SSM-practice, which were adopted by group farmers. These practices merit wider dissemination to other new communities.

The selected and trained capable ELF started providing their services in some districts since May 2001. They respond to the demand for services by groups of farmers outside of the command area of the CI. Sixty nine demand proposals (DP) were implemented in year 2001 and 402 in year 2002 in wider farmers groups after agreement between ELF and farmer groups where ELF is major supply actors. DP is the agreement proposal between ELF and group farmers, which specifies the responsibilities of ELF and group farmers, their commitments and implementation plans within the agreed topic. This agreement serves as the activity proposal for funding under SSMP through district based F-T-F committee.

The topic of agreement is on the priority subject of the farmers group and on the expertise of the ELF. DFGs (demand farmer groups) are the group farmers of the farm communities outside of the SSMP command area in mid hill districts, where ELF provide services in specific topic. Preference is given by SSMP to demand proposals of the socially disadvantaged groups. ELF are providing services to the farmer groups through training, follow up visits (coaching) and also involving in final evaluation of the effectiveness of the intended technology. One demand proposal (agreement) is sought per farmer group.

This agreement and ELF service contract system provides group farmers alertness about their commitment for adopting the new SSM technology and ELF for accountability towards demand farmer groups. Table 2 gives the demand proposal, demand actors, service provider ELF and participating farmers in ELF services and the proposal topic in year 2001. More than 58% participant farmers in demand farmer group are women.

The demand proposals were financed to DFGs through demand actor institutions and directly by F-T-F committee. Each demand proposal amount to about NRs2,500 to 4,000. In year 2001, the approved budget of DP was forwarded to the respective DA, which provided funds to DFGs. The payment was given to DFGs after getting training from ELF, the remaining other activities were fulfilled afterwards. A final evaluation sheet was filled out by the respective group farmers and ELF. From year 2002, the approved amount of fund was directly provided to the respective DFGs from F-T-F committee.

ELF service received demand farmer groups were increased in year 2002 and the number was 402 (Table 3). Total household received ELF service was 9145 and among them 66% were women farmers. Only 44% of the trained ELF provided service to the demand farmer groups.

Table 2. List of demand proposals, demand support actors, service provider ELF and participating farmers in farmer to farmer diffusion in 2001

District	DP (DFGs), n	Participating farmers			Service provider ELF, n	Agreed topic to provide service
		M	F	Total		
Kavre	14	188	118	306	6	FYM/compost management, organic pest control and Vegetable cultivation
Sindh	10	100	138	238	2	FYM/compost management and Vegetable cultivation
Syangja	10	159	105	264	6	FYM/compost management and Coffee cultivation
Parbat	30	198	444	642	6	FYM/compost management and Vegetable cultivation
Doti	3	-	45	45	4	FYM/compost management and Vegetable
Baitadi	2	-	46	46	4	FYM/compost management and Groundnut cultivation
Dailekh	0	-	-	0	0	FYM/compost management and legume Vegetable cultivation
Total	69	645	896	1541	30	

Table 3. District wise ELF service received demand farmer groups with male and female farmers in 2002

District	DFGs served	Male	Female	Total	Service provider ELF, n	Received technology/services from ELF
Sindh	50	507	651	1158	8	Vegetable, legume, OPM and FYM/compost management
Kavre	60	154	1312	1466	10	Coffee, vegetable, OPM, legume and FYM/compost management
Syangja	51	656	568	1224	8	Coffee, vegetable, legume, OPM and FYM/compost management
Parbat	52	470	749	1219	5	Vegetable, legume, OPM and FYM/compost management
Baglung	36	244	576	820	8	Vegetable, legume, OPM and FYM/compost management
Surkhet	68	381	1104	1485	8	Ginger, vegetable, legume, OPM and FYM/compost management
Doti	30	96	577	673	3	Ginger, legume, vegetable, OPM and FYM/compost management
Baitadi	55	560	540	1100	6	Ginger, groundnut, citrus, OPM and FYM/compost management
Total	402	3068	6077	9145	56	

EXPERIENCES WITH FARMER-TO - FARMER DIFFUSION

ELF selection, their capacity building, agreement signing with demand farmers groups, assessing demand proposals and financing ELF-services to demand farmers groups is the process of FTF adopted in the pilot testing for wider dissemination of successful SSM cases. This approach of diffusion is effective and efficient if demand driven and community led leadership and processes are recognized and internalized by the public and other agriculture service providers. Pluralistic approach to extension service delivery can hope to meet the needs of the diverse rural communities and a rapidly changing socio-economic environment (Rivara et al 2002). Agricultural extension services are under increasing pressure to become more effective, more responsive to clients and less costly to government (WB, 2002). Participatory interactive extension system is more effective in difficult areas of developing countries for agriculture development (Axinn 1997). Farmer-to-farmer diffusion is cost effective and more responsive to farmers.

PRELIMINARY ADOPTION STUDY

It is too early to study adoption in the service received communities from ELF, however small adoption study (follow up visit) was done in 5 districts where F-T-F programme was implemented. The sample cluster was purposively selected. Table 4 shows the low level of adoption of SSM technology and higher level of adoption of

cash commodities in farm households. Farmers are more interested in short term cash income than long term soil sustainability. Lowest adoption of urine utilization and improved FYM/compost management in Baitadi was due to the migratory livestock keeping system and cattle sheds are located below the surface level, resulting difficulties in urine collection. Therefore the adoption of technologies by farmers may reflect rational decision making based upon farmers' perception of the appropriateness or inappropriateness of the attributes of the technology (Joshi, 2003). Same technology is adopted in one socio-economic and environmental domain and not adopted in another domain (Paudel 2098, Weber and Paudel 2002). Farmers adapt technology in their ecosystem and if found suitable, then only they adopt slowly (Paudel 2002).

Table 4. Adoption of sustainable soil management technology and cash crops in demand farmers' groups, where ELF provided services

District	Adoption of SSM technology (HH)	Adoption of cash commodities (HH)
Sindhupalchowk	38 (46%)	97 (116%)
Kavre	245 (63%)	393 (110%)
Baitadi	29 (10%)	280 (100%)
Parbat	252 (78%)	295 (91%)
Syangja	108 (52%)	378 (180%)
Mean (district basis)	49.8%	119.4%

Source: Sustainable soil management report, 2002.

The following lessons are learnt while interacting with farmers and other agriculture development stakeholders in different levels.

Strength

- Promising means of effective scaling-up of successful technologies.
- Both, the service provider (ELF) and demand groups (DFG) are farmers, therefore this program directly benefits farmers.
- The technology providers are directly accountable to the farmers unlike extension workers of GO and NGOs, which are accountable to their respective institutions.
- Feeling of more ownership of group farmers about the technology adoption
- Cost effectiveness for wider dissemination than other system of extension (DADO, NGO)
- Builds on farmers field experience with the technology not on extension messages
- Builds on farmer local communication skills
- Commitment from both demand and supply sides are better realized to fulfill their responsibilities
- More effective in heterogeneous environments and illiterate farm communities
- Technologies adopted from ELF services are likely to be more stable and sustainable, because they only disseminate successful technology

Challenges

- Very small project agreements, wide scattered geographic area coverage, many proposals and difficulties in financial management and monitoring
- The success of programme depend mainly on quality of ELF, but selection of ELF is difficult task
- The facilitation from CI for this process is important, but CI are reluctant to do this since the institutions do not financially benefit from this process
- The effective ELF are reluctant in paper work like filling agreement proposal form, maintaining diary and preparing lesson plans in the training
- Difficulties in seeking demand groups according to the expertise of ELF
- Farmers interest is mainly on short term profitable technologies, less on long term SSM
- There are only limited availability of successful cases for wider dissemination

Opportunities

- Forming district level FTF committee to handle the process at the district level
- Explore opportunities of collaborating with NARDF and LTFB fund under Ministry of Agriculture and District Development Committees
- Demand driven approach and activities are based on the priority of the demand farmers groups
- Opportunity of involving women and other disadvantaged group of people in the sustainable soil management process

- Opportunity of capacity building of farmer organizations
- Recognized by agriculture extension policy in 10th five year plan (NPC 2003)

CONCLUSION

SSMP experiences indicate that FTF offers good chances of reaching many people quickly with new technologies. But, methods of more flexible handling of the FTF-process should be sought for effective implementation. There are a lot of challenges to implement farmer -to- farmer diffusion although this process may well complement the present national extension system. The importance of the farmer- to- farmer extension is increased in the context of contract extension and under the decentralized local governance system, which are both under implementation in Nepal. The local trust fund under district development committees could be better utilized through this approach as the fund is managed at the district level.

REFERENCES

- Axinn GH. 1997. Challenges to agricultural extension in the twenty-first century. **In:** *Farmer-Led Extension* (V Scarborough, S Killough, DA Johnson and J Farrington, eds). Intermediate Technology Publications, London, United Kingdom. Pp.13 -22.
- Joshi GR. 2003. Farmers' perceptions and decision on rice technology adoption in the rainfed ecosystem of Nepal. *PhD Thesis*. University of The Philippines Los Banos, Philippines. 254pp.
- NPC. 2003. *Tenth 5th year plan, policy document* of His Majesty Government of Nepal. National Planning Commission, HMG, Kathmandu, Nepal. 540pp.
- Paudel CL. 2002. Scaling up sustainable management practices through farmer-to-farmer diffusion. **In:** *Proceedings of workshop on biophysical and socio-economic tools for assessing soil fertility*. Lumle Agriculture Research Station, Nepal.
- Paudel CL, BR Kafle and B Bajracharya. 2002. Training manual on farmer-to-farmer diffusion process for sustainable soil management practices in Nepal. *Sustainable Soil Management Programme*, Helvetas, Kathmandu, Nepal.
- Paudel CL. 1998. Experiences in resource management with farmers' participation in ARS Jumla command area. **In:** *Proceedings of Fourth National Outreach Workshop*. Agricultural Research Council, Kathmandu, Nepal.
- Rivera WM, W Zijp and G Alex. 2002. Contracting for extension: Review of emerging practices. *Agriculture Knowledge Information Systems Thematic Group*, World Bank. 26p.
- SSMP. 2002. *A report on support to the promotion of a farmer- to- farmer diffusion approach*. SSMP Document 82. Sustainable Soil Management Programme, Bakundole, Lalitpur, Nepal.
- WB. 2002. *Decentralizing agricultural extension*. World Bank, Washington DC USA. 16 p.
- Weber G and CL Paudel. 2000. Farmers' decision taking on soil fertility management and implications for extension. **In:** *Proceedings of biophysical and socioeconomic tools for accessing soil fertility initiation workshop* (AE Jones and B Tripathi, eds). 17-18 Oct 2000, Agriculture Research Station, Lumle, Nepal and Silsoe Research Institute, UK.

Maize Husbandry Practices Study at Outreach Research Sites Pakhribas

RB Katuwal

ARS, NARC, Pakhribas

ABSTRACT

Maize is largely cultivating using traditional methods and contaminated varieties. Observations, visits, surveys and experiences revealed that maize yields are less than expected potential in the hills. Nitrogen deficiency, low plant population, poor supply of external inputs, poor crop management, and lacking of suitable inter-cropping practices in the farmers' field were the possible causes of low productivity. A total of two trials namely, the effect of nitrogen fertilizer and planting density on grain yield of maize under maize + bean/millet inter-cropping system (mid hill) and soybean inter-cropping in double plant per hill system under maize + soybean (mid and high hills) were conducted in 2001 and 2002. Based on two year's result, double plant per hill (100- x 50-cm) of maize with 60 N kg/ha was found equally good with 75- x 25-cm spacing the national recommendation for mid hill. It had good yield advantages of inter and relay crops of bean and millet under maize + bean/millet cropping system. This could also be implied for other inter-crops like ginger, soybean, groundnut and vegetables. Double plant per hill with 30 N kg/ha produced higher total yield (9966 kg/ha) of three crops (maize, bean and millet) under the system. Statistically there was no yield and the other agronomic trait advantage among the treatments at high hills. There was no effect of soybean inter-cropped with maize at high hills. In case of middle hills, combined analysis of variance over locations showed significant ($P < 0.01$) yield difference among the treatments. However interaction effect between locations and plant spacing showed not significant results. Maize Manakamana-3 produced higher grain yield 6317 kg/ha and 5660 kg/ha in 75-x 25-cm single plant per hill and in 75-x 50-cm double plant per hill systems respectively and these are statistically at par. The combined yield of maize + soybean was released more (6593 kg/ha) from 75-x 25-cm single plant per hill system of maize. Because of very low yield poor plant establishment and performance of soybean, variety CN-60 and Lumle-1 were not suitable for inter-cropping with maize Ganesh-1 and Manakamana-3, in inter-cropping condition.

Key words: Dhankuta, husbandry practices, maize

INTRODUCTION

The agricultural system of the hills that combines crops, livestock and forest is generally complex. A great variation exists within the system in term of physical, biological and socioeconomic situation. Maize (*Zea mays* L.) is the most important cereal in the hills of Nepal. It is grown in an area of 824,525 ha with a production of 1,484,112 tones (ASPSD/MOA 2000/2001) with a productivity of 1.8 t/ha. Of the total mid hills alone occupies 70 percent areas of maize production. In the eastern hills, maize is grown from low to high (300-2500 m) altitude (Tiwari et al 1997).

Maize in mid hills is mostly grown in a maize/millet, maize+soybean and maize-toria cropping systems. Maize/millet relay is a predominant cropping pattern at mid elevation of the eastern hills. Maize/millet cropping pattern covers about 67% of total *bari* land (170,346 ha) in the mid altitude of the eastern hills (Chand and Thapa 1992). Likewise, maize + soybean is the second important after potato + maize cropping system at high hills.

Since maize is a crop grown under a wide range of agro-climatic condition the main problems associated with its production are varied. As maize is usually inter-cropped with other crops such as millet, soybean, beans and potato, varieties suitable for inter-cropping situation are required (Gurung et al 1993).

Maize is largely cultivating using traditional methods and local and contaminated varieties. The experiences, observations, visits and surveys revealed that maize yields are less than expected potential in the hills. Use of low yielding varieties, low plant densities both in inter-cropped or sole crops, poor supply of external inputs, weed infestation low soil fertility management, poor crop management and lacking of suitable inter-cropping practices in the farmers' field were identified as possible causes of low productivity.

Nitrogen is one of the major nutrients for maize production. Maximizing nitrogen use efficiency is an increasingly important aspect of crop management system because of both economic and environmental pressure (Neupane 1996). High levels of nitrogen are generally thought to increase the susceptibility of plants to disease, whereas phosphorus and potassium result in more resistant plants (Bair 1987). So, there is need of continuous research on maize in order to identify suitable technology for the hills.

This report covers the result of the effect of nitrogen fertilizer and planting density on grain yield of maize under maize+bean/millet cropping system and soybean inter-crop in double plants/hill system under maize conducted at the outreach research sites in 2001/2002.

A. EFFECT OF NITROGEN FERTILIZER AND PLANTING DENSITY ON GRAIN YIELD OF MAIZE UNDER MAIZE+BEAN/MILLET INTERCROPPING

One of the major aims of the ARS, Pakhribas is to avail and recommend new adaptive technology to the farmers that fit in to their local cropping systems. Though, the technologies, which have greater yield potential, farmers reluctant to adopt if it is not suitable for their condition. One of the major constraints that widen the yield gap in maize is the limitation of system technology i.e. combination of plant nutrients and densities, suitable for inter-crops and profitability of the maize + bean/millet system. Considering the situation, this trial was carried out at Belhara OR site in 2001. Objectives of this study were to determine the effect on nitrogen and plant density (N x D) on the productivity of maize under maize+bean/millet system and to determine a combination of nitrogen rate and population density, which recommended to farming system and farmers would give an acceptable economic return?

MATERIALS AND METHODS

A trial consisting of nine treatments was conducted at Belhara mid (1400 m) altitude site under maize+bean/millet system in 2001 and 2002. The trial was planted in a RCB (split-plot arrangement) design (3 leaves of nitrogen and 3 leaves of plant densities) and replicated three times within a farm (farmer's field). The plot size was 7.5m². Maize Manakamana-3 (Pop-22) and bean (local are simi- bush bean) sowed on April. Seeding and transplanting of millet (Okhle-1) was done on June and July respectively. Sowing of maize and application of fertilizers was done as per treatments (Appendix 1) for treatment details) and bean and millet were sown as per farmers' practice uniformly in all plots and replications. Weeding and other intercultural operations were done according to the farmer's time and method. Observations such as plant stand, maturity, plant stand per plot, plant and ear height, diseases/pests, stover, straw and grain yields whatever needed were recorded. Statistical analysis was performed for the important parameters.

RESULTS AND DISCUSSION

Statistical analysis of variance showed a significant ($P<0.01$) effect of the nitrogen (N) level on grain yield of maize (Table 1). However, statistically the density (D) and its interaction effect with nitrogen (N x D) showed non-significant results ($P<0.05$). The highest grain yield was released by the application of N 60 kg/ha (4497 kg/ha) followed by N 30 kg/ha (4037 kg/ha). The difference in yield between N 30 and N 60 is not significant.

Likewise, plant stand of maize at harvest was found significant ($P<0.01$) with the application of N and planting density was also showed significant ($P<0.05$) difference (Appendix 4). However, the interaction between N X D was found not significant ($P<0.05$). The highest plant (40) from 0 N kg/ha and lowest plants (34) were harvested from 100 x 50 cm (double plants/hill) system. In contrast, the plant stand of millet and bean did not difference

significantly among the N levels and maize density and interaction between N x D. Statistical analysis of stover yield was showed significant ($P<0.01$) difference on the application of N (Appendix 1).

Table 1. Effect of N x D on grain yield (kg/ha) of maize, 2002

Density	Nitrogen, kg/ha			Mean
	0	30	60	
D ₁	3196	4169	5148	4171
D ₂	2993	3918	4203	3705
D ₃	3442	4024	4140	3896
Mean	3210	4027	4497	3915
F test	**	D= NS	N x D= NS	
SE	131	402	226	
CV, %	10.0			

D₁ = 75-x25-cm single plant/hill, D₂ = 100-x50-cm double plant/hill and D₃ = Farmers' practices (behind the below)

If we considered the combined analysis of yield maize, bean and millet, there was significant ($P<0.01$) difference. If we considered the analysis of variance on combined yield of three crops (maize, bean, millet), there was significant ($P<0.01$) yield difference among the N applied treatments. The highest combined yield released from 60 N kg/ha (8369 kg/ha) followed by 30 N kg/ha (7969 kg/ha). These two levels of N application are statistically at par.

Table 2. Effect of Nitrogen (N) on grain yield (kg/ha) under maize+bean/millet system combined over years

N level	Maize	Bean	Millet	Combined
0 N	3727	982	3141	7703
30 N	4801	1030	3372	9202
60 N	5089	1088	3275	9452
F test	NS	NS	NS	NS
Interaction	-	*	NS	*
CV, %	14.9	29.4	9.8	8.9
Mean	4539	1003	3263	8786

Combined analysis of variance over years and its interaction effect was found not significant ($P<0.05$) on grain yields of all crops as well as combined yield with the application on nitrogen. However, there was an interaction effect between the yield of bean and combined yield and years (Table 2).

Table 3. Effect of Density (D) on grain yield (kg/ha) under maize+bean/millet system combined over years

Density	Maize	Bean	Millet	Combined
D 1	4484	1038	3068	8534
D 2	4457	1146	3534	9137
D 3	4676	825	3186	8685
F test	NS	**	*	*
Interaction	NS	*	NS	NS
SE±	-	98	75	261
Interaction	-	69	-	-
CV, %	14.9	29.4	9.8	8.9
Mean	4539	1003	3263	8786

Likewise, the combined analysis of variance over years and its interaction effect with planting density of maize was found significant ($P<0.01$) on pod of bean. Similarly, grain yield of millet and combined yields of three crop was also differed significantly ($P<0.05$) with planting density. However, the interaction effect between planting density x years was not significant. The highest bean yield was produced from double plants per hill (100- x 50-cm) and single plant per hill (75-x25-cm) system of maize (Table 3). Millet produced more (3534 kg/ha) from double plants per hill system of maize. There was no difference in maize yield. The higher combined yield was released from double plant per hill system of maize. The higher yield of bean, millet inter-crops and combined yield of three crops was found mainly due to the line sowing with double plants per hill (100- x 50-cm) of maize (Table 3). Interaction (N x D) plots for the combined yield production of three crops is presented in Figure 1.

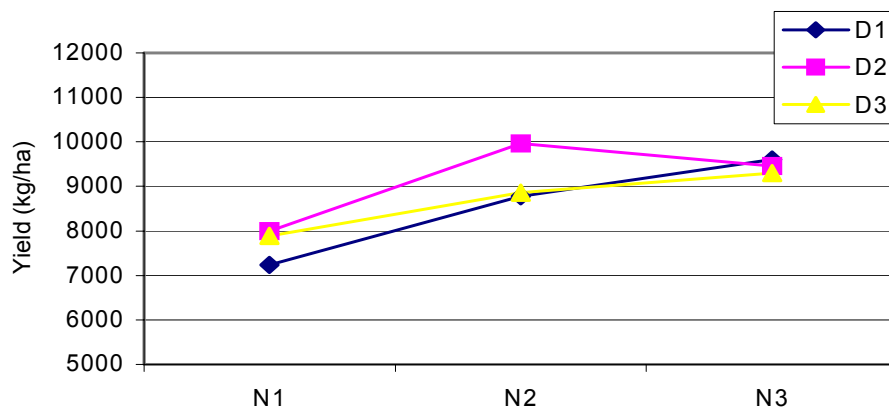


Figure 1. Interaction (N x D) plots for combined yield production.

Double plant per hill (100- x 50-cm) with 30 N kg/ha was out yielded in the study. It indicated that there was good effect of nitrogen application for maize and more space for inter-crops was favoured for higher combined yield within this system. There was no variation in crop maturity due to the same varieties in all treatments. None of the treatments were free from rat damage on millet crop and barren plants in maize crop. Rat damage was observed more in millet crop and scored accordingly.

CONCLUSION

Based on two year's result, double plant per hill system (100- x 50-cm spacing) of maize with 60 N kg/ha was found better and/or equally good with 75- x 25-cm spacing, the national recommendation for maize production in the hills. It had good yield advantages (total yield of three crops in double plant per hill with 30 N kg/ha) for inter and relay crops of bean and millet crops under maize+bean/millet cropping system. This could also be implied for other inter-crops like zinger, soybean, groundnut and vegetables. Therefore, it needs to test and verify this technology for wider adaptation in the hills of Nepal.

B. SOYABEAN INTERCROPPING IN DOUBLE PLANTS/HILL SYSTEM UNDER MAIZE

Maize in the high and mid hills cultivating traditionally and inter-cropping of soybean, potato, millet and vegetables are common. Compatibility of crop and crop species with the appropriate crop geometry is the most for good profitability from inter-cropping practices. On the ground of poor crop management and lacking of suitable inter-cropping practices and plant density of maize, this trial was planned and implemented at the outreach research sites of high and mid hills of ARSP. The objective was to determine the effect of plant populations (density) of maize on the productivity of maize+soybean inter-crop system that affect on the grain yield of maize.

MATERIALS AND METHODS

The trial was conducted in Basantapur and Mudhesanischare high altitude and Fakchamara and Fikkal mid altitude outreach research sites in 2001/2002. It was executed in a RCB design and replicated three times in each site. Maize variety Ganesh-1 and Manakamana-3 (Population-22) were included at high and mid altitudes respectively. There were five treatments in the trial and seed was sown according to the treatments (75- x 50-cm double plants/hill, 100- x 50-cm double plants/hill, 75- x 25-cm single plant/hill, and 100- x 25-cm single plant/hill and farmers' practice). Soybean variety CN-60 for the first year and Lumle-1 for the second year were used and sown as per farmers' practice. The plot size allocated to each variety was 9m² area. Fertilizer 60:30:0 NP₂O₅K₂O and 10 t/ha FYM (farmers' practice) was applied for the maize crop. Two weeding were done and soybean was sown just after the first weeding of maize. Weeding and other intercultural operations were done as

per farmers' practice. Observations such as plant stand, maturity, plant height and yields were recorded. Statistical analysis for the yield and other important parameters were done.

RESULTS AND DISCUSSION

High altitude

Results from the study showed non-significant ($P < 0.05$) differences between most of the variables analyzed at the high hills (Table 4). Combined analysis of variance over locations, however, showed significant result ($P < 0.01$) in number of ears of maize whereas its interaction with the location and plant spacing showed not significant results. The higher ears were obtained from 75- x 25-cm double plant per hill and farmers' practices (Table 4). Barren maize plants were recorded irrespective of the treatments.

Table 4. Grain yield (kg/ha) of maize + soybean inter-cropping combined over locations, 2001/2002.

Treatment	High altitude			Mid altitude		
	Maize	Soybean	Total	Maize	Soybean	Total
75 x 50 cm double plant/hill	6741	150	6891	5660	270	5930
100 x 50 cm double plant/hill	6429	105	6534	5048	358	5406
75 x 25 cm single plant/hill	6606	109	6715	6317	276	6593
100 x 25 cm single plant/hill	6540	153	6693	5159	409	5568
Farmers' practice	6584	101	6685	5292	271	5563
F test	NS	-	-	**	-	-
Interaction	-	-	-	NS	-	-
CV, %	13.8	-	-	11.1	-	-
SE $\pm$	-	-	-	248	-	-
Mean	6580	-	-	5495	-	-

There was no effect of soybean inter-cropping at high altitude sites, Basantapur and Mudesanischare. Varieties CN-60 and Lumle-1 were not appropriate for inter-cropping with the tall, high yielding and longer duration maize Ganesh-1. Vegetative growth and seed yield of soybean was very poor at both sites (Table 4). Wild rabbit attacked Soybean at the early stages of crop at Mudesanischre site.

Mid altitude

Combined analysis of variance over locations showed significant ($P < 0.01$) yield difference among the treatments. However interaction effect between locations and plant spacing showed not significant results (Table 4). The highest maize yield was released from 75- x 50-cm double plant per hill and 75- x 25-cm single plant per hill system and these are statistically at par.

If we considered the combined yield of maize and soybean, treatments 75 cm x 25cm single plant per hill (6593 kg/ha) and 75- x 50-cm double plant per hill (5930 kg/ha) systems produced higher yields. It was observed and known that variety CN-60 and Lumle-1 were not compatible for inter-cropping with maize variety Manakamana-3 (Population-22) at mid hills. Farmers from Fikkal thought that CN-60 would be better if planted as sole crop or on paddy lips.

CONCLUSION

Statistically there was no yield and other agronomic trait advantage at high hills. Manakamana-3 in single plant per (75- x 25-cm) and double plant per hill (75- x 50-cm) systems gave encouraging results. However, soybean CN-60 and Lumle-1 used, as inter-crops were not suitable under maize Manakamana-3 at mid hills. Therefore, it needs to test and find out the soybean variety conducive for inter-cropping with maize first.

ACKNOWLEDGEMENTS

The authors express sincere gratitude to Mr PL Karna ARS, Pakhribas for his continuous support in carrying out this research. Similarly, I am very grateful to the Maize Research Programme, Rampur for research materials and technical help. Dr J Ransom, Dr F Gonjlez, Dr N Rajbhandary and Dr TP Tiwari, CIMMYT, Nepal is highly acknowledged for their financial and technical support. The collaborators and the participating farmers deserve due thanks for their coordination and assistance in carrying out this report. I am also grateful to all my colleagues especially Dr TP Barakoti and Mr PP Khatiwada field staff for their continuous help on this research. A sincere thanks also goes to Mr DP Sharma for his assistance in computing the report.

REFERENCES

- Bair W. 1987. The effect of time and rate of N-side dress application on Nitrogen corn leaf blight severity and the associated yield loss. *Journal of Production Agriculture* JPRAEN 3: 44-48.
- NARC. 2002. *The 23rd national summer crops workshop on maize research and production*. National Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal.
- Neupane AM. 1996. Effect of variety and level of nitrogen on the grain yield of baby corn. Asian maize training center. *Training report*, 2nd regional training course on maize.
- Tiwari TP, BD Gurung and DK Rijal. 1997. Variety selection criteria of agronomical crops (cereals, legumes, oilseeds and potato): Guidelines for better consideration. *PAC Working Paper No. 180*. Pakhribas Agricultural Centre, Dhankuta.

Appendix 1. Effect of nitrogen fertilizer and planting density on grain yield of maize under maize+bean/millet cropping system at outreach research site, Belhara in 2002

Treatment	Maize					Bean			Millet			Combined yield, kg/ha	
	Plant stand/plot	Plant height, cm	Barren plant, %	Stover yield, t/ha	Grain yield, kg/ha	Plant stand/ plot	Straw yield, t/ha	Pod yield, kg/ha	Plant stand/ plot	Rat damage, %	Straw yield, t/ha		Grain yield, kg/ha
D ₁ + N ₀	40	219	8	6.2	3196	33	2.1	618	103	12	10.0	2786	6259
D ₁ +N ₃₀	39	229	3	7.8	4169	23	1.4	680	99	8	10.5	3323	6967
D ₁ +N ₆₀	41	230	3	7.4	5148	25	1.7	502	98	12	10.7	2901	6833
D ₂ +N ₀	28	225	7	5.5	2993	28	1.7	471	99	16	10.5	3062	7711
D ₂ +N ₃₀	29	240	2	6.0	3918	24	1.8	680	114	26	9.7	4028	8686
D ₂ +N ₆₀	29	236	6	6.7	4203	26	2.0	511	113	8	10.1	3003	7510
D ₃ +N ₀	37	226	6	6.4	3441	24	1.6	507	105	12	9.9	3057	8701
D ₃ +N ₃₀	33	236	2	6.4	4024	22	1.4	676	99	19	10.8	4028	8934
D ₃ +N ₆₀	39	237	2	7.8	4140	21	1.4	498	103	12	10.6	2844	7472
F test, N	**	NS	-	**	**	NS	NS	NS	NS	-	NS	NS	**
D	*	NS	-	NS	NS	NS	NS	NS	NS	-	NS	*	NS
NxD	NS	NS	-	NS	NS	-	NS	NS	NS	-	NS	NS	NS
CV, %	5.5	4.7	-	9.6	10.0	-	26.7	26.7	7.0	-	7.0	9.6	10.3
SE ±:N	0.9	-	-	0.2	131	-	-	-	-	-	-	-	153
D	0.6	-	-	-	-	1.6	-	-	-	-	-	113	-
NxD	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	35	231	-	6.7	3915	25	1.7	429	103	-	10.3	3226	7675

D₁ = single plant/hill (75- x 25-cm), D₂ = Double plant/hill (100-x 50-cm), D₃ = Farmers' practice (behind plough).

Maize in Transition from Food to Feed Crop: Policy Implications and Sustainability Issues

Kamal R Paudyal¹ and Netra P Osti²

¹ CIMMYT, South Asia Regional Office, Kathmandu

² Animal Nutrition Division, NARC, Kathmandu

ABSTRACT

Traditionally maize is grown for food in Nepal. However, its importance as a feed crop is growing very fast especially in accessible areas. A recent estimate shows that a total of 151,000 tons of maize is used to prepare compounded poultry feed in the country each year to feed almost 9 million commercial poultry birds. Another 154,000 tons of maize is used annually as feed for other animals including cattle, fish, pigs and backyard poultry birds. As the domestic production is not enough to satisfy the increasing demand for maize from the growing maize consuming population and fast growing feed industry, the increased demand is mostly met through imports. High dependency of Nepalese feed industry upon imported raw materials makes it highly vulnerable to any type of disturbances and shifts in the domestic as well as external trade policies. Resource cost ratios also indicates that Nepal has a comparative advantage in producing maize for domestic use rather than importing it. This clearly demands for policy interventions to provide a conducive environment for increased maize production and to remove bottlenecks on commercial maize production for supporting the development of poultry sector in Nepal.

Key words: Comparative advantage, feed, maize, poultry, protection coefficients

INTRODUCTION

Nepal produces 0.25% of the world's maize supply (600 million tons) whereas its two neighbors, China and India, produce 20% and 2% of the world's total maize, respectively. Thus, from the global perspective maize production in Nepal appears insignificant. However, within Nepal maize is the second most important cereal. In the hills, it is the most important food crop from production as well as consumption perspectives. It is cultivated on slopping upland terraces under rainfed conditions in the hills during March-September. In the irrigated low-lying areas of river basins and the terai, it is also cultivated as a winter and spring crop.

Maize production grew by 1.93 percent per annum during the last one decade while population grew by 2.27 percent per annum. This has created larger gap in demand and supply of maize in the country. In addition demand of maize kept increasing from the ever-increasing commercial poultry sector.

The concept of commercial poultry production was introduced in Nepal in the 1970s. The decade of 1980 was the era of popularization of broiler meat in Nepal. In the decade of 1990, the commercial poultry industry experienced a tremendous growth making the country self sufficient in broiler meat and chicken eggs. Lohani (2002) estimated that chicken meat and eggs production recorded a growth rate of 22.7% and 23.4%, respectively, that ultimately resulted in a 22.5% growth in the production of poultry feed in the country between 1996/97 and 2001/02. The contribution of the commercial poultry sector (including the feed industry) in total GDP is 4% and is estimated to have provided employment to 68,082 people in the country (Lohani 2002, personal communication). As maize is the main domestic feed ingredient, the sustainability of the poultry industry depends on its production and related policies that guide its ultimate supply.

Feed production is a major component of the poultry industry as it accounts for more than 60% of the total cost of production. Consequently, the demand for compounded feed in Nepal depended upon the growth and

expansion of poultry industry. Bhatarai et al (2001) estimated that 95% of the compounded feed production was poultry feed, 4% cattle feed and remaining 1% included pig feed, rabbit feed, horse feed and fish feed.

FAOSTAT shows that 17 to 19% of the total maize supply in Nepal went to animal feed whereas use of other cereals in animal feed remained less than 1% of their total supply during 1995-2000. The present survey also suggests that maize consists of up to 50% of compounded poultry feed. Some of the feed mills used wheat in poultry feed during lean seasons, but its ratio to total feed never exceeded 10%.

There has been an import of maize to fill the gap between domestic supply and demand in the recent past. The volume of maize imports during 1996/97 to 2000/01 ranged from 300 to almost 14,000 mt in a year (FAOSTAT). However, the actual import is probably much higher as unregistered imports are often reported through the open border with India. People associated with the feed industry believe that imported maize accounted 40-50% of total maize they used as feed ingredient, last year. The objectives were to estimate maize demand from the livestock sector; to analyze the comparative advantage of domestic production versus the import of maize and to recommend policy options for sustainable improvement of maize and poultry farming in Nepal.

MATERIALS AND METHODS

The analysis is based on secondary and primary data collected through sample surveys of the feed industries and poultry farms. Maize production and trade statistics were taken from FAOSTAT and publications of the Ministry of Agriculture and Cooperatives (MOAC). Information on maize import from 1999/00 to 2001/02 was also collected from four major customs offices-Nepalgunj, Bhairahawa, Birgunj and Biratnagar¹

Information on the informal import of maize through the open border was captured by conducting RRAs along the border towns of Nepal. The time series cost of production and prices were collected from the Economic Analysis and Statistics Directorate (EASD), Marketing Development Directorate (MDD) and Nepal Rastra Bank (NRB) publications. The present number of hybrid birds in the country is based on information on the import of breeder chicks collected from the Nepal Poultry Association and feed and poultry industries. The Domestic Resource Cost (DRC) ratio and the Nominal Protection Coefficient (NPC) are used to examine resource use efficiency of maize production in the country and effective incentives to maize farmers.

RESULTS AND DISCUSSION

Feed production in the country

It is reported that there are all together 154 private sector feed industries in the country (Maharjan 2002) but only 94 were registered with the Nepal Feed Industry Association as of January 2003. Almost 60% of these feed industries (mills) are concentrated in the Central Development Region (Table 1).

Table 1. Numbers of feed mills registered with feed entrepreneurs association

Development region	Ecological zone	No. of feed mills
Eastern	Hills	-
	Terai	3
Central	Hills	40
	Terai	16
Western	Hills	23
	Terai	10
Mid and far-western	Hills	-
	Terai	2
Total		94

Source: Nepal feed industry association.

¹ More than three fourths of import takes place from these customs (MOF 2001).

The production capacity of the surveyed feed mills varied widely from 2 ton per day to 80 ton per day. Of the 35 feed mills surveyed 14 have less than 10 ton/day capacity, 13 have 10-20 ton/day capacity and 8 have more than 20 ton/day capacity. It is found that 5 of them are running at less than 25% of their capacity, 18 between 25%-50% of their capacity and 12 at more than 50% of their capacity. Based on these findings it is estimated that the existing feed mills are capable of supplying the required quantity of compounded feed in the country if they run at their full capacity. Of the 35 private sectors feed mills interviewed 14 (40%) reportedly produced poultry and other (mainly cattle) feeds. The rest of the mills produced only poultry feed in the last three years. The average poultry feed production among the surveyed feed mills ranged from 0.4 to 32 tons per day with an average of 7.4 tons per day. Average level of cattle feed production was about 2 tons per day (Table 2).

Table 2. Average daily feed production by the surveyed feed mills in 2001/02

Feed type	Number of mills	Average Daily feed production, mt		
		Mean	Maximum	Minimum
Poultry feed	35	7.4	32.0	0.4
Cattle feed	14	2.0	8	0.1

The only public sector feed industry “Animal Feed Production Development Committee” was established three decades ago in Hetauda with the objectives of supplying quality animal feed to the public and private sector. It has a compounded feed production capacity of 16 tons per day (2 tons/hour). It produced and sold 1,502 mt of feed in the last year utilizing only over 31% of its installed capacity. Out of the total animal feed it supplied, 45-55 % was poultry feed, 20-25 % was cattle feed and the rest was pig, fish and other feeds. The record of parental stock import maintained by Nepal Hatchery Industry Association shows that a total of 166,242 and 230,680 female broiler breeders were imported into Nepal in 2000/01 and 2001/02, respectively. Similarly, 32,200 and 29,435 female layer breeders were imported in the country in 2000/01 and 2001/02, respectively (Table 3).

Table 3. Import of breeder chicks in 2000/01 and 2001/02

	2000/01				2001/02			
	Broiler breeder		Layer breeder		Broiler breeder		Layer breeder	
	Male	Female	Male	Female	Male	Female	Male	Female
July/Aug	926	7,020			1,750	14,350		
Aug/Sep	1,050	10,700	700	4,700	4,605	31,170	257	2,135
Sep/Oct	150	2,872			2,458	14,600	420	5,900
Oct/Nov	440	4,400	400	3,000	2,308	15,750	390	3,200
Nov/Dec	4,168	31,900	540	4,500	2,005	9,670	715	4,000
Dec/Jan	4,020	26,200	750	4,200	675	4,500		
Jan/Feb	2,350	16,500	216	1,800	7,594	52,890	900	6,000
Feb/Mar	1,040	12,600	225	1,500	1,009	6,950	252	2,100
Mar/Apr	2,775	24,600	300	2,000	2,915	20,600		
Apr/May	695	5,850			4,640	35,100		
May/June	1,465	9,050	750	5,000	2,313	14,250		
June/July	2,355	14,550	690	5,500	1,795	10,850	952	6,100
Total	21,434	166,242	4,571	32,200	34,067	230,680	3,886	29,435

Source: Nepal Hatchery Industry Association.

Based on the number of breeder chicks imported into the country (Table 3) and their average productivity, it is estimated that there are 4,426,533 commercial layers and 4,065,324 commercial broilers in the country. The total demand of compounded feed for breeder stock and commercial poultry is estimated to be 359,394 tons in one year. About 5% of the compounded feed is estimated to have been demanded from backyard poultry. Thus a total of 378,309 tons of compounded poultry feed is demanded in the country in a year. A large part of this demand is met by the feed industry while part of the demand is met by preparing feed by the poultry farms themselves (mainly large farms). Available statistics indicate that the production of compounded cattle, pig, fish and other type of feed accounted for about 5% of total compounded feed produced in the country. This estimate indicates that the feed industries are supplying a total of 19,911 tons compounded feed for cattle, fish, pig and other animals.

Demand of maize from poultry and livestock sector

Based on the population data and assuming that poultry feed and cattle feed contains 42% and 25% of maize, respectively, 163,868 tons of maize is being used by the commercial feed industry in one year. A substantial amount of maize and other cereals are fed to milking cows and buffalos as home made feed called KUNDO. Based on statistics published by the Ministry of Agricultural and Cooperatives (MOAC) and data collected

through PRA it is estimated that 130,597 tons of maize is fed to milk animals as homemade feed. Similarly, it is estimated that a total of 11,067 tons of maize is fed directly to backyard poultry in a year. Thus 305,531 tons of maize is used annually for livestock and poultry sector in Nepal. This is equivalent to 20% of the total maize production in the country.

Sources of feed ingredients

Twelve of the 35 feed mills interviewed used only Nepali maize in the last year, while the rest (23) used a blend of Nepali and imported maize. All of the rice polish, wheat bran and molasses that the feed mills used were Nepali products. Soybean meal, groundnut cake, fish meal, meat meal, oyster shells and vitamin/mineral/amino acids were imported. The rest of the ingredients including mustard cake, sesame cake, sunflower cake, deoiled rice polish, wheat, bone meal and limestone were partly Nepalese origin and partly imported.

Data collected from four major customs offices² along the Indo-Nepal border shows that a total of 17,452 tons of maize was imported through these offices in 2001/02. It is estimated that the total maize imported through other customs throughout the Indo-Nepal border amounted to a similar quantity.

People associated with feed business believe that the actual amount of maize imported from India should be much larger than the official import figures as they have seen tons of maize being imported through the porous border without knowledge of the authority. The feed industry survey also shows that imported maize consisted of about 43% of the total maize used by feed mills in the last one year. Based on these findings it is estimated that some 30,000 to 40,000 tons of maize is being imported annually through the porous border illegally. Thus the total import of maize in Nepal amounts about 65,000 to 75,000 tons annually. Most of the maize import takes place between December-May. This is because most of the inner routes along Indo-Nepal border are impassable by vehicles during the rainy season. Assuming an average price of Rs10 per kg, 650 to 750 million Rupees is spent on the import of maize in a year.

It is time to consider whether Nepal should continue such import or increase domestic production for import substitution. One of the important points to be considered in the decision-making is to look into comparative advantage. This can be done through an assessment of resource use efficiency and effective incentives to the farmers that are involved in production front. Sustainability of the system is the other important issue.

Indicators of resource use efficiency in maize production

A crop with a comparative advantage is one that can be produced more cheaply than other countries of the world. In order to use the agricultural resources efficiently, a country should maximize the production of crops for which it has a comparative advantage and import those commodities, which can be produced more cheaply elsewhere. The concept of Domestic Resource Cost (DRC) remains the most widely used indicator to examine the comparative advantage in production of different commodities.

The DRC is the ratio of the total value of domestic resources (primary sources of production) used in the production of a commodity to the value of foreign exchange saved (through import-substitution) or earned (through exports). If it costs fewer domestic resources (in terms of opportunity values) to save or earn a unit of foreign currency, the production activity is considered efficient and the country is said to have comparative advantage.

A simple equation for calculating the DRC would be as follows:

Where A_{ij} quantity of the j^{th} input required to produce a unit of commodity i ;

$$DRC_i = \frac{\sum_{j=k+1}^j A_{ij} P_j^s}{P_i^w - \sum_{j=1}^k A_{ij} P_j^w}$$

p_j^s shadow price (social price or opportunity cost) of j^{th} non-traded inputs (in Rs);
 p_i^w world reference price (border price equivalent) of commodity i adjusted for transportation, handling and marketing expenses(in \$);

² Nepalgunj, Bhairahawa, Birgunj and Biratnagar.

p_j^w	world reference price (border price equivalent) of j^{th} traded input, adjusted for transportation, handling and marketing expenses (in \$);
$j=1..k$	directly traded inputs plus the tradable elements of non-traded inputs obtained after decomposing the non-traded items into tradable and non-tradable;
$j=k+1..j$	primary inputs plus non-traded elements of non-traded inputs obtained after decomposing the non-traded items into tradable and non-tradable.

This expression provides the 'true cost' of domestic resources that are needed to save/earn a unit of foreign exchange by production of commodity i . Supposing the economy-wide shadow price of foreign exchange is given exogenously, we can apply this in the denominator of the expression for DRC to convert the world reference prices into local currency units. The resulting expression would be a ratio commonly known as the Resource Cost Ratio ($RCR_i = DRC_i/\text{shadow exchange rate}$). If the ratio is greater than unity, it indicates that the 'true cost' of the production of the commodity under consideration is more than the value of the resources required to save/earn a unit worth of foreign exchange. This indicates that the commodity under consideration is not maximizing efficiency in resource use, and therefore, at the margin, its production should be curtailed. The opposite would be true if the RCR happens to be below unity.

The RCRs presented in Table 4 are estimated based on the domestic cost of production and prices published by Economic Analysis and Statistics Directorate (EASD), Marketing Development Directorate (MDD), Nepal Rastra Bank (NRB) and world market price published by the World Bank. The results show that RCR coefficients were less than one for the period considered. The results in general indicate that there is a comparative advantage in Nepal for production of maize rather than importing it.

The average RCR coefficients are lower in the terai (0.62) compared to the hills (0.78) indicating that, at the margin, resources are more efficiently utilized in the cultivation of maize in the terai than in the hills, at current levels of technology and prices. This clearly indicates that the government needs to emphasize increased maize production in the Terai.

Table 4. Efficiency indicators of maize production in Nepal, 1987/88-1998/99

Years	Resource cost ratios	
	Hills	Tarai
1990/91	0.78	0.65
1991/92	0.74	0.58
1992/93	0.86	0.66
1993/94	0.73	0.60
1994/95	0.76	0.64
1995/96	0.61	0.50
1996/97	0.71	0.61
1997/98	0.99	0.69
1998/99	0.84	0.68
Average	0.78	0.62

Source: Based on data published by EASD; MDD; NRB; and World Bank Pink Sheet.

Effective incentives to maize farmers

The divergence between domestic prices and international prices shows the level of effective incentives/disincentives for the producers of various agricultural commodities. If the domestic price of a particular crop is higher than its corresponding international price, the crop in question receives high effective incentives, compared to another crop for which the domestic price is lower than its corresponding international price. There are several variants of incentive indicators that have been used in the literatures. The Nominal Protection Coefficient (NPC) is one of them.

The NPC is defined as the ratio of domestic price to the international reference price of the output. The common domestic price used in these computations is the wholesale price while the world reference price is the international price adjusted for transport costs (both international as well as domestic), handling and other costs necessary to make the commodity comparable.

This may be written as:

$$NPC_i = P_i^d / P_i^w$$

Where, NPC_i = Nominal Protection Coefficient of commodity i

P_i^d = Domestic price of commodity i

P_i^w = World reference price (border price equivalent) of commodity i, adjusted for transportation, handling and marketing expenses.

The coefficients are estimated under the importable hypothesis, as Nepal is a net importer of this commodity. The world market prices are adjusted to estimate reference prices for the terai and the hills. The estimated nominal protection coefficients for maize in the hills and terai remained less than one for the period considered in this study (Table 5). These results indicate that the production of maize is unprotected or in effect taxed in Nepal, compared to the situation that would prevail under free trade. It also implies that maize in Nepal is an efficient import substitute.

Table 5. Nominal protection coefficients of maize in Nepal (importable hypothesis)

Years	Nominal protection coefficients	
	Hills	Tarai
1990/91	0.85	0.73
1991/92	0.82	0.76
1992/93	0.89	0.73
1993/94	0.69	0.57
1994/95	0.86	0.80
1995/96	0.63	0.67
1996/97	0.68	0.69
1997/98	0.67	0.72
1998/99	0.90	0.90
1999/00	0.87	0.95
Average	0.79	0.75

Source: Based on FOB price of No. 2 yellow maize at US gulf ports (WB Pink Sheet) adjusted for transportation, handling and marketing expenses up to the main markets and domestic wholesale prices published by NRB and MDD.

Marketing and prices

A recent study has shown that a very small proportion of maize produced in the hills (1-6 percent) is sold (Paudyal et al 2001). Out of the amount sold, most of it is bought by fellow farmers and nearby villagers from the farmers' store. Thus maize produced in the hills hardly enters into the formal market. Contrary to the hills, almost half of the maize produced in the terai enters the market. A part of terai maize makes its way to the hills for consumption, while the remaining goes to feed mills. Many of the feed mills in the terai reported that they prefer to use imported maize, as it is available in large consignments throughout the year.

The price of maize increased slightly more than two and a half times between 1990/91 and 2000/01 in domestic currency. The trend in maize price did not differ much with rice and wheat during the period. The price of layer feed (#3) and cattle feed increased by more than maize price during the period. The prices of feed recorded an annual growth rate of 8.24% to 9.65% during 1990/91-2001/02, but prices of hen egg, chicken and milk grew by 6.62%, 7.40% and 7.82% per annum, respectively, during the same period (Table 6). This indicates feed producers have been getting more incentives than farmers.

There is vertical integration of inputs and product markets in the poultry sector. Those traders that have hatcheries own feed mills and many have their commercial farms. If one has feed mill but does not have hatchery, he forms a linkage with one of the hatcheries so that he can supply the main inputs, chicks and feed, from a single source. A few traders called Gaddiwala supply most of the imported raw materials for feed. They do not have a conventional type of shop. Only samples are kept at their show room and materials are directly supplied to the mill-gates once a deal is final. Some of the large feed mills reported that they deal directly with India-based wholesalers for the raw materials.

Some of the local wholesalers buy imported raw materials and supply them to smaller mills and poultry farmers that have feed production facility. They also collect locally produced raw material and supply to feed mills. The average prices of different raw materials reported by the feed mills are presented in Table 7.

Table 6. Prices of maize, animal feed and poultry products, 1990/91-2001/02

Year	Maize, Rs/kg	Layer feed, # 3 Rs/kg	Broiler feed, Finisher	Cattle feed, Rs/kg	Mutton, Rs/kg	Chicken, Rs/kg	Hen egg, Rs/No	Milk, Rs/liter
1990/91	4.8	5.7	7.2	4.4	66.7	66.9	2.3	9.6
1991/92	6.2	6.4	7.6	5.1	75.2	69.9	2.4	11.0
1992/93	7.0	7.4	8.9	6.1	84.1	75.5	2.6	11.5
1993/94	6.4	8.0	9.6	6.5	90.0	84.4	2.9	12.7
1994/95	7.6	8.9	10.7	7.5	96.2	87.2	3.2	13.3
1995/96	8.4	8.8	10.7	7.4	105.2	98.8	3.5	14.9
1996/97	9.2	9.8	11.8	8.3	120.3	113.5	3.8	16.9
1997/98	9.6	11.9	14.2	9.8	137.4	124.9	3.9	17.7
1998/99	11.5	13.7	15.0	10.7	151.4	128.3	4.2	19.3
1999/00	14.0	14.3	15.6	11.9	159.0	135.4	4.4	20.3
2000/01	NA	14.5	16.0	12.0	167.5	139.2	4.5	22.1
2001/02	12.2	16.5	17.5	13.0	177.7	133.2	4.5	21.8
Annual growth rate		9.58%	8.24%	9.65%	9.18%	7.40%	6.62%	7.82%

Source: Statistical Information on Nepalese Agriculture (2000/2001) and interviews with feed industries.

Table 7. Prices of major feed-ingredients, 2002

Ingredient	Source	Prices, Rs/kg		
		Average	Maximum	Minimum
Maize	Nepal and India	12.23	14.00	11.00
Soybean meal	India	19.02	22.00	17.50
Mustard cake	Nepal & India	11.39	13.00	8.50
Sesame cake	Nepal & India	15.51	17.50	14.00
Sunflower cake	Nepal & India	12.96	14.50	9.00
Rice polish	Nepal	8.34	10.00	6.80
Deoiled rice polish	Nepal & India	6.63	8.00	5.00
Wheat grain	Nepal & India	11.17	12.00	9.75
Wheat bran	Nepal	8.04	8.70	7.01
Fish meal	India	18.7	22.00	17.00
Bone meal	Nepal & India	11.92	18.50	10.00
Meat meal	India	15.85	19.00	11.00
Oyster shells	India	9.94	11.00	8.00
Molasses	Nepal	5.29	6.50	3.00

Compounded feed and chicks are supplied to numerous farms through dealers located at different places. Hatcheries/feed mills also provide their clients with veterinary services, extension services, marketing and credit arrangements through dealers. Some of the larger farmers nearby feed mills buy chicks and feed directly from hatcheries/feed mills saving about 6% of the price that otherwise go to dealers. The price structure of different types of feeds is presented in Table 8.

Table 8. Prices of different types of feeds, 2002

Feed type	Unit	Consumers price	Commission	Bonus	Dealers price
Broiler pre-starter	Rs/50 kg	890	35	15	840
Broiler starter	Rs/50 kg	875	35	15	825
Broiler finisher	Rs/50 kg	875	35	15	825
Layers # 1	Rs/50 kg	875	35	15	825
Layers # 2	Rs/50 kg	775	35	15	725
Layers # 3	Rs/50 kg	825	35	15	775
Cattle feed	Rs/40 kg	520	28	12	480
Pig feed	Rs/40 kg	540	28	12	500

The feed mills also help farmers to market their final product through their dealers. Farmers are free to sell their product. However, if they do not have market access and/or do not want to take the risk they simply request the feed mills and their dealers to help them with output marketing. In such cases feed mills collect the product from the farmers and dispose it to appropriate market. Of course there is reasonable margin for the feed mills for such

service. In many instances farmers receive the inputs as loans and when the final product is marketed by feed mills they deduct the due and return the rest to farmers.

Sustainability issues

The commercial poultry sector is capable of meeting the growing demand for chicken meat, egg, day-old chicks and feed, making the country self sufficient for these products. However, the industry has a huge dependency on imported raw materials for poultry feed and parental stocks. In the absence of a research and development network in the country all of the breeder chicks are imported every year from India and abroad. Despite the fact that Nepal is basically an agricultural country and 95% of the feed ingredients are agricultural products, a recent study shows that local supply could meet only 54% of the raw materials needed for commercial poultry feed production (Bhattarai et al 2001). The local feed mills have to depend on imported raw materials for the remaining 46%, mainly from India. Such a heavy dependence of the Nepalese feed industry on imported raw materials makes it highly vulnerable.

The quality of feed ingredients, vitamins, minerals and feed premixes is highly inconsistent in the local market. The quality standards for feed ingredients are either unavailable or are not applicable in local conditions. There are no laboratory services available to the feed industries and poultry farmers to examine the quality of ingredients and final products. They basically have to rely on what the suppliers tell them.

Major problems and issues

Maize production

Maize cultivation has always been a way of life for most hill farmers. It is the traditional crop cultivated by resource-poor farmers using marginal and semi-marginal land. Use of modern inputs is very low or non-existence because of the higher prices of those inputs and lower purchasing power of people and partly because of nonavailability of the inputs. The increase in the irrigated area has negative impact on summer maize area because it permits the substitution of irrigated rice for rainfed maize. Thus, maize in the hills is being pushed to more marginal land that ultimately has had negative impact in the overall yield level.

Among the several problems constraining maize production, the lack of high yielding varieties suitable to different agroecological pockets, the slow pace of adoption of available technology mainly caused by the lack of a strong extension mechanism, declining soil fertility and increasing disease/pest infestation were among the priority problems in the hills (Paudyal et al 2001). Absence of proper post harvest technologies and an under developed market mechanism resulted in a lower output price to farmers, making maize production less attractive.

The warmer temperature and better irrigation facilities in the terai/inner terai offer a suitable environment for maize cultivation, especially winter/spring maize. Many farmers use hybrid seed. However, most hybrid seeds are imported and the unsystematic approach to importation of hybrid seeds is a setback to maize production in the terai. Inadequate crop management technologies, lack of a regular seed supply mechanism, inadequate post harvest technologies, drought and pests are the other priority problems in the terai (Paudyal et al 2001). Because expansion of the commercial maize area is feasible in terai and inner terai agroecozone (winter and spring season), the government should take extra initiative to resolve the problems and provide sufficient incentive to the farmers there.

Feed production

The government policy towards the feed industry is not very clear and conducive for its development. There are also some serious flaws in the taxation policy that are detrimental to the development of Nepalese feed industry. For example maize and other agricultural products that are imported for raw materials to produce feed are taxed at a rate of 13.5% of the value at the point of import³. However when ready feed is imported (defined as feed supplements) into the country the total tax is only 1%. Earlier it was 4.5%. This policy is harmful for the feed industry in Nepal.

Some of the district development committees collect tax while transporting goods from one district to another. There is also tax on scrap (bone, bran, oilseed cake) levied by local authorities. These taxes and barriers directly affect the cost of production.

³ 10% agricultural services tax – 1% exemption + 1.5% local development tax + 3% special tax = 13.5%.

Though the poultry sector is purely an agricultural activity it is not having the privileges of lower interest rates and subsidies that other sectors in agriculture enjoyed in the past. There is no specialized public sector institute to resolve the problems/issues in this sector.

The other major issue raised by the respondents was the exorbitant cost of transportation. There are two reasons behind the high cost of transportation. First, the road condition in several parts of the country is very poor. Many feeder roads are non operational during the rainy season. Second, there are transport syndicates that often fix the transportation fee at high rates.

There are no large-scale slaughterhouses and cold storage for storing meat and egg safely. At the same time there has been several strikes and forced closure of traffic in the past. This has often resulted into huge losses of poultry products that ultimately affect the feed industry. Processing facilities are required for product diversification such as egg powder and canned foods.

CONCLUSION

The tremendous growth in poultry production in the past was made possible mainly by the private sector without much effort from the government. The development of this sector will not only conserve the scarce national reserves of foreign currency through import substitution, but will also have a high potential for export to the Tibet, autonomous region of China as the environment for poultry production in Nepal is more suitable than in Tibet. Therefore, this sector deserves special attention by the government. Some of the issues that need government intervention are the elimination of taxes being raised by local bodies in the movement of inputs and outputs within the country and the exemption of customs duty on those inputs that the country does not produce.

It is a bitter fact that despite being an agricultural based economy with maize as its second most important crop, thousands of tons of maize is being imported into the country every year. Several analysts suggest that the demand of maize is increasing at 4% per annum, while the domestic supply increased by 1.93% per annum in the last one decade. Given the present environment it is not expected that the domestic demand of maize will be met by domestic production in the near future unless substantial investment is made in research and development activities to stimulate production.

Considering the domestic resources used in the production of maize it is found that the production of maize in the terai as well as in the hills of Nepal has a comparative advantage. The average resource cost ratio is 0.78 for the hills and 0.62 for the terai, meaning that it takes 0.78 dollar and 0.62 dollar equivalent of domestic resources to produce one dollar worth of maize in the hills and terai, respectively. This clearly indicates that there is advantage to produce maize in the country rather than import. Production of maize for import substitution is also required to reduce heavy dependency of the feed industry in imported raw materials.

The existence of several agroecological pockets provide a good scopes of increased production of soybean, sesame, groundnut sunflower and mustard, which are being imported now as raw material for feed. Increased efforts are, therefore, required to boost the production of those crops in the country to save the scarce foreign currency and insure the sustainability of the feed industry.

Good quality control mechanism including grading, packaging and storage, and organized marketing arrangements are equally important to compete with imported maize. Marketing arrangement for poultry products deserves equal importance. Organized markets need to be developed near urban centers with adequate good quality storage facilities. Prices of inputs and outputs in different parts of the country need to be widely published.

Finally there should be a government body with the mandate and responsibility of coordinating and supporting the poultry sector in problem solving/promotion/ development of the sector as a whole. This body should also be responsible for developing future policy and provide the much needed energy to sustain the growth of the poultry sector in the country.

REFERENCES

- Bhattarai T, S Bhattarai and B Shrestha. 2001. Current status of poultry feed production and quality in Nepal. *A paper presented in National Symposium on Poultry Production and Health*, Sauraha, Chitwan, 23-24 November 2001.
- CBS. 2001. *Statistical year book of Nepal*. Central Bureau of Statistics (CBS), Kathmandu, Nepal.
- Dhakal T. 2001. Present status of Nepalese poultry industry. *A paper presented in National Symposium on Poultry Production and Health*. Sauraha, Chitwan, 23-24 November 2001.
- EASD. 1999. *Cost of production of major crops. Various issues (1990/91-1998/99)*. Lalitpur, Nepal. Economic Analysis and Statistics Division (EASD), MOAC.
- Lohani MN. 2000. Animal feed industry in Nepal: A review of pertinent issues. *A paper presented at the 4th National Animal Science Convention*. Nepal Animal Science Association, Nepal Administrative Staff College, Kathmandu, 29 Nov -Dec 01, 2000.
- Lohani MN. 2002. Performance of commercial poultry sector in Nepal. *A paper presented at the Nepal Feed Industry Association General Assembly*, Kathmandu, 20 Sept 2002.
- Maharjan BL. 2002. Demand and supply of feed crops and potentials and constraints for their expansion in Nepal. *A working paper prepared for CGPRT*, Bogor, Indonesia and NARC, Nepal.
- MDD. 2002. *Agricultural marketing information bulletin: Special issues (1996-2002)*. Marketing Development Division (MDD), MOAC Lalitpur.
- MOAC. 2001. *Statistical information on Nepalese agriculture: Various issues (1997/98-2000/01)*. Agricultural Statistics Division, Ministry of Agriculture and Cooperatives, Kathmandu, Nepal.
- MOF. 2001. *Foreign trade statistics: Fiscal year 1999/00*. Ministry of Finance (MOF), Kathmandu, Nepal.
- NRB. 2000. *Economic report: Various issues (1980/81-1999/00)*. Nepal Rastra Bank (NRB), Kathmandu, Nepal.
- Paudyal KR, JK Ransom, NP Rajbhandari, K Adhikari, RV Gerpacio and PL Pingali. 2001. *Maize in Nepal: Production systems, constraints and priorities for research*. NARC and CIMMYT, Kathmandu, Nepal. 48pp.

Opportunity of Early Mid Hill Potato in Tarai Markets of Nepal

TR Chapagain¹ and Bhim B Khatri²

¹ Agricultural Research Station, NARC, Pakhribas

² Potato Research Program, NARC, Khumaltar, Kathmandu

ABSTRACT

Potato (*Solanum tuberosum*) is one of the most important vegetable crop in Nepal. A market survey of potato was carried out at different markets across the Mahendra high way from Kakadbhitta (East) to Mahendra Nagar (West) in 2056 and 2057 to explore the market for early (Bhadra planted) Mid hill potato, which is harvested in Kartik-Mangshir. Some local markets (Fikkal and Dhankuta) and Central market (Kalimati) was also visited during the. Survey was conducted in two phases, the eastern sector (Kakadbhitta-Narayanght) and the western sector (Butwal-Mahendranagar). Semi-structured questionnaire was used different traders were interviewed. The wholesale price collected by Agro Enterprise Centre (AEC), Nepal from the different markets was considered as a secondary database. During the study major emphasis was given to the market demand early potato, supply sources of fresh potato, colour consciousness, import from India and Bhutan, internal production and price situation specially in Kartik-Mangshir. The collected information was analyzed in SPSS computer package. The result indicated that there is high demand and high price during autumn in the Terai markets. It has also identified that demand is met through the import from India and Bhutan. The market unit price is always remains higher than Rs12/kg at retailers and the consumer's preference has towards the red skinned varieties. Internal as well Indian cold stores are the major sources for seed tuber. The study concluded that the production of potato in Mid hills during autumn has high market potential. The established market network for potato trading has been explored.

Key words: Autumn, early planted, off-season

INTRODUCTION

Potato (*Solanum tuberosum*) is grown in all 75 districts and in all ecological zone from Tarai to high hills and yield varies from 2 to 35 tons/ha (Lama et al 1996, Sthapit et al 1987). Potato occupies fifth position in area compared with rice, maize wheat and finger millet in Nepal. The area under production and productivity were estimated 1,29,019 ha and 10.2 t/ha. The estimated annual production is 13,13,717 mt (CBS 2002). Potato is an important vegetable in Mid-hill to Tarai region while it is considered as a staple food in the High-hills. The average annual consumption of the potato is 30 kg/capita, which is higher consumption rate in Asia (Khatri et al 2059) indicates that the demand of potato in Nepal is increasing. The demand is fulfilled through internal production but considerable amount of potato is imported from India and Bhutan. The agro-climate condition as well as the existing farming system of eastern Mid-hill favours for early potato (Bhadra planting) production (Chapagain 2059). The early potato has the opportunity of getting off-season price in the Tarai markets. The market demand of this crop has not been studied so that it is very difficult to recommend the farmers of Mid-hill to adopt the early potato production practices.

In this context the study of market was crucial. The market study was carried out to explore the source of potato supply in the Tarai markets basically in the Kartik-Mangshir so that the early potato can be supplied from the Mid-hills. It was also important to identify the preference of the consumers over various types of potatoes for demand led supply. This study was also important to highlight the market channels used in potato supply and the traders of different types.

MATERIALS AND METHODS

Survey was conducted in 30 markets across the Mahendra Highway through out the country. Data were gathered through the interviews conducted on various types of potato traders with semi-structured questionnaires. The survey was completed in two phases (Eastern Sector-Markets of Eastern and Mid Development Region and western sector-Markets of Western, Mid Western and Far Western Region). Data collected by the AEC (Agro Enterprise Centre), Nepal was used as secondary information. At least one market corresponding to the main entry points from India to Nepal's border was explored. This sector was assumed to be a continuum with respect to the potato flow and the informal discussion was made with the Indian traders. All the information gathered were analysed through Software Package for Social Science (SPSS) computer package.

RESULTS AND DISCUSSION

Source of potato supply in the Tarai markets

The demand of potato is fulfilled through internal production and import. Five potato production places as a source of potato supply for the consumption in the eastern region were identified (Chart 1). Though the amount was not known but it was made clear that Indian potatoes come in the Tarai markets through out the year. Bhutanese potato also comes in the market in Bhadra-Mangshir when the price of potato in the market is high and there is little supply from internal production areas.

Chart 1. Major source of potato and their corresponding season of supply in eastern sector

Major source of potato supply	Season of potato supply in the market				
	Year round	Bhadra-Mangshir	Aswin-Mangshir	Push-Falgun	Asadh-Bhadra
KTM Valley					
Terai Local					
Bhutan					
Indian					
High hill area					

Internal sources: Potato is supplied in the Tarai markets from adjoining production area (Tarai/high hill) in respective production seasons. In the markets like Dharan, Biratnagar potato is supplied from high hills (Basntapur, Sidhuwa area) and in case of Birtamod, Damak it is supplied from Panchther, Ilam etc. The local Terai production comes from Jhapa, Mechi and Sunsasari. In Hetauda and Birganj, potato is supplied from Tistung Palung and Terai production zones. In Narayanghat potato is supplied from Kathmandu valley and some times from Gorkha areas.

In western sector markets, very nominal potato comes from the adjoining hill area. The local Tarai production of Rupandehi, Kapilbastu and Nawalparasi comes in the markets like Butawal and Bhairahawa. In the markets of Dang Valley potato comes from the Salyan production areas and valley itself produce potatoes. In Birendaranagar potato is supplied from Rukum districts and Surkhet valley. Potato also comes from adjoining Tarai production areas.

External sources: It is noticed that in the eastern sector markets potato is supplied from the India, Bhutan, and adjoining Terai local production area, adjoining High hills and from Kathmandu valley. India is the largest supplier and supplies the potato in the markets throughout the year. In autumn season the existence of Nepali potato is very nominal as indicated in the AEC reports and according to traders very minimal amount is supplied from the Kathmandu valley production. In western sector potato is supplied mainly from India. The export of potato from the country is not known during the survey.

High price season of potato

The 43% of the traders of the eastern sector (Figure 1) suggested Kartik-Mangshir as the high price season but the high price season starts from Bhadra and remains relatively high up to Mangshir. The western sector traders responded that the high price season starts from Jestha and remains high up to Push. AEC result shows Jestha to Mangshir as high price period (Figure 2 and 3) and it can be concluded that the autumn season is the high price season of potato.

The price increment in the market from Jestha is due the ending of Tarai late production, arrival of cold stored potato, fresh potatoes from High hills and the high price in the Kartik-Mangshir is due to fresh potato in the market because consumer prefers fresh potato as compared with cold stored for vegetable purpose. The early Mid-hill potato can definitely high price during Kartik-Mangshir.

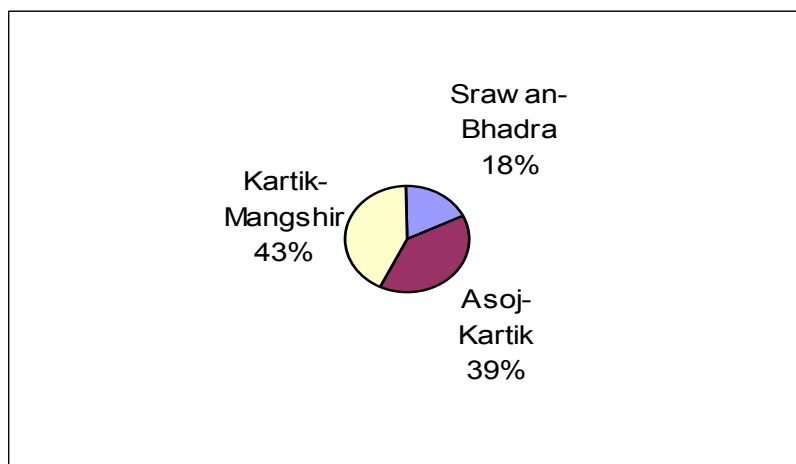


Figure 1. Traders view about high price season of potato.

Demand of the fresh potato in the markets

In the eastern sector, according to the 92.8% traders there is price variation between fresh potato and cold stored potato and is in between Rs1-3 and some time more than Rs3. It indicates that fresh potato can be supplied in the market for higher price in this season (Table 1).

Table1. Showing the response of different parameters in Eastern and Western sector

SN	Parameters undertaken in the survey	Variables	Eastern sector, %	Western sector, %
1.	Type trader surveyed	Retailers	25.7	12.9
		Wholesalers	21.3	19.4
		Wholesaler cum retailers	30.2	22.6
		Wholesaler cum commission agent	22.8	45.2
4.	Price difference due to colour	Red	97.1	87.1
		White	2.9	12.9
6.	Actual price difference in Rs	1	46.2	48.4
		2 or More than 3	53.8	51.6
	Difference in price due to size	Yes	20.2	12.9
7.		No	79.8	87.1
8.	Competition to the hill potato starts due to Terai product	From Mangshir	21.6	9.7
		From Push	78.4	77.4
9.	Supply of fresh potato from India	In Mangshir-Push	100	100
10.	Month of the arrival of potato from Indian cold store	After Chaitra	-	74.2
		After Jestha	-	25.8
11.	Price of the potato increase in the market	After Jestha up to Mangshir	16.2	19.3
		After last Bhadra-Push	10.5	6.4
		After Asoj up to Mangshir	38.2	45.2
		Kartik -Mangshir	45.1	20.1
13.	Actual Price differences bet fresh potato and cold stored potato when consumed as vegetable.	Rs1-3	92.8	83.9
		More than 3	7.2	16.1
14.	Farmers purchasing the seed tubers	Yes	100	100
	Price of potato effects the price of other vegetables	Yes	51.4	41.9
		No	48.6	58.1

It is now clear that if the production of potato comes in the market during autumn season there will be no marketing problem and farmers can get better price than the other season.

Colour consciousness of the consumers

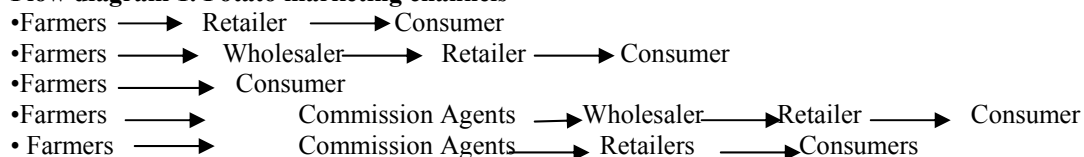
All the traders strongly agreed that price varies according to colours and usually the price of red potato remains higher than the white potato (Table 1). The monthly average price collected by AEC also strongly supports this fact that in both the year (Figure 2 and 3) the price of red potato is higher. According to the trader the home consumer always prefer to buy red skinned potatoes while hotel business do not give much emphasis on colour because their concern is only price. According to them consumers preference to the colour might be due to attractive colour of red skinned variety and associated good taste.

Potato traders, marketing system and channels

Basically three different types of traders were found involved in the potato trading viz. retailers, wholesalers and commission agents. Some time they perform different role in the market such as wholesaler becomes commission agent and sometime retailers too due to that we interviewed four types of traders. Though the exact number of potato traders was not identified but the retailer's number is high than the other types of traders. We can simply divide the producer as large and small producers and can demonstrate their involvement in the marketing. Mostly the large producer sells their commodity to the commission agent and wholesalers (Flow diagram 1) but the target trader of small producer are wholesalers and retailers. It is often noticed that the small producer sells their produce in the small markets themselves.

In this study mostly wholesaler and commission agents were found involved in handling large amount because they know the market channels, source of supply and season. In spite of this, large volume of potato is traded in commission basis because the traders do not want to take risk of damage in the storage during handling and if produce damages during the handling the loss will have to bear by producer themselves. The amount of commission was also found varying in different markets but it was same within the markets. In the eastern sector it was found 6% and in Butwal and Bhairahawa it was 8% while in Krishnanagar it was again 6%. In Indian market the commission was found 3% in Indian currency.

Flow diagram 1. Potato marketing channels



Monthly market price of potato

The month wise analysis of market price of 2056 shows that the price of potato starts increasing after Baisakh and reaches to its peak in Mangshir and starts to decline from Push. Almost same trend is noticed in both types of potato though the price of red potato is always higher than the white ones (Figure 2 and 3.). The high price season from Jestha is due to shortage of Tarai production. The price reaches to its peak in Mangshir is due to arrival of fresh potato in competition with cold stored potato as vegetable.

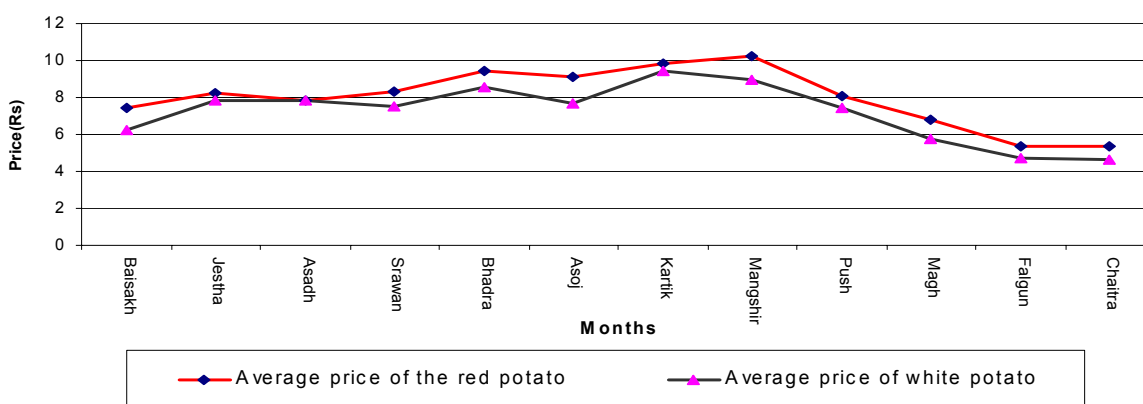


Figure 2. Average monthly price of red and white potatoes 2056.

The price information of 2057 shows that the average price of red potato is higher in Bhadra and the lowest rate in Baisakh. The trend of the price in both the type of potato is same though the price of red potato is noticed higher in every month. The higher price season as reflected by the graph is Srawan to Bhadra though the price is still higher till Mangshir. So in conclusion Kartik and Mangshir are identified as high price month

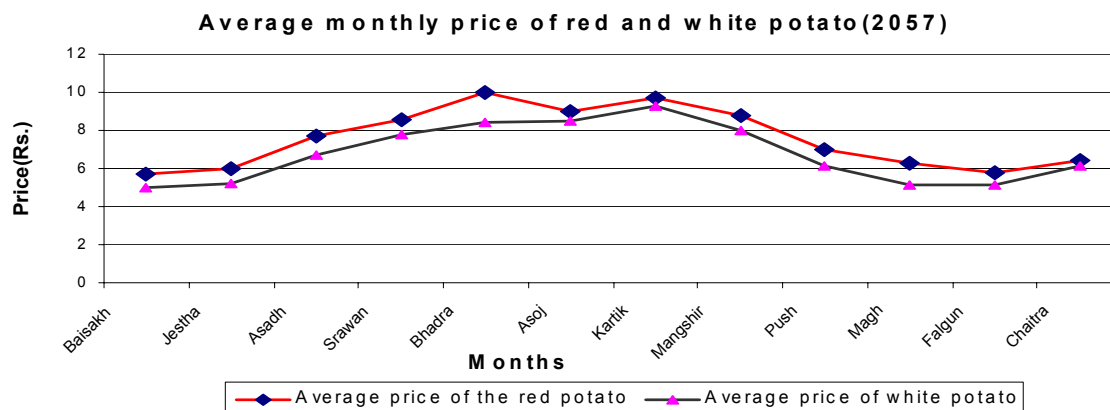


Figure 3. Average monthly price of red and white potato (2057).

Market based demand of potato

The survey revealed that Dang valley is the only place where the price of white potato is higher than the red potatoes due to their local white potato which tasty and popular among the consumers (ARSP 2001). The general trend analysed through the AEC data shows that relatively potato is cheap in western sector markets as compared with eastern sector (Figure 4 and 5).

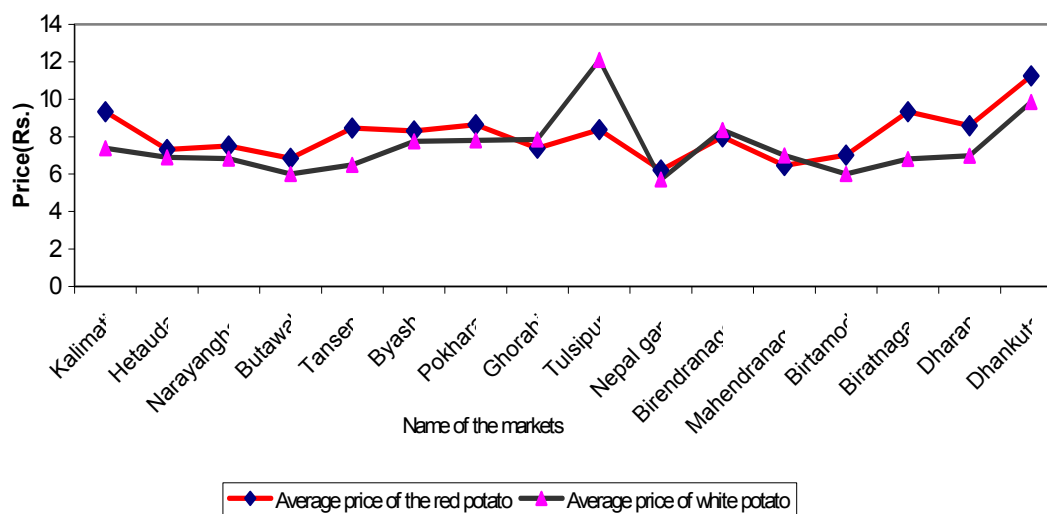


Figure 4. Annual average price of red and white at different markets (2056).

Effect of potato price on other vegetables

In this issue a clear conclusion was not drawn through the survey that the eastern sector traders (51.4%) said that the decreased price of potato also reduce the price of other vegetables because if the price lowers normal consumer buy relatively high amount of potato than buying other vegetables. But in the same issue 58.1% traders in the western sector pointed out that there is no relation in the price of other vegetables with the price of potato. In their view potato is consumed in mix vegetable so that the consumer also buy other vegetables and there is no direct price relationship.

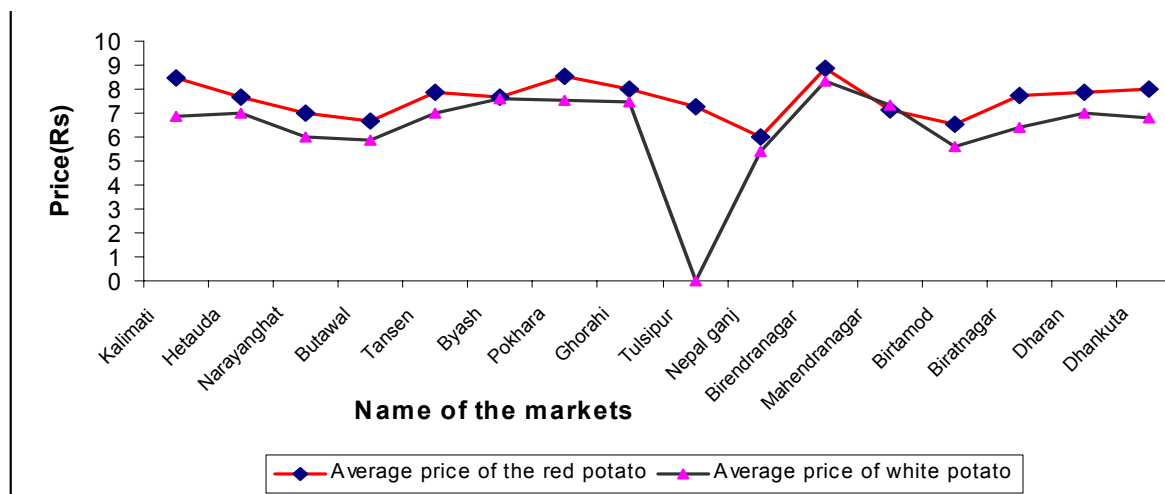


Figure 5. Annual average price of red and white at different markets (2057).

Seed potato marketing

All the traders were found involved in the seed tuber marketing. In the eastern sector seed was mostly found supplied through internal cold storages while in the western sector traders were seen dependent on Indian cold storage. The potato varieties mainly supplied by them are Cardinal, Desiree, Lalgulab, Rajendra-1, Lalma, Kufri Sinduri, etc.

CONCLUSION

The early potato can get high price in Kartik-Mangshir in Terai markets. It is identified that the scope of early potato in Terai markets is remarkably high because at that time potato either supplied by cold storage or by imported from India. Consumer prefers the red skinned varieties. Producer will not have any marketing problems because a established market net work also exit in the market.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to HARP for funding to this piece of work under HARP PP: 42/99. We are also grateful to PG Rood, Research Advisor for his encouragement throughout the project period. All the members involved in the survey are highly appreciated for their co-operation.

REFERENCES

- ARSP. 1999. *Annual report-1999*. Agricultural Research Station, Pakhribas (ARSP).
- CBS. 2002. *Statistical yearbook of Nepal*. Central Bureau of Statistics, National Planning Commission, Kathmandu, Nepal.
- Chapagain TR. 2059. *Early potato production technology and market management*. Agricultural Research Station, Pakhribas.
- Khatri BB, SL Shrestha and GP Rai. 2059. *Potato cultivation*. Potato Research Program, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal.
- Lama TL, GP Rai and BB Khatri. 1996. Potato programs in Nepal: Collaboration with CIP, Peru. *A paper presented in the seminar on CIP in South Asian Region, 25th Anniversary celebration, 2-3 Dec 1996, Kathmandu, Nepal*.
- Sthapit BR, CK Sen, PM Pradhang and KD Subedi. 1987. *Potato trail work at Lumle: A review (1975-1987)*. Lumle Agricultural Centre Technical Paper No. 87/16.

Marketing Management of Maize Seed Produced by Community Farmers: An Experience in the Western Hill of Nepal

Kiran R Joshi and Yogendra P Yadav

Agriculture Research Station, NARC Lumle, Kaski

ABSTRACT

A Marketing Rural Rapid Appraisal Survey (MRRAS) was conducted from 12 - 16 June 2002 in Bhakimli (high hills, 1725 to 1850 m) of Myagdi district. Two factors such as gender (male and female) and wealth category- rich (A), medium (B) and poor (C) were considered in the accessible area. Semi-structured questionnaires and checklist were used to collect information on maize seed production, marketing opportunities, marketing system for producers/consumers and traders. The objectives of the study were to understand existing maize seed production, demand and supply; to identify the problem associated with the seed marketing system and policy options for sustainable maize seed production. Farmers under category A had total cultivated area of 1.18ha (0.62 ha khet and 0.56 ha bari land), under category B had 0.46 ha (0.19 ha khet and 0.27 ha bari land) and under category C had 0.26 ha (0.10 ha khet and 0.16 ha bari land). Category A farmers cultivated improved maize variety (Manakamana 1) in 0.46 ha while farmers under category B and C cultivated improved maize in 0.25ha and 0.14ha respectively. The productivity of maize was found higher (3.7 t/ha) for farmers under C category, followed by category B (3.5 t/ha) and category A (3.2 t/ha). Group A, B and C required total seed of 14.0 kg for 0.46 ha, 7.3 kg for 0.25 ha and 6. kg for 0.14 ha and produced 484.0 kg, 280.0 kg and 170.0 kg respectively for selling to different stakeholders in addition to grain for household consumption. Category A required 12 kg of improved seed, category B 5.8 kg and category C 3.5 kg. Farmers group which involved in maize seed production and also managed marketing system at Bhakimli. Successful seed production for long-term would ensure a continuous supply of OPV seed in farmers' level. Seed production as a new commercial enterprises creates employment opportunities and economically profitable in the Western hills of Nepal.

Key words: Community farmers, maize seed, marketing management, Western Nepal

INTRODUCTION

Maize is the second most important crop in Nepal. It is a staple crop of the hill people that occupy about 824525 ha land and contribute 78.3% to the total maize production (1484112 t) in the country. Nearly 68.8% of the area in the hills is under local varieties. An improved variety has higher productivity over local by 42% and 39% in the high hills and hills respectively. Although a number of composites have been released for cultivation, their larger spread is impeded by farmers' lack of access to seed. Myagdi district occupies 8750 hectare of land with the production of 14350 t and average productivity of 1640 kg/ha. Productivity has not increased or slightly decreased (SIONA 2000/2001). Community managed on farm maize seed production program was implemented in three Village Development Committee at different altitudes of high hill (Bhakimli), mid hill (Arthunge) and river basin (Dhudhekhola) which helped business for employment, income generation and seed enterprises business (Joshi et al 2002). Marketing research on seed is the systematic gathering of information concerning the consumers need, desires, buying habits and availability of the seed for farmers (LARC 1997) The objectives of marketing survey were to understand existing maize seed production, supply and demand; to identify the problem associated with the seed marketing system; and Policy options for sustainable maize seed production.

METHODOLOGY

A survey on identification of marketing potential of maize seed production was conducted from 12 – 16 June, 2002 at accessible area of Bhakimli ward No 5. Mainly questionnaires and checklists were focussed on existing maize production and supply system, demand and problem associated with seed marketing system and policy options for sustainable maize seed production. Secondary data were also collected from ADO, Myagdi and Palpa, SSSP, Beni and Agrovets of Pokhara. Informal survey was mainly focused on three categories group A for food sufficient, more than 12 months, group B for food 6 to 12 months; and group C for food less than 6 months; maize cultivated area by improved and local maize during 2001 and 2002. After completion of field survey, group discussion was held with farmers' who managed community maize seed production.

Two factors were considered viz gender (male and female) and wealth categories of food sufficiency groups more than twelve-months (rich A), six to twelve months (medium B) and less than six months (poor C). The questionnaire was asked to each of male or female-headed households five in each group (A, B and C) of farmers.

A joint meeting was organised in ADO, Myagdi with participation of maize team members of ARS, Lumle, ADO officers and personnel from SSSP, Beni. A community managed grain seed production program has been initiated in the district since 1999.

Activities

1. Marketing survey meeting with researchers, ADO and stakeholders

- First of all, a joint meeting was organised at Agricultural Research Station, Lumle among the maize team members to discuss on the methodologies to understand the existing maize seed production system, supply and demand, identify the problem associated with the seed and policy options for sustainable maize seed production.
- A meeting was also organised at Agricultural Development Office (ADO), Beni where Maize Team Members of ARS, Lumle, Agricultural Development Officer and Seed Sector Support Project of Beni, Myagdi were present, where community managed maize seed production program was initiated from 1997.

2. Marketing rapid rural appraisal (MRRA) survey

Semi-structured questionnaire was developed for marketing survey. A total of twenty-two questions related to seed production systems, supply and demand were considered and asked to each of the accessible community farmers. Group discussion was held to discuss on problem of marketing system of maize associated with improved and local maize seeds. Farmers raised problem related to socio-economic and marketing constraints and spread mechanism of improved seed among the farmers communities.

3. Primary and secondary data collection

Primary data was collected during survey on identification of marketing potential at Bhakimli. Primary data collection were mainly focussed on the total cultivated area, area under maize production, maize area grown by improved and local varieties, seed demand, supply and maize seed grown by the community based farmers as enterprises, improved seed demand from neighbouring farmers, local market price of improved maize seed and price of maize grain.

Secondary data were collected from different institutions such as Agricultural Development Office, Beni Myagdi, Seed Sector Support Project (SSSP) Baglung, Agrovets Babiyachaur, Arthunge and Palpa. Annual marketing price of maize grain, maize seed and seed demand, dissemination of improved seed by ADO, Myagdi and SSSP along with seed yield were also calculated.

4. Analysis on cost of production of maize seed

The economic analysis of maize seed production was considered. Partial budget were used for the analysis of labour cost from planting to harvesting, chemical fertiliser, labour cost for drying and packing/labelling/sewing/transporting and total cost for maize seed production. Gross yield, net benefit and output/input ratios were also calculated on the basis of cost of production of maize seed. Economic analysis help to find out cost and benefit of maize seed an

enterprise.

RESULTS AND DISCUSSION

In the survey area, farmers were growing maize and finger millet relayed with maize in bari land. Maize growing time is March – August and millet growing time is July – November. Farmers in category A had a total cultivated land (khet and bari land) of 1.18 ha. While farmers in category B and C had 0.46 ha. and 0.26 ha respectively. Total maize cultivated area of category A was higher (0.62 ha.) as compared to category B (0.35 ha) and category C (0.22 ha). Improved maize varieties were cultivated in 0.46 ha (0.01ha khet and 0.45 ha bari), 0.25ha (0.01 ha khet and 0.24 ha bari) and 0.14 ha (0.03 ha khet and 0.11ha bari) under category A, B and C respectively. Similarly local maize were grown in 0.16ha, 0.10ha and 0.08ha under category A, B and C respectively. Farmers grow improved varieties of Manakamana 1, White hill pool, Yellow hill pool and Rampur Composite and local maize were Seto Makai, Pahanlo Makai and Khairo Makai. Group A produced maize grain yield of 3.2 t/ha group B produced 3.5 t/ha and group C produced 3.7 t/ha in bari land of Bhakimli in 2001/2002. (Table 1).

Table 1. Existing maize production system of Western hill of Myagdi, district in 2001/02

SN	Farmers categories	Bhakimli VDC, ward No. 5								
		Group A, Maen		Total area, ha	Group B, Mean		Total area, ha	Group C, Mean		Total area, ha
		Khet	Bari		Khet	Bari		Khet	Bari	
1	Cultivated area, ha	0.62	0.56	1.18	0.19	0.27	0.46	0.10	0.16	0.26
2	Maize cultivated area, ha	0.16	0.46	0.62	0.10	0.25	0.35	0.08	0.14	0.22
3	Maize covered area, ha									
	A) Improved	0.01	0.45	0.46	0.01	0.24	0.25	0.03	0.11	0.14
	B) Local	0.15	0.01	0.16	0.09	0.01	0.10	0.05	0.03	0.08
4	Maize production (improved), ton/ha									
	2000/01	-	3.0	3.0	-	3.5	3.5	-	3.5	3.5
	2001/02	-	3.2	3.2	-	3.5	3.5	-	3.7	3.7

An average five farmers group (mean), A # Food sufficiency ≥ 12 month, B # Food sufficiency 6 to 12 month, C # Food sufficiency ≤ 6 month, ARS, Lumle # Agricultural Research Station, Lumle, SSSP # Seed Sector Support Project, ADO # Agricultural Development Office
Source: Marketing Rural Rapid Appraisal Survey at Bhakimli 2002.

Community based maize seed production program has been started from 2000/2001 in Bhakimli, Myagdi. Farmers' group A, B and C required improved seed of 14.0 kg for 0.46 ha, 7.3 kg for 0.25ha and 6.0 kg for 0.14 ha respectively. Average improved seed demand per household from the neighbour farmers was about 12.2 kg for 0.46 ha. Similarly, farmers of categories of A, B and C of were required maize seed of 12.4 for 0.54 ha, 7.5 kg for 0.33 ha and 4.2 kg for 0.20 ha respectively (Table 2).

Table 2. Opportunities of maize seed production demand and supply system of Western hill of Myagdi in 2001/02

SN	Farmers categories	Bhakimli VDC ward No. 5		
		Group A, Mean	Group B, Mean	Group C, Mean
1	Maize varietal grown by farmers, ha			
	a) Improved	0.46	0.25	0.14
2	Total house hold seed required, kg	14.0	7.3	6.0
3	Local price for improved maize seed, kg	18.66	18.60	18.66
4	Local price of maize grain for home consumption, kg	10.0	10.5	10.5
4	Expenditure for buying seed, kg	246.0	142.0	114.0
5	Seed production for sell purpose, kg	484	280	170
6	Source of seed	ARS, Lumle	ARS, Lumle	ARS, Lumle
7	Utilisation of selected improved seed for different area, ha			
	a) Selected from own land, ha	0.37	0.24	0.10
	b) Obtain from neighbour, ha	0.09	0.01	0.04
8	Are you member of community based managed seed production	Yes	Yes	Yes

WHP # white hill pool, M- 1 # Improved Manakamana-1, FLM-1# Farmers local Manakamana -1, ARSL # Agricultural Research Station, Lumle, CBS # Cobs big size, CH # Cobs hanging, TB # tin bin, SK # Stacking, CR # Cobs in room, PB # Plastic bin, JB # Jut bag, SG # Seed growers group, WG # Women group and IV # Improved variety. I # Increasing.

Out of the total amount of seed sold to different agencies, ARS, Lumle purchased 1000 kg of Manakamana 1, 500 kg of Arun 1, 500 kg of White hill pool, 500 kg of Manakamana 3, 45 kg of Yellow hill pool and 45 kg of ZM – 621. Community based farmers group sold their maize seed to different agrovets and institutions. The cost of maize seed production was Rs11.60/kg in Myagdi. Similarly the cost of production of maize seed were Rs11.44/kg and Rs9.95/kg in Baglung and Palpa respectively.

Agrovets purchased maize seed @ Rs18/kg from the seed growers and their selling retail price about Rs21 – 26/kg. Generally, agrovets received marginal profit of Rs3– 8/kg. However, ARS, Lumle was adding 25% cost for seed losses, seed treatment and transportation cost. The production cost of maize seed was also recorded from Baglung and Palpa district, where community managed seed production was conducted by ARS, Lumle (Joshi et al 2002). In Myagdi district of Western hills of Nepal, seed production has been initiated jointly between Agricultural Research Station Lumle, Agricultural Development Office (Myagdi) and Seed Sector Support Project as a partnership program. Seed production was a new commercial enterprise after initiation of community based maize seed production program in the Western hills by ARS, Lumle. It created employment opportunities for seed enterprises and gives more profitable as compared to others cereal crops at Bhakimli.

Table 3. Marketing of maize seed enterprises for different institution in 2001/02

SN	Particular	Different agencies/institutions							
		ARS, Lumle	ADO			SSSP	Agrovet		
			Myagdi	Baglung	Palpa		Beni	Pokhra	Palpa
1	Amount of seed sold to different agencies, kg								
	a) Manakamana -1	1000	500	400	-	500	82	-	-
	b) Arun – 1	500	500	100	-	275	27	-	-
	c) Arun – 2	-	-	90	-	169	10	-	-
	d) Ganesh	-	-	100	-	103	-	-	-
	e) Rampur Composit	-	-	150	-	-	-	-	-
	f) White hill pool	500	200	-	200	-	-	100	-
	g) Population – 22	500	-	-	-	-	-	-	200
	h) Yellow hill pool	45	-	-	-	-	-	-	-
	i) ZM 621	45	-	-	-	-	-	-	-
	Cost of production of maize grain, Rs/kg	-	7.63	7.85	6.73	-	-	-	-
	Cost of maize seed production, Rs/kg	-	11.60*	11.44*	9.95*	-	-	-	-
2	Buying price, Rs/kg	18	18	21	18	18	18	18	18
3	Selling price, Rs/kg	23	23	24	23	18	25	26	25
4	Marginal profit	5	5	3	5	0	7	8	7

Adding 33 % cost for seed dheller, drying, storage losses, grading and transportation cost Rs1- 1.50/kg.

Discussion with seed production group revealed that major problems of improved seed growers in the area where lack of high yielding Variety, storage pest problem, lack of maize sheller, storage bin and tarpaulin against excessive moisture. The problem raising is given in Table 4.

Table 4. Problems of improved maize seed growers at Bhakimli, VDC (matrix ranking) 2001/02

SN	Problem indicator	1	2	3	4	5	6	7	8	9	Total	Rank
1	Lack of high yielding variety	X	1	1	1	1	1	1	1	1	8	1
2	Group mobilised not effectively	X	X	3	4	5	6	7	8	9	0	6
3	Timely unavailability input (chemical fertilizer)	X	X	X	4	5	6	7	8	9	1	5
4	Pest problem (army worm and white grub)	X	X	X	X	5	6	7	4	9	3	4
5	Disease problem (cob smut and head smut)	X	X	X	X	X	6	7	8	9	3	4
6	Tarpaulin against excessive moisture	X	X	X	X	X	X	7	8	6	5	3
7	Lack of seed grain storage structure	X	X	X	X	X	X	X	8	9	5	3
8	Lack of corn sheller	X	X	X	X	X	X	X	X	9	5	3

9	Storage pest problem (weevil and moth)	X	X	X	X	X	X	X	X	X	6	2

Lack of awareness in selecting quality seed, availability of poor quality seed and seed storage problems were first ranking in marketing problem indicators. The next important problem in seed marketing system was recognised in lack of information on marketing system, lack of support price and lack of seed traders in (Table 5).

Table 5. Problems of marketing system of maize seed production at Bhakimli, VDC (matrix ranking) 2001/02

SN	Problem indicator	1	2	3	4	5	6	7	8	Total	Ranking
1	Lack of proper marketing system	X	1	3	4	5	6	7	8	1	3
2	Transportation problem for seed	X	X	3	4	5	6	7	8	0	4
3	Lack of seed traders	X	X	X	4	5	3	7	8	3	2
4	Lack of support price for seed production	X	X	X	X	5	6	7	8	3	2
5	Seed storage problem	X	X	X	X	X	5	7	5	6	1
6	Lack of information on marketing system	X	X	X	X	X	X	7	8	3	2
7	Availability of poor quality seed	X	X	X	X	X	X	X	8	6	1
8	Lack of awareness in selecting the quality seed	X	X	X	X	X	X	X	X	6	1

Figure of marketing function at different level indicates that grain prices in the local markets were less than nearest regulated markets. An average grain price was Rs12/kg and an average seed price was Rs22/kg in regulated market. Retailers were perceived at marginal profit of Rs2 –8. Majority of the farmers preferred to sell seed in Beni Bazar (market), Baglun Bazar and Palpa Bazar. Maize seed of Manakamana 1, Arun 1, Arun 2 and White hill pool are available at agrovet of Beni, Baglung, Parbat and agrovet of Kaski. Seed Sector Support Project (SSSP) is playing vital role as a mediator for seed marketing development and co-ordinate between seed producer groups and traders (Figure 1).

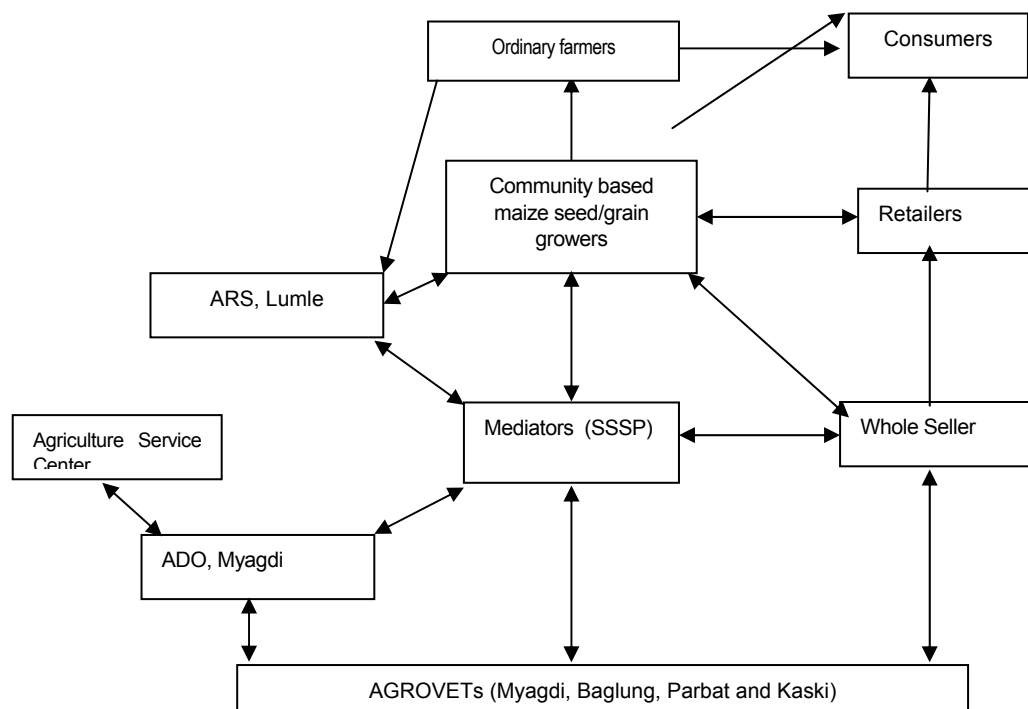


Figure 1. Marketing system at different level.

Source: Myagdi, Beni market, 2002.

Lack of markets: Markets for maize seed are very thinly spread. Due to inadequately developed markets for maize, farmers usually received less prices in the local (village) markets than the organised markets, which were located at some 3 – 4 hours distance from the village. The loss due to non- existence of maize market in village is computed as follow:

$$\begin{aligned} L_m &= \{ (PRM_m - PRM_v) - TC_{m.v} \} * MQV \\ &= \{ (18 - 14) - 1.50 \} * 500 \\ &= \{ 4 - 1.50 \} * 500 \\ &= 2.50 * 500 = 1250 \end{aligned}$$

Where, L_m is the loss due to lack of market in the village, PRM_m is the price received by the farmers in the approachable market; PRM_v is the price received by the farmers in the village; $TC_{m.v}$ is the transportation cost between organized market and MQV is the quantity of maize sold in the village (Joshi et al 2001). Above mentioned formula indicate that local market price of maize seed was Rs.14.0 at Bhakimli and transportation cost from Bhakimli to Beni market was Rs 1.50. When seed producers sell 500 kg of Manakamana -1, farmers lose Rs 2.50/kg seed and a total loss of Rs 1250.0 in the local seed market.

DISCUSSION ON POLICY OPTIONS FOR SUSTAINABLE MAIZE SEED PRODUCTION SYSTEM

The livelihood of ten million hill people depends on maize grain because it is a staple food for humans and feed for animals. Approaches of CIMMYT on ensuring cereal seed supplies study conducted in hills of Nepal (Rajbhanday 2001) found that efforts should be made to increase the productivity of maize seed in Nepal. Maize – based cropping system must introduce new adapted varieties with assured supply of quality seeds, improved crop management techniques by addressing the decline in soil fertility. Increasing the access to improve maize seeds by farmers can be an important step towards increasing productivity of maize in the farmer's field. In such a situation, a community based seed enterprise development seems to be the only alternative in the remote areas for increasing maize productivity through easy access and adoption of HYV of maize. Maize variety deteriorated quickly in the farmer's field circumstance, continuous back stopping and upgraded skill and knowledge of farmers group should be implemented for a sustainable increase in maize productivity in the hills. Agricultural development office and community based organisation should play role in creating grassroots awareness and farmers' self-help community mobilisation. For successful seed production enterprises programs should develop a long-term strategy that would ensure a continuous supply of OPV seed, extensive training on maize seed production, quality control, marketing information/marketing system. A study conducted in Nepal (Seeley, 1998) found that farmers using regulated OPV seed notice significant changes in a maize plant and has stressed the need to develop a long term strategy that would ensure a continuing supply of OPV seed. Agricultural Development Bank should provide loan at the minimum interest charge for community based maize seed production in hills.

LESSIONS LEARNED

Maize being cross pollinated crop, it is imperative to follow limited generation plant of seed multiplication renewal of seed from breeder to farmers so as to maintain a reasonable level of genetic purity under condition of uncertain isolation for seed multiplication in hills. When the farmer themselves involve in selecting the best genotypes of maize in their own field and once convinced seed producer group and marketing in a group managed by community seem promising in the hills.

CONCLUSION

Government policy should be focussed on the extension of improved varieties of maize in Western hills. There should be announcement of minimum support price for maize seed/grain before planting season. Agricultural development bank should provide loan at minimum interest for community based seed producers in remote hilly areas. There was great scope of extending the area under improved maize varieties in the hills through community based maize seed production program. Researcher and extension should conduct combine training on post harvest technologies for seed

production and NGO/INGO will explore marketing enterprises.

ACKNOWLEDGEMENTS

We would like to express our gratitude to Dr RP Sah, ARS, Lumle for his encouragement in implementing this project successfully. It is great pleasure to acknowledge the considerable technical and financial support of Dr Joel Ransom, Dr N Rajbhandari, Dr K Paudyal and Dr TP Tiwari and staff from CIMMYT, KTM and support staffs from Lumle. Collaboration of District agricultural development Office, Myagdi is highly acknowledged. Thanks to Mr BS Shrestha and YR Pandey for review of this paper. We are also thankful to the staff of Seed Sector Support Project, District Office, Myagdi for their valuable co-operation in implementing the program.

REFERENCES

- Joshi KR, TB Karki and S Paudel. 2002. Community managed maize seed production program: An experience of ARS, Lumle. *LARC working paper No. 2002/3*.
- Joshi PK and NP Sing. 2001. Intensification of maize production in upland area of India. Prioritisation for research and development plans. *The paper presented in the 4th workshop*. 4–8 June Kathmandu.
- LARC. 1997. *LARC strategy paper No. 97/7*. The strategy for Maize Research, Lumle Agricultural Research Center.
- NSB. 2001. *Proceedings of the Third National Seed Seminar*. 13-14 August 2001. Kathmandu, HMG/Nepal, Ministry of Agricultural and Cooperatives, National Seed Board, Kathmandu, Nepal.
- Seeley J. 1998. Household maize variety selection in Lumle Agricultural Centre, extension Command Area, *LARC Technical Paper No. 88/24*.
- SIONA. 2001. *Statistical information on Nepalese agricultural*. HMG/MOA and Cooperatives, Agribusiness Promotion and Statistical Division, Sing Durbar, Kathmandu, Nepal.

Modeling Decisions: An Agricultural-Anthropological Perspective

Bipin K Acharya

Department of Sociology, Anthropology, Patan Multiple Campus, Tribhuvan University

ABSTRACT

This paper reflects the use of ethnographic decision modeling (EDM) in farming systems research and extension (FSRE). The conceptual and methodological strengths and relevance of EDM are discussed with some illustrations. The EDM schemes are helpful to know why stakeholders involved in FSRE do what they do and to come up with new policies designed to make things better. The cognitive and psychic aspects of decision-making are concerned with predicting of individual stakeholder's behavior. Along with the adoption of ethnographic fieldwork techniques, researchers and extension workers better understand the relevance of qualitative method to complement and triangulate the quantified data. Accomplished with the field techniques like ethnographic interview, participant observation, etc. the technicians involved in FSRE are capable of assuming that the decision makers, whether farmers or businessmen or NGOs themselves are the experts on how they make the decisions they make. In other words, elicitation of specific decision criteria used by decision makers is imperative of seeing the insiders' world through the insiders' eyes.

INTRODUCTION

Anthropology to date has covered a vast range of concepts and methods of accumulating knowledge on human culture. Discourse among anthropologists has led to the possibility of a more theoretically powerful and informed concept of culture (Geertz 1973, Kuper 1999). Anthropology deals with the culturally constructed pluralism, multiplicity and diversity. By enabling ourselves to explore the varieties of cultural worlds that human groups create and inhabit, anthropology helps appreciate distinctive ethos or worldview of each culture with its own logic and coherence. Socio-cultural anthropology thus serves as a bridge across "cultures". The cross-cultural learning model widely adopted by anthropologists enables "to achieve an 'out-of-culture' experience through immersion in another way of life; to transcend one's own cultural boundaries and limitations, and see - really see - new worlds through the eyes of others"(Nolan 2000).

Participant observation and ethnographic interviews are the basic techniques used for data collection from social settings. Trend of such research or fieldwork practices has established grounded connections to communities' realities, aspirations and needs and consequently, applied and/or practicing anthropologists became engaged with the issues of social well being, health, and environmental and economic crises. They did not confine themselves to esoteric, antiquarian and arcane topics or minority groups (Ervin 2000) or exotic others.

Some anthropologists began their studies on specific aspects of human culture independently and some were invited for consultation services by various development agencies. Such a shift occurred during the post World War period created new directions for academic and practicing anthropologists both. They started dealing with specific issues and problems. Anthropology then made excursions into applied concerns with attempts to hold a stake in multidisciplinary teams employed by foreign aid/assistance departments. Since anthropology has been dealing with cultural diversity, heterogeneity, specificity and plurality; it has fostered the concept of relativism and a sense of coexistence. Holistic perspective has been thus reflected in ethnographies.

After 1950s, many anthropologists who were employed by development aid agencies/departments and those who were independently devoted to applied sectors began to explore socio-cultural milieu of adaptation, livelihood and material conditions or physical environment they embedded with. Such endeavors created opportunities to take stake in interdisciplinary teams comprised of agriculturists, health/medical practitioners, economists,

geographers, engineers, management experts and so on. This type of combined/joint efforts made all the stakeholders (team members) share and exchange ideas, concepts, theories, methods and approaches.

APPLICATION OF ANTHROPOLOGY IN AGRICULTURE

Anthropologists' concern to explore the history of human behavior and to make an analysis of cultural adaptation to given ecological niche linked to the history of food systems. The study of a food system urged joint ventures between agriculturists and anthropologists. Moreover, the "culture" suffixed with "Agri" is the very essence what cultural anthropology has been dealing with. In other words, anthropologists' concern with agri-history is one of the crucial efforts to make a scientific history of human world. Similarly, those agriculturists who possessed holistic vision realized the need of historical and/or cultural understanding of the 'intercultural' practices within a food production and consumption culture.

Despite the efforts made by the Agriculturists to take account of and pay attention to different aspect of food production, anthropologists began to demonstrate their keen interest in food production and consumption areas. Also, development agencies in their projects used anthropologist as collaborators and consultants as well (Acharya 1998 and 2000).

There are many cases in which anthropologists have been playing vital roles. For instance, in the late 30s, the American Office of Indian Affairs embarked upon a Large Scale Natural Survey with the Department of Agriculture. For anthropologists were employed, the result of such survey came up with the recommendation having emphasis on "the necessity of taking persistent Indian attitudes into account in planning for their social and economic adjustment to dominant American values". (Barnett 1956 quoted in Gardner and Lewis 1996). Another case is the involvement of US anthropologists along with the leadership of John Collier in 1934. They worked in the project under Soil Conservation Service related to Native American land use (Ember and Ember 1993). Anthropologists viz F G Bailey, S Epstein in the 50s and 60s has dealt with the effect of economic change at the micro level. They have worked in South Asia and shown how changes in production due to new technologies/input did not led to major social readjustment (Bailey 1958, Epstein 1962, 1973). Similarly Farmer et al (1977) have noted how new production technology has resulted in competition over scarce resources, together in some cases with displacement of labour.

Ecological approach in anthropology has added a lot of theoretical and practical dimension, ie. Anthropogeography, possibilism and environmental determinism (Geertz 1970), with cultural-ecological perspective in agriculture. Beside, Geertz (Ibid) has provided a historical account of Indonesian agriculture and has shown how colonial policies encouraged the development of a partial cash economy in which peasant farmers were forced to pay taxes to support plantation and production for export. Hill (1985) has discussed about the practical need for a socioeconomic classification of tropical agrarian system consistent with economic-anthropological inquiries. Layton (1985) discussed about the role of anthropologist in the presentation of land claims. Similarly, land reform movement during post-war period sought anthropologists' involvement critical and essential.

International Potato Centre (CIP) based on Lima, Peru is one of the reputable institutions that involved the anthropologists as core staff, eg there were a dozen of anthropologists involved during (1973-87) fourteen years' period (Horton 1985). Similarly, Collaborative Research Support Programs (CRSPs) also invited anthropologists for addressing strategic/policy issues, technology development and household food security, consumer demand, food policy, sustainability of natural resources, property issues and so on (Anonymous 1992).

The prospect of agricultural-anthropology (Rhoades 1984) must burrow its basic retrospective concerns. The more applied anthropologists are concerned to make to deal with various aspects of agriculture, the more prosperous and comprehensive prospectus will suffice our pursuit of learning agriculture as food-system interwoven with human civilization. Anthropologists like and unlike other social scientists can play ranges of vital role as per Knowledge, attitude and practice (KAP) he/she has possessed. Since agriculture is itself considered as one of the applied-biological sciences, an anthropologist involving in it is supposed to have elementary (at least) knowledge in order to deal technical concerns. In case of attitude, anthropologists' vision demands a holistic perspective, i.e. intuitive conscience composed of rational character traits resulting in horizontal relationship of the "self" with "others". Similarly, practical concern of anthropologists dealing with agricultural matters demands an experience be interknitted with actual observations than the rhetoric ones.

Anthropologists' involvement in agriculture sector generally characterizes a unified consideration of socioeconomic and cultural milieu of farm-communities or peasant societies, contents a wide range of issues to be dealt with the help of various theoretical and methodological back up. Furthermore, anthropological pedagogy reflects the pros and cons associated with its involvement in applied sectors like agriculture. In this case, anthropologists become, for agriculturists realize the role of anthropologists essential for completing the process of technology generation, verification and dissemination, a part of inter/multidisciplinary team. Such a condition necessitates anthropologists possess multi-facet personality in order to adjust him/herself in varied contexts and create a balanced relationship with other stakeholder participating in particular program/activities. Anthropologists encounter with disciplinary conflict in these cases. Variation in theoretical and methodological command leads to some extent the agriculturists feel anthropological feedback bothering and indigestible. For instance, anthropologists may find out that technology developed and extended by agriculturists without prior consideration of farmers' actual need and preferences may be rejected or non-adopted by the farmers. Such a finding clarifies the efficacy/performance of agricultural research and extension. Consequently, though positively targeted, expected outcome is not achieved while compared to the resource use.

Though anthropologists have been better participating in many of the agricultural program/activities for addressing specific issues, their applicability depends on disciplinary command (theoretical and methodological understanding), personal motivation, devotion and initiative; type of group involved, nature of job contracted and so on.

ANTHROPOLOGICAL QUERIES ON CHOICE BEHAVIOR (DECISION MAKING)

Each person makes a choice in different situations. The choice made by an individual is reflected as a personal or a group behavior. In other words, decision-making is most frequently an individualized enterprise, although groups of people in meetings and individuals on their own both make decisions. Social scientist, especially anthropologists and psychologists are found more capable of telling why most of the individuals in group make the choices they do (Gladwin 1989).

Applied anthropologists have been assessing the needs of people for a number of purposes, especially in preparing for grant applications, budgeting, setting priorities, and developing programs (Ervin 2000). Of the three suggested types of need assessment, the Decision-making Model is a preferable and more developed one which focuses on the actual needs and values of current and potential clients and leads to better services by an organization (McKillip 1987 cited by Ervin 2000). The ethnographic decision models differ from other expert systems or rule-based models that are less context-sensitive. These are culturally tuned by some specific group of individuals and then tested against choice data from other individuals in the group. These models are similar to cognitive science models like taxonomies, componential analysis, and plans or scripts, described in detail elsewhere.

WHO'S DECISIONS TO BE MODELED?

All the planners and policy makers make many decisions during the course of a project. These decisions are made under conditions of uncertainty and ambiguity, where opinions as to the proper course of action differ and where the difference between right and wrong choices is not apparent. The case of the SODESP livestock project in Senegal (Boyle 1984 cited by Nolan 2000) clearly shows how a key decision-maker influences the overall project design. Furthermore, Nolan (2000) has shown how anthropological input can help guide choices in directions that are culturally feasible and appropriate.

The anthropologists have intensively used ethnographic decision models during the past three decades in many cultures to predict the actual choices of individuals in a group. Gladwin (1989) has cited the cases of decisions made by Ghanaian fish sellers in deciding between markets, farmers' adoption decisions in Puebla, Mexico; farmers' cropping decisions and peasants' choices of treatment in illness in Pichatero, Mexico; United States farmers' decisions to cut back production and sell land during a farm crisis, African farmers' decisions to get credit from modern inputs, namely fertilizer, etc. These illustrations clearly show that ethnographic decision models are best used to analyze the decisions of the farmers in varied contexts. Moreover, each actor in all situations makes decisions. All the stakeholders of farming system research and extension (FSR and E), education and agricultural marketing, too make decisions in the process of production, distribution and

consumption. Decisions made by these stakeholders can be analyzed, modeled and tested, when required. The decision making process is shown in Figure 1.

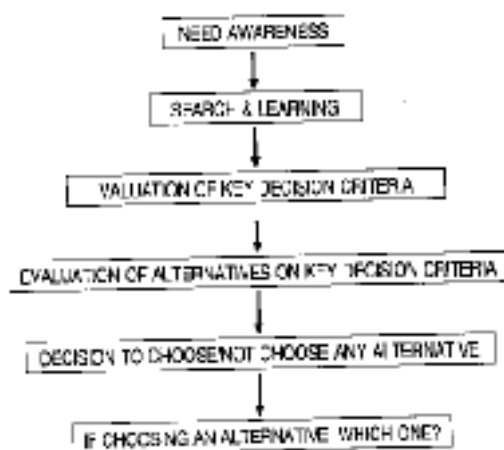


Figure 1. Decision making process.

WHY MODEL DECISIONS?

Once decision models are developed through decisions analysis techniques by grouping together individuals who have similar vectors of choice responses for the same choice sets, such models can be applied to many academic and action research problems. These models further help in the analysis of service options for new extension and credit services, forecast of demand for modern high yielding varieties (HYVs), agriculture input products and the identification of optimum packages of technologies, extension services and options.

Understanding and predicting the choices/alternatives that individual farmers and group of farmers are likely to make in response to competitive actions is of major strategic and tactical interest to those involved FSR and E. The importance of understanding and forecasting choice behavior has encouraged the development of better approximation to farmers' choice/decision processes (Louviere 1988). In an academic sense, endeavors pertinent to decision analysis and modeling underscores the value of a wide range of ethnographic techniques to scientific inquiry and to improve the quality of abstract and applied qualitative research.

Gladwin (1989) has illustrated that agricultural experts in the Third World wanted to know why farmers were not adopting the improved technologies coming out of their research stations and "on-farm" trials and economists in sub-Saharan Africa wanted to know if African farmers would still use chemical fertilizers when the fertilizer subsidy was removed. In these cases, agricultural experts and economists wanted to know why farmers in a certain group did what they did. They needed to know how these farmers made real-world decisions, and they needed to know the specific decision criteria used by the farmers in question, in case they could intervene in the decision-making process with a new policy designed to make things better. In other words, they needed/wanted an anthropologist or a psychologist to tell them why most of the individuals in the group make the choices or select the alternatives they do.

Ethnic decision modeling assumes that the decision-makers (here, specifically the farmers) themselves are the experts on how they make the decisions they make. Anthropologists thus tend to see the insiders' world through the insiders' eyes. In other words, ethnographic decision modeling is applied to draw meanings from culture bearer themselves.

HOW MODEL DECISIONS?

Most anthropologists have been studying the physical and cultural entirety (Rhoades 1984) of human communities. In course of ethnology, wide range of cross-cultural ethnographic data were gathered and

analyzed. Typologies of sociocultural structures/ institutions and processes were developed. The vast range of ethnographies helped develop models of social institutions and processes. Relevance of such models largely depended on the formulation of basic theoretical propositions based on observation of specific situations. The general philosophical orientation and epistemological root helped develop refined set of concepts and use models of culture to fit the data that represented varied sociocultural identities. In due course of anthropological efforts to the understanding of human actions, some muddles in the models (Scheider 1965) were also observed owing to inconsistencies, errors and inadequacies in some ethnographies.

The models developed and tested using quantitative methods (eg factor analysis, multidimensional scaling, cluster analysis, metric conjoint analysis, etc.) are also accepted by anthropologists. But these types of models are likely rule-based black-box technique to test the researcher's interpretation of the insiders' culture (Gladwin 1989) and generally used to impose the external logic. Contrary to this, ethnographic decision models are developed following qualitative methods and explore the internal logic. Such models are built through expert-systems models of insiders' decision processes from the insiders' own terms and phrasing of their own decision criteria. These models are combined/presented in the form of a decision tree, table, flowchart, or set of "if-then rules" which can be programmed on the computer.

DECISION TREE: THE MOST PREFERABLE MODEL

This is a distinctive form decision analysis in contrast to linear additive models or even less context-sensitive, rule based models. An anthropologist (ethnographer) avoids making unrealistic behavioral assumptions and armchair propositions about how people in the real world make important decisions. Because Decision Tree Models use more realistic assumptions about individuals' cognitive capabilities, they are capable of being tested (Gladwin 1989). This type of model blend quite different research approaches, viz cyclical-discovery process of ethnographic research and straight-line (linear) research plan of other social sciences (Figure 2).

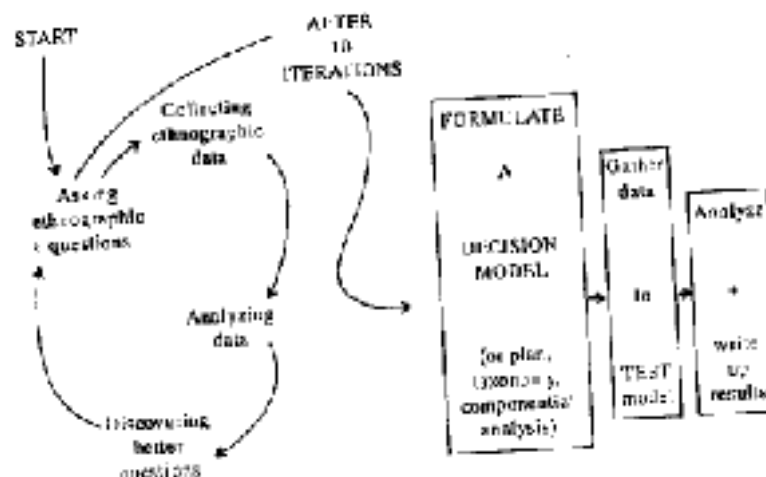


Figure 2. Combining the ethnographic research cycle and linear hypothesis-testing plan (Adopted from Gladwin 1989).

This type of modeling uses both of these approaches in order to first grasp the native's point of view, his relation to life, to realize his vision of his world (Malinowski 1922 cited by Gladwin 1989). Here the ethnographic part of the process (model building) can take a few weeks or up to two years, while the model testing part can take a few weeks or up to six months, depending on the fieldwork situations and ethnographer's experience.

Decision Trees are thus testable cognitive models. These are formal techniques used to combine individual decision makers' criteria and rules into a computer programmed decision model for the group that can be tested against actual choice data.

Following are the steps to be followed while developing a tree model:

- ☞ Decide which decisions are to be studied
- ☞ Decide on the set of alternatives in the decisions
- ☞ Remember how to conduct an ethnographic interview and find informants in appropriate cultural scene and practice on him/her
- ☞ In addition to ethnographic interviews, do some participant observation
- ☞ Decide on the sample of decision maker farmers to use to build the model and decide when and where to interview them
- ☞ Select/specify the decision criteria or constraints to use in the model
- ☞ Build a composite decision model for the group from the individual decision tree
- ☞ Combine all the different decision trees from all informants in the model-building sample and combine them in a logical fashion while preserving the ethnographic validity of each individual decision model

Following are the steps to be followed while testing a tree model:

- ☞ Make up a formal interview schedule or a questionnaire to test the composite model already developed, using each decision criteria as a question
- ☞ Decide on a sample of decision maker farmers to use to test the model and decide when and where to interview them
- ☞ Also elicit quantitative data about what the informant farmer is actually doing so that the researcher knows what choice is really made and ask the farmer questions about why he or she is making that choice
- ☞ During the test interviews, know when the model already built is failing and identify the errors of the model
- ☞ After the test interviews, calculate the error rate (and success rate, too) of your model(s)
- ☞ Listen to what "the errors" say about why they do what they do, and devise an alternative model to predict their choices, by (a) rephrasing or generalizing an existing criterion, or (b) adding another criterion, or (c) switching the order of criteria or even whole paths of the tree

LIMITATIONS OF THE MODEL

Some common problems and errors that can be encountered by decision tree modelers are:

- ☞ Decision tree is a simplistic model which can be simply represented by a checklist because it is a simple straight-line elimination by aspects model
- ☞ Ambiguity of the informants, ie informant may not like yes/no answer or who can not answer yes/no to certain questions
- ☞ The use of circular criteria limits the possibility of prediction outcomes and choices and proper phrasing the criterion
- ☞ There is a chance of the lack of falsibility, ie sometimes we can't get a single informant whose choice the given model fails to predict. This is because every model is an imperfect representation of the real world
- ☞ A lot of decision episodes or stories about why and when and how the informants did X and elicits very detailed decision criteria and puts them all verbatim into a tree, which then turns into a long, windy vine.
- ☞ There is a problem that another outcome suddenly appears in the outcome box that was not present in the initial set of alternatives
- ☞ There is no ordering aspect, i.e. something - some aspect - is maximized or minimized in every choice, subject to constraints

Steps to cope with decision models that suddenly starts to expand:

- ☞ Recognize the signs that there is more than one decision to be modeled in the decision context
- ☞ Identify the other related decisions in the series, and figure out which decisions are logically prior to which
- ☞ Once the sequence of decisions is specified, model each decision by following each step, interview more informant farmers, identify the alternatives and criteria in each decision and make up a composite model(s) to test
- ☞ Once all decisions are modeled, check them for logical consistency and the proper "fit" of the decision criteria
- ☞ Add feedback loops in models where they belong to allow decision maker farmers to go back and forth between the related decisions. This allows more flexibility and simultaneity between models

Researchers involved in applying ethnographic decision models better come up with policy recommendations. These decision models can also provide valuable feedback to planners. Such models are useful in carrying out evaluation, social impact assessment, social soundness analysis, needs assessment, technology development research and cultural resource assessment (Van Willigen 1985). Decision modeling is helpful for those involved in farming systems research and extension. The hypothetical example of a cropping decision model as suggested by Gladwin (1989) is shown in Figure 3:

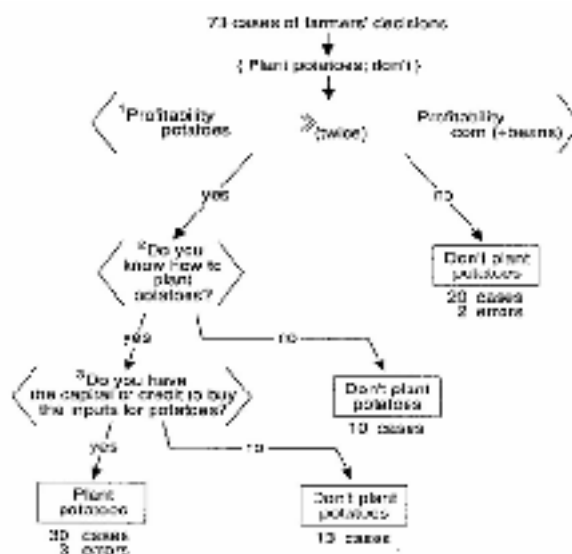


Figure 3. A Hypothetical Example of a Cropping Decision Model (Adopted from Gladwin 1989).

Sociocultural and economic factors, viz caste/ethnicity, gender, economic status, etc. affecting the decision making processed must be addressed while developing and testing a decision model.

Those who are involved in FSR and E can better use the models for many purposes. Agriculture scientists can use it in outreach research (OR) sites during site description surveys, participatory appraisals and village level workshops. Similarly, extension workers (JT/JTAs and SMSs) can explore reasons behind farmers' choices on specific technologies and give feedback to the agricultural scientists.

In order to develop better working decision models, researchers and extension workers should address the socio-cultural and economic factors associated with farmers' choice behavior.

REFERENCES

- Acharya BK. 1998. Need and application of agricultural-anthropology. **In:** *DISCOURSE* Vol. 1. Department of Anthropology/sociology, Patan Multiple Campus.
- Acharya BK. 2000. Participatory technology development: An overview of farming system research and extension. **In:** *DISCOURSE* Vol. 3. Department of Anthropology/sociology, Patan Multiple Campus.
- Ahmed AS and CN Shore. 1995. Is anthropology relevant to the contemporary world? **In:** *The future of anthropology. Its relevance to the contemporary world*. The Athlone Press, London.
- Apthorpe R. 1985. Pleading and reading agricultural development policy. **In:** *ASA monograph 23* (R Grillo and A Rew, eds). Tavistock Publication, London.
- Ervin AM. 2000. Applied anthropology: Tools and perspectives for contemporary practice. London, Allyn and Bacon.
- Geertz C. 1970. Agricultural involution: The process of ecological change in Indonesia. Berkely, University of California Press.
- Gladwin CH. 1989. Ethnographic decision tree modeling. *Sage University paper series on qualitative research methods, vol 19*. Beverly Hills, CA: Sage
- Kuper A. 1999. *Culture: The anthropologist's account*. Cambridge, Harvard University Press. Pp.1-11.
- Lewis IM. 1995. Anthropology for sale ? **In:** *The future of anthropology. Its relevance to the contemporary world*. The Athlone Press, London.
- Louviere JJ. 1988. Analyzing decision making: Metric conjoint analysis. CA, Sage.
- Nolan R. 2002. *Development anthropology: Encounters in the real world*. UK, Westview Press.
- Rhoades RE. 1984. *Breaking new ground: Agricultural anthropology*. Lima, International Potato Center.
- Rogers EM. 1962. *Diffusion of innovation*. The Free Press, New York.
- Schneider DM. 1965. Some muddles in the models. **In:** *The relevance of models for social anthropology* (M Banton, ed). *ASA Monograph 1*. London, Tavistock
- Van W. 1985. *Training manual for policy ethnography*. USA.

Opportunities and Constraints of Off-Season Vegetables Marketing in Tarai and Indian Markets

KP Shrestha¹, S Baidya¹ and NS Thakur²

¹ Agriculture Research station, Pakhribas

² Outreach Research Division, Khumaltar, Lalitpur.

ABSTRACT

A study was made during the fiscal year 1998/99-1999/2000 at ARS-Pakhribas command area along the Dharan-Basantapur road corridor. The project aims to identify the marketing opportunities and constraints of off-season vegetables in Tarai and Indian markets. Questionnaires were prepared, pre-tested, and survey carried out with growers, cooperatives, and traders. Recording were also with during discussion with different concerned. There are ample opportunities of supplying off-season vegetables in the *Tarai* as well as in the Indian markets. It has also found that there is far better marketing opportunity in Bangladesh than in India. It was revealed that, the quantities of export of off-season vegetables could be doubled in Indian markets where as in *Tarai* markets it can be increased by 20 per cent. However, assiduous thought should be given on quality improvement in the field as well as during transportation to distant markets. The other major constrains found are: poor packaging materials, lack of markets and price information, lack of training package (technical know-how) on cultivation practices, no marketing yard at Dharan and Biratnagar and transit yard in Kakabhita, administrative burden like illegal taxes charged by police and in barriers, no agreement between Nepal and Bangladesh government for export.

Key words: Constraints, marketing, off-season vegetables, opportunities

INTRODUCTION

In the context of the eastern hill farmers' socio-economic and biophysical conditions, diversified farming systems and geo-climatic circumstances are the major problems (PAC 1994). In the past, farmers had no access to roads and markets for selling their agricultural produce and there was no possibility of expanding the vegetable growing areas. But now, the supply of vegetables from the hills has been started to the *Tarai* markets as a result of the Dharan-Basantapur road and its link to Terhathum and Sankhuwasabha.

Off-season vegetables in this context is defined as those vegetable grown in the area for off-season market supply elsewhere. The vegetables grown in the high hills like Sindhuwa, Jorpati, Hile, Namje, Okhre and Danda bazaar area are off-season for *Tarai* market.

After research carried out by PAC (now known as ARSP), Centre for Environmental and Agricultural Policy, Research, Extension and Development initiated vegetable growing and channeled vegetable production and marketing through farmers' groups and co-operatives. In 1992, six cooperative formed and partly sponsored the construction of four vegetable collection yards at Sindhuwa, Jorpati, Hile and Mulghat. However, only the Sindhuwa multi-purpose co-operative was functioning well during the study period. The APP (1995) also emphasized the need to strengthen co-operatives as viable competitors of private firms.

Farmers in and around the Sindhuwa area are supplying their produce to the Sindhuwa Multi-purpose cooperative because of its assured marketing and due payments over time (Regmi et al 1997). Apart from the Sindhuwa co-operative, 22-25 *Katawala* (having weighting balance) are collecting vegetables and selling in bulk to Tarai markets. But, there is a great difference between farm gate and wholesaler prices. So, it was proposed to conduct study to identify possible constraints of marketing and also explore possible solutions, which will benefit the vegetable growers.

Apart from farmers' marketing problems, they are using hybrid and costly imported seeds (Coronet and Snow crown variety of cabbage and cauliflower). These vegetables are heavy feeders of inputs and farmers are currently growing them-with the application of high doses of inorganic fertilizers, pesticides and other chemicals. These practices may eventually lead to environmental degradation and declining soil fertility. Insects and diseases are also becoming severe problems in vegetable production.

MATERIALS AND METHODS

A visit was made to different institution like CEAPRED and NO-FRILLS-Kathmandu, IAAS-Rampur and NARC library Khumaltar to review the literature. An exploratory visit conducted consisting, Project team members, off-season vegetables growers, and cooperative managers of the study. The team were visited to the main vegetable growing areas like Sidhuwa, Chitre, Basantapur, Dhankuta, Mulghat, and Bhedetar. They were also visited to the major *tarai* markets of like Dharan and Biratnagar where and discussion were made with commission agents (CA) for market management for off-season vegetable for *Tarai* markets.

Based on review of literature and exploratory visit a set of semi-structured questionnaires were prepared, pre-tested, and survey conducted with off-season vegetable growers, cooperative people, and traders of the study area particularly collection centre command area (Basantapur, Chitre, Sindhuwa, Jorpati, Hile, Mulghat and Bhedetar).

Project leader and a team member also made a visit to major Indian wholesale markets of west Bengal and Bihar includes: Siliguri, Forbesganj, Purnia, Kathihar and Patna so as to collect the scenario of demand and supply along with opportunities and constraints of off-season vegetables in northern Indian markets. The collected information analysed in SPSS.

RESULTS AND DISCUSSION

Crop and variety grown

The major vegetables grown by the farmers in the Koshi hills which are termed as a off-season for the Tarai markets are Radish, Cabbage, Cauliflower, Beans/cowpea, Broad Leaf Mustard (Rayo), Green pea and others (Table 1).

Table 1. Off-season vegetable and variety growing by the farmers of Koshi hills

Crop	No. of respondent	Variety, %	
		Local	Improved
Cabbage	115	0	100
Cauliflower	102	0	100
Radish	126	25	75
Pea	36	3	97
Bean	81	44	56
Cucumber	6	100	0
Rayo	51	88	12
Balsom apple	16	100	0
Brinjal	8	0	100
Chilly	14	79	21
Green Coriander	8	100	0
Tomato	28	36	64
Carrot	20	0	100
Chayote	23	100	0

Problem on nursery management

Problem for nursery management, particularly for cole crops like cabbage and cauliflower were analysed. Total of 58 per cent responded problem for nursery management (Figure 1).

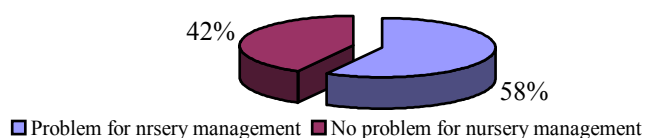


Figure 1. Problem on nursery management of cole crops.

Farmers' gave first priority to problem in nursery management particularly for damping off. Similarly, second to Insect damage (red ants, cut worms, white grubs, and cabbage butterfly), third to timely unavailability of pesticides, and fourth priority to frequent rainfall (Figure 2),

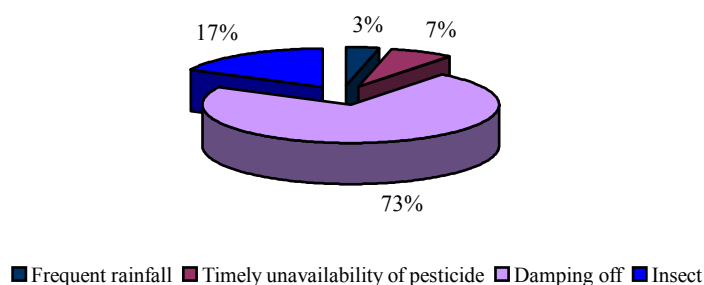


Figure 2. Farmer's priority problem for nursery management.

Use of chemical pesticides and days to harvest vegetables

About one forth (23%) farmers harvest their vegetables within a week of spraying pesticides in the vegetables. 14 per cent harvest before 2 weeks of praying, and about half of the population wait for 3 weeks (Figure 3).

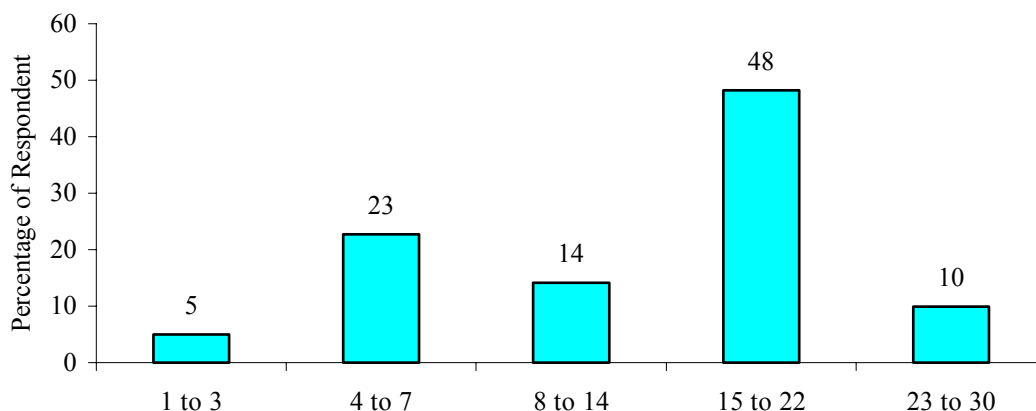


Figure 3. Days to harvest vegetable after applying pesticides.

While asking the farmers about the harmful effect of chemical use, 51 per cent of the respondent found aware about where as 49 per cent were not aware (Figure 4).

There was six major harmful effect of chemical use in vegetables production described by the respondent farmers (Figure 5).

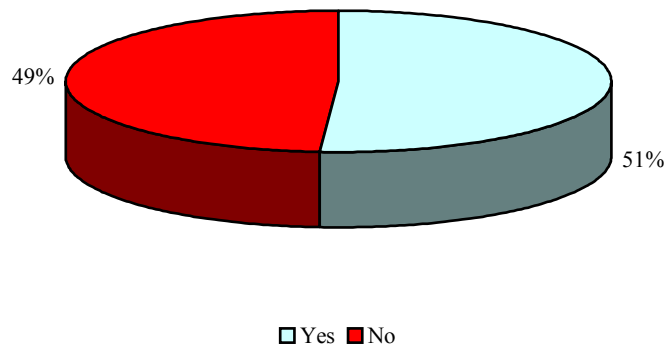


Figure 4. Response on the harmful effect of chemical use in vegetable production.

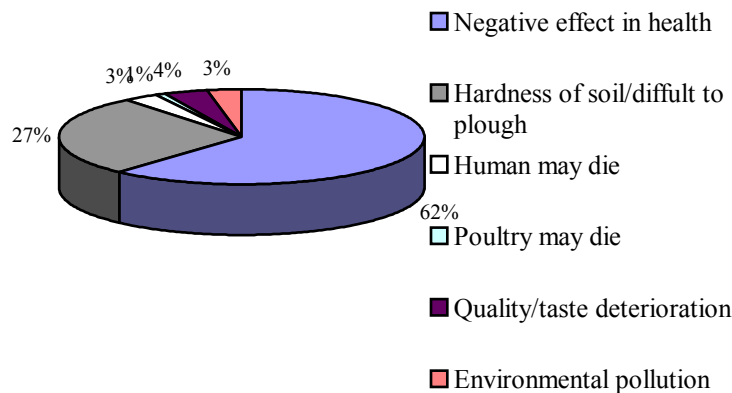


Figure 5. Harmful effect of pesticide in used for vegetable production.

Market price/information

There is lack of market information. Farmers do not aware with daily price of vegetables at different wholesale markets. They are bound to give vegetables as per price fixed by traders. They supply to commission agents at Dharan and Biratnagar who further sold to retailer or middleman to supply retailer taking 5 to 7 per cent commission. But in case of Sindhuwa multipurpose Cooperative, they get information from different markets and fixes prices accordingly in next days.

Marketing channel and steps

There are several market channel and steps for selling off-season vegetables (Figure 6 and 7). These channel and steps also varies according to the production and marketing places. For example producer of Basantapur site either directly sold to retailer at local market or sold to *Kharide* at Basantapur who further supply to commission agents at Dharan and Biratnagar, they also supply to retailer or middleman and/or commission agents of Indian markets. But in case of Sindhuwa, cooperative collects the vegetables and directly supply to commission agents at Dharan, Biratnagar, and Indian markets. However, there is also case like Basantapur while *Kharide* collects the vegetables at Sindhuwa.

In case of Mulghat, the case is different. There are three cases: (i) Farmers directly supply to retailer or commission agents at Dharan, (ii) Sold to retailer or *Kharide* who further supply to Commission agents at Dharan and Biratnagar, (iii) Give on contract basis. For example, Agricultural Enterprises Centre makes contract with farmers for the production and supply of Hybrid tomato (Avinas-2) to export Bangladesh.

The major marketing steps and channel are as follows:

Basantapur

- Producer---> Consumer
- Producer---> Local Retailer---> Consumer

- Producer---> *Kharide*---> Local Retailer---> Consumer
- Producer---> *Kharide*---> (CA) Commission agent (Tarai)---> Retailer---> Consumer
- Producer---> *Kharide*---> CA (Tarai)---> Supplier to Retailer---> Retailer---> Consumer
- Producer--> *Kharide*--> CA (Tarai)--> CA (India)--> Wholesaler--> Retailer--> Consumer

Sindhuwa

- Producer--->Consumer
- Producer--->Local Retailer--->Consumer
- Producer---> Cooperative---> CA (Tarai)---> Retailer---> Consumer
- Producer---> Cooperative--> CA (Tarai)--> Supplier to Retailer--> Retailer---> Consumer
- Producer---> Cooperative---> CA (India)--->Wholesaler---> Retailer---> Consumer
- Producer---> *Kharide*---> Local Retailer---> Consumer
- Producer---> *Kharide*---> CA (Tarai)---> Retailer---> Consumer
- Producer---> *Kharide*---> CA (Tarai)---> Supplier to Retailer---> Retailer---> Consumer
- Producer--> *Kharide*--> CA (Tarai)--> CA (India)--> Wholesaler--> Retailer--> Consumer

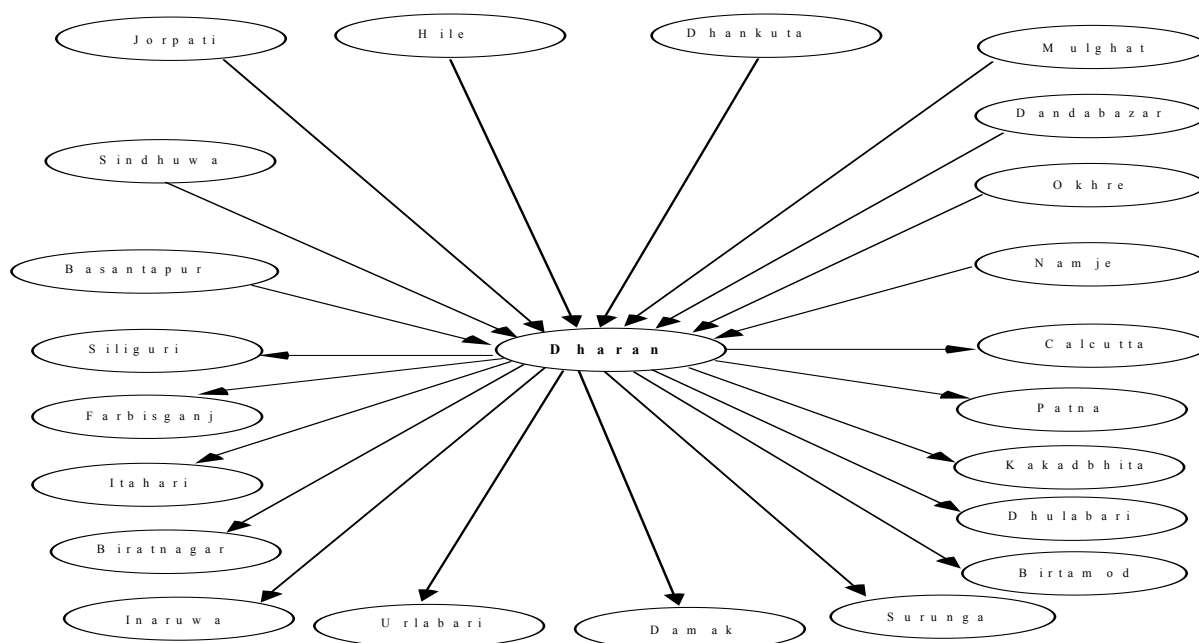


Figure 6. Major marketing network/transaction of off-season vegetables at Dharan.

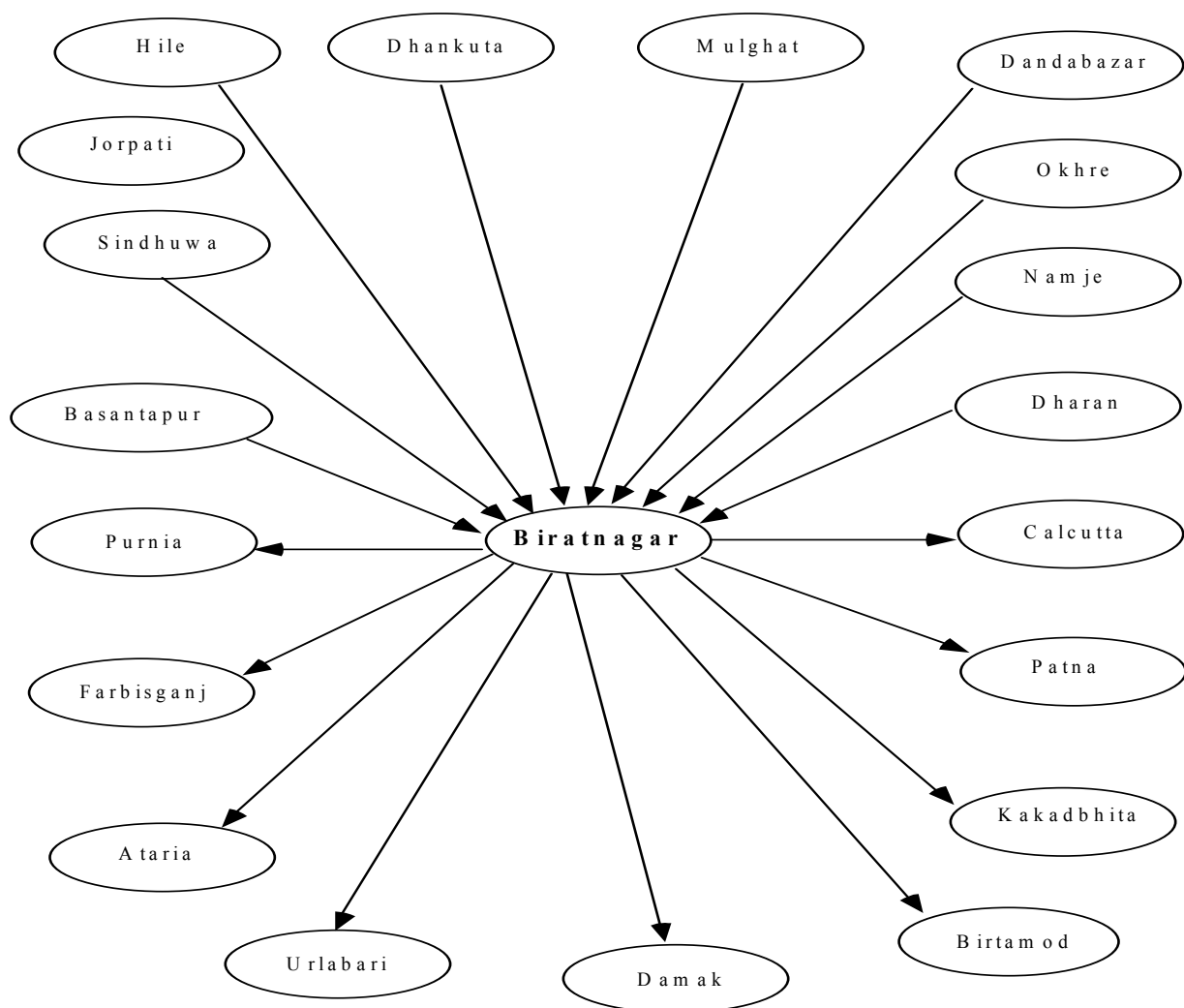


Figure 7. Major marketing network of off-season vegetables at Biratnagar.

Market opportunity in Indian markets

Siliguri and adjoining area: Siliguri is the focal point of all commercial and agricultural activities in the North Bengal of India. A huge number of farmers, growers, and purchasers come to the principal market yard of Siliguri Regulated Market (SRM). It is located at the foothills of Himalayas. Siliguri has been a trade center meeting the requirements of North Bengal, Sikkim, Bhutan, North Eastern India, and Nepal for years. The principal market yard is set up on a land measuring 50.53 acres at Mallaguri. Wholesale marketing of fruits and vegetables transaction was started in November 1983. At present, 97 numbers of fruit and vegetable shop cum go-down holders are doing business. More than 360 tons of fruits and vegetables are being handled per day in the market.

Generally, three to five truckloads of cabbage are being supplied to SRM from Nepal (mainly from Koshi hills) every day except Sunday (holiday). One truckload contains about 100 *tokaris* of cabbage (one *tokari* contains about 70 kg). So, on an average, daily supply of cabbage SRM can be estimated as 25-30 metric tons from Nepalese high hills along the Dharan-Basantapur Road (mainly from Sindhuwa, Jorpati, Guranse, Hile and Dhankuta).

Bhutan is the other producer country of cabbage being marketed at SRM. They supply about one to two truckloads of cabbage that compete with the produce of Nepal. But, due to long distance and damaged road

caused by heavy rain, the quality of cabbage gets deteriorated (turns yellowish) and thus gets lower price (about two rupees per kg) compared to the Nepalese cabbage (looks fresh and green).

Jogbani-Forbesganj-Purnea-Katihar: Jogbani is the border market at India near Biratnagar. There are seven retailers who directly purchase off-season vegetables from Dharan/Biratnagar and sell them at their local market. Five medium-level suppliers from Jogbani are further supplying off-season vegetables to Forbesganj, Purnea and Katihar using bus and train as transportation means. There are about 25% losses due to handling injuries during transportation leading to further deterioration in quality, which damages to outer leaves that need to be removing to make cabbage marketable appearance. Fluctuation in the price of vegetables depends upon the amount of rainfall occurring and availability of other vegetables at the markets. Amount of rain increases, availability of local vegetables decreases, price of Nepalese off-season vegetables increases and vice-versa.

Both tokariload and truckload suppliers said that there was a big problem of paying money unofficially or illegally to the people of Nepalese custom, Nepalese police and Indian Roads and customs. In case of tokariloads, Nepali Custom charges Rs10-20/*tokari*, Nepali Police charges Rs10/*tokari* and Indian Road and customs charge Rs5/*tokari*. Similarly for truckload, they charge Rs100, 100, and 50 per truck respectively without giving any receipts.

Commission agents reported that, quality of cabbage in general was poor and this problem is in increasing direction. It is likely due to use of heavy doses of chemical fertilizers, insecticides/pesticides, infestation by insects and diseases. If quality of cabbage can be improved, its market demand and price both will also increase. The major problem is the development of concentric black spots/stripes extending from the outer leaves to the inner ones due to high moisture and increasing temperature ultimately leading to the poor quality of the cabbage. They reported about 25 to 50 per cent of damage. They suggested that bamboo-packaging material is not good for cabbage and also for radish. It should be modified based on some studies. They also suggested that the high moisture content in the cabbage at the time of transport should be reduced using any appropriate means so as to minimize deterioration in quality due to development of concentric ring and handling injuries. Grading of vegetables is also quite essential for quality improvement and fetching higher price.

Patna (Western sector): There are two major wholesale markets of green vegetables in Patna; they are: Maslampur Haat and Mithapur *Sabji Mandi*. There are more than 40 wholesalers/commission agents in these markets. According to Wholesaler, cabbage that comes from eastern hills of Nepal was better than that supplied from Birganj (produced around Tistung-Palung area) because of its small size, compact and comparatively less damage. If quality of cabbage can be improved, then it would be the preference of local consumers due to its lower price and better taste.

Cauliflower is also coming to Patna and Calcutta markets from Nasik and production in small scale has also started at Hajipur. Quality of Indian cauliflower is better than that of Nepalese one; so Nepalese cauliflower cannot compete in Patna market. Nepalese radish also does not possess good market due to its bigger size compared to smaller size of Indian radish. Indian consumers prefer radish smaller in size and pungent in taste. There might be good market for Nepalese Peas in India. Now a day, Peas are also coming to Indian markets from Ranchi.

Fulbari-Banglabandh: Fulbari-Bangabandh is a border area of India and Bangladesh. This is the official cum commercial road entry point of agricultural and other commodities to and from Nepal. The main route to reach Fulbari-Bangabandh is through Kakadbhita (Nepal)-Panitanki (India) - Bagdogra - Fulbari - Bangabandh. Nepal Transit and Warehouse Company Limited (branch office at Kakadbhita) is responsible for the undertaking, clearing and forwarding of commodities and their supplies to Bangladesh. They charge 0.15% for undertaking and 0.2% for clearing in case of export items and 0.3% for import ones. There are high scopes and better opportunities for supplying vegetables to Bangladesh as we can fetch higher price for our vegetables than in Indian markets. It is because production of vegetables in Bangladesh is much less due to flooded situation during the rainy season. The distance between Kakadbhita and Fulbari-Bangabandh is only 56 km. A loaded truck from Nepalese border can reach Fulbari-Bangabandh border in about two hours. This route has been used since September 1, 1997 and the transaction of commodities through this route has been increasingly going up.

CONCLUSION

The quantity of export of off-season vegetables could be doubled if there has been given proper thought on quality during transportation. Nepalese commission agents of Dharan and Biratnagar had also agreed on this statement. They are not getting even half of the required quantity of vegetables both for Nepalese and Indian markets. According to the commission agents of Dharan and Biratnagar, it is experienced that local vegetables markets of the country could consume additional 20 per cent vegetables per year due to the growing urbanization as well as increasing awareness on the role of vegetables on human diet. Flooding in India is also one of the reason of supplying off-season vegetables from the eastern hills. Increasing monsoon rain decreases the production of Indian vegetables which ultimately, increases the demand as well as price and vice versa in the given markets.

Farmers of the study area have built confidence after visiting different markets for growing more off-season vegetables in higher hills. It resulted in revitalization/functioning of Basantapur Multipurpose Cooperative, which was closed earlier. Expansion of road has been reached at Myanglung bazaar, district head quarter of Terhathum, and Turture of Sankhuwasabha via Basantapur which encourages people to grow more vegetables. Marketing of vegetables either through cooperative or through commission agents found better for fetching reliable price to producers. Because of many steps between growers to consumers, farm gate price of vegetables is comparatively lower. The middlemen (also called *Kharede*) either gives lower price or do cheating while weighing and/or counting vegetables.

RECOMMENDATION

Based on the combine efforts of growers, cooperative personnels, commission agents working for the off-season vegetables at Dharan and Biratnagar research team of the projects made the following recommendations for the future betterment and delivery of outputs.

- Techniques of nursery rising and management, particularly for cabbage and cauliflower during the rainy season should be developed.
- Appropriate dose of manure and fertilizer application for semi commercial crops should be developed. Alternative of chemical fertilizer for nutritional management should also be identified.
- Research on appropriate packaging materials based on the type of vegetables to reach the long distance markets should be carried out so as quality of vegetables can be increased/maintained.
- Appropriate plant protection measures for different kind of insects like red ants, cutworms, white grubs and diseases like sclerotinia, alternaria leaf spots, damping off, root rot should be identified and reached to the growing area is a immediate need.
- Farmers want to have re-functioning of their cooperative. Therefore, reasons for non-functioning should be studied and ways for reviving identified.
- Governments and/or AIC should make arrangements for the timely availability of inputs like fertilizers, pesticides, seeds, micronutrients and agricultural equipments.
- Farmers training should be organized by concerned institutions, particularly for nutritional management and insect and disease management.
- Market information on, name of commission agents and their addresses, types of off-season vegetables and appropriate time of selling should be reached to the growers.
- Daily market price information of all major markets should be collected and broadcasted through Radio, TV, and newspaper.
- Marketing Yard should be constructed at Dharan and Biratnagar with all facilities at suitable place. Similarly, transit godown should also be constructed at Kakadbhita.
- Administrative burden like illegal taxes paying to police at road and barriers should be abandon.
- Nepal government should make arrangements with government of Bangladesh so as Nepalese vegetables suppliers (cooperative and commission anemgs/wholesaler) can work easily.

ACKNOWLEDGEMENT

The authors would like to acknowledge the HARP team specially Mr JB Abington and Dr SB Mathema for providing financial support to implement the project. Similarly, the working team of this project are also due acknowledged for their painstaking support during the project period.

REFERENCES

- APROSC and John Mellor Associates. 1995. *Nepal agriculture perspective plan (Final report)*. Prepared for National Planning Commission, His Majesty's Government of Nepal and Asian Development Bank.
- Gurung HB, PP Subedhi, TB Gurung, YB GC and HP Gurung. 1994. *Production and marketing constraints to fresh fruits and vegetables in the Western hills of Nepal*: A Field study report. Lumle Agricultural Research Centre, Pokhara, Nepal.
- PAC. 1994. *Annual research work programme, 1993-1994*. Pakhribas Agricultural Centre, Dhankuta District, Koshi Zone, Nepal. c/o BAPSO PO Box 106, Kathmandu, Nepal.
- Regmi KR, AJ Ghimire, IP Gautam, KB Adhikari, BB Silwal and UP Wagle. 1997. *A brief visit report on facilitation of vegetable marketing along the road sides from Basantapur to Biratnagar 12-15 August 1997*. Pakhribas Agricultural Centre, Dhankuta.
- Thapa GB, GP Koirala, GJ Gill and MB Thapa. 1995. *Constraints on agricultural marketing in Nepal*. Research Report Series No. 29. Winrock International, Policy Analysis in Agriculture and Related Resource Management, PO Box 1312, Kathmandu, Nepal.

Opportunities and Constraints of Sunflower Cultivation in Nepal

Ram N Chaudhary

National Oilseed Research Program, Nawalpur, Sarlahi

ABSTRACT

Sunflower is emerging as a potential oilseed crop in Nepal. Due to its non-cholesterol properties, the demand and consumption of sunflower oil is increasing every year. The increasing demand is met by import of sunflower oil. During 2001/2002 sunflower oil worth Rs112644292 was imported from overseas countries. The trend in import of sunflower oil has increased to 754% during 1996/1997 to 2001/2002 periods. There are ample opportunities for sunflower cultivation in Nepal despite numerous constraints on its cultivation. Research and development efforts on sunflower have been carried out by different organizations. With the availability of sunflower seed, oil extraction and good marketing facilities the sunflower cultivation in Nepal is expected to expand rapidly.

Key words: Constraints, opportunities, sunflower

INTRODUCTION

Sunflower (*Helianthus annuus* L.) crop is one of the potential oilseed crops grown in Nepal. Sunflower crop is expanding to all agro-climatic situations due to its wide adaptability. Sunflower was introduced in Nepal probably during 1979 and to start with one Russian variety Peredovick was introduced and evaluated at Nawalpur. The commercial cultivation of this crop probably started in 1994. Until late 90's the crop was mainly confined to central and eastern part of the country. However, during the 7-8 years period, the crop has spread to western and far-western Tarai of the country. It is estimated that sunflower is has been cultivated in around 1000 ha of land in Nepal.

The phenomenal increase in area and production of the sunflower in the country since its introduction is due to following advantages of the crop.

- ◆ Wide adaptability to wide ranging agro-climatic conditions and soil type.
- ◆ Short duration (90-100 days), which enables fitting in different cropping systems.
- ◆ Photo-insensitivity which enables its cultivation in rainy season, post rainy season and winter /spring seasons.
- ◆ Availability of varieties /hybrids with diverse duration and high yield potential which enable the crop to fit into multiple and inter cropping systems.
- ◆ Easy cultivation and crop management.
- ◆ High seed multiplication ratio of more than 1:80.
- ◆ Drought tolerance and ability to revive rapidly after prolonged period of drought.
- ◆ Good quality oil with high poly-unsaturated fatty acids and non-cholesterol properties.

Sunflower seeds produce high quality cooking oil. Sunflower seed contains 45-50% oil and the oilcake contains 40-44% protein. Sunflower oil has around 64% linoleic acid, which is good for health. Due to its non-cholesterol properties, this oil is ideal for consumption by heart patients. The trend in consumption of sunflower oil is increasing every year. During 1998/99, sunflower seeds worth Rs830000 and oil worth Rs88100000 were imported, while in 2001/2002, sunflower seeds worth Rs1894 and oil worth Rs112644292 were imported from overseas countries.

RESEARCH EFFORTS

National Oilseed Research Program (NORP) has been conducting research on various aspects of sunflower cultivation. In addition source seed is being produced and distributed annually.

SN	Name of research activity	Major achievements	Year
1	Performance of hybrid sunflower and varieties	Hybrids gave 72% higher seed yield than composite varieties in spring season. Sunflower hybrids PAC-36, PAC-302 and NFSH produced higher seed yields around 2000 kg/ha.	1997-98, 1998-99, 1999-00
2	Inter-cropping of sunflower with maize, groundnut and sesame	Sunflower + groundnut (1:3 row proportion) recorded highest net return of Rs23219/ha.	1998 and 1999
3	Integrated management of Alternaria blight in sunflower	Effect of spacing and cultural practices on disease development was evaluated. Higher disease was observed in closer spacing 45- x 20-30-cm. Effect of fungicide spray was evident on disease development.	2001/02
4	Preliminary study of insect pests of sunflower and yield loss	Head borer, Spodoptera, hairy caterpillar, jassids, semiloopers, grass hoppers, termites, bugs, cut worms, field crickets and aphids were found causing damage to sunflower. Of them head borer, hairy caterpillars and sucking bugs were found most common and damaging. Due to borer attack nearly 20% damage was recorded.	1999/2000 & 2000/01
5	Varietal difference in response to fungicide use in sunflower against foliar blight	During rainy season disease development was very fast and severe. Varietal difference and application of fungicide did not work.	1999/2000 & 2000/01
6	Dates of seeding trial on sunflower	Sunflower is not suitable for growing during rainy season. Spring season was found ideal for growing sunflower. Fourth week of Magh (February 1 st week) was found optimum date for planting sunflower.	1997/98 & 1998/99
7	Inter-cropping of wheat with sunflower	Wheat and sunflower planted @ 4:1 and 9:1 row ratio has been found ideal inter crop combination and gave wheat equivalent yield of 2769 % & 2720 kg/ha	2002/2003

DEVELOPMENT EFFORTS

Golchha organization

Cultivation of sunflower was initiated by Golchha organization in Morang and Sunsari districts of eastern region. Farmers were supplied with improved seeds and necessary inputs by the organization and technical assistance was provided. After the harvest of the crop, the produce was purchased by the organization.

Agro-enterprises center

The center started popularization of sunflower cultivation in Kailali and Kanchanpur districts of far-western region around 1996. Hybrid sunflowers along with inputs and technical support were provided to farmers. National Oilseed Research Program collaborated in the program during 2000/2001. Farmers showed encouraging response.

Irrigation projects

The Ground Water Irrigation Projects in Bhairahawa, Bara and Jhapa are encouraging farmers to cultivate sunflower during winter/spring seasons in their command areas. Bhairahawa Lumbini ground water project has put more emphasis on sunflower cultivation in Rupandehi district.

National oilseed research program

National Oilseed Research Program is carrying out research activities in various aspects of sunflower production. Seed is produced and distributed to farmers and various agencies. Technical advice is given to farmers and agencies.

OPPORTUNITIES

Sunflower can be grown in any season of the year due its photo-insensitiveness. Sunflower can fit into different cropping systems after the harvest of paddy, potato, rapeseed-mustard and wheat in terai of Nepal. The

productivity of sunflower is higher than major oilseeds like rapeseed-mustard. The area under irrigation is increasing and during winter and spring seasons some lands are left fallow. Sunflower can be grown successfully in such land.

Increasing demand

Consumption of sunflower oil is increasing in urban areas. As a result the demand for sunflower oil is increasing every year. In four years period (1998/99-2001/2002) the import of sunflower oil increased by 28% in the country.

Increasing irrigation facilities

Due to increase in irrigation facilities the area under sunflower is increasing. Irrigation projects are giving emphasis on cultivation of sunflower in their command areas for crop intensification program. Irrigation projects are trying to increase cropping intensities in the command areas by introducing sunflower during winter and spring seasons.

Multi-season crop

Sunflower is a photo-insensitive crop and can be grown round the year under terai conditions. However, the results of the experiments conducted in NORP Nawalpur have shown that winter and spring seasons are best for sunflower cultivation.

Fitting into inter cropping system

Sunflower can be inter-cropped with number of crops namely maize, sugarcane, groundnut and wheat. Sugarcane inter cropped with sunflower is gaining popularity in Sarlahi district. Inter cropping of wheat and sunflower (4:1 or 9:1 row) has been found more profitable than sole wheat crop.

Vegetable oil industries

There are 16 large-scale vegetable oil/ghee industries operating in the country. The capacity of these industries is to produce 800000 tons per year. These industries are running at 40% of their capacities and require huge amount of raw materials and the requirement is met by import of crude oil from the overseas countries. This indicates a huge domestic market of oilseeds.

CONSTRAINTS

Crop adoption constraints

The very advantages associated with sunflower have in fact worked against the crop leading to poor productivity levels. The crop has been taken to marginal and sub-marginal lands of all types where it is not possible to provide favorable environment for high productivity. Likewise, because of photo-insensitivity of the crop, we find the planting of the crop by farmers at all times of the years in some areas, which again is not ideal. Despite photo-insensitivity of the crop, there are certain limits within which the crop needs to be planted for high yields. The planting time has to be adjusted in such a way during rainy season that flowering period does not coincide with continuous drizzling and cloudy weather that cause pollen indehiscence, poor seed set and low yields.

Planting materials constraints

Use of quality seeds of improved varieties/hybrids is an important input for high productivity. Presently, nearly 70-80% of the crop area is covered by hybrids. Hybrid sunflower seeds available are produced by private companies of India, where it is not possible to check the quality. Many unscrupulous producers sell seeds of poor quality to unsuspecting farmers leading to poor crop and yield. Moreover, the hybrids are very expensive and farmers need to replace each year. This discourages farmers from cultivating sunflower as and when they need. Likewise, with varieties, farmers tend to continuously use their own seeds leading to deterioration in quality of seed. Production and distribution of quality seeds is one of the constraints in increasing area under sunflower. The seeds of sunflower varieties produced at NORP and others could hardly meet the 10-20% of the demand.

Crop husbandry constraints

This is one of the major production constraints especially under rainfed conditions. It is always a common sight to find gap or crowded plant stands of sunflower on farmers' fields. Due to poor quality seeds or insufficient moisture, gaps are observed which lead to sub-optimal yield levels. If the germination is normal, with recommended seed rate one can expect at least 50 percent more plants than the recommended plant stand. These

excess plants need to be thinned in time which normally not done by many farmers leading to low yields. Likewise, many times proper spacing, timely weed control is not followed which again reduce the yield levels.

Nutrition constraints

Sunflower is an exhaustive crop. The average nutrient removal by the crop to produce 1-ton seed yield of sunflower is 63.3 kg N, 19.1 kg P₂O₅, 122.6 kg K₂O, 11.7 kg S, 68.3 kg Ca, 26.7 kg Mg, 47 g Zn and 1075g Fe (Hegde, 1998). However, in most cases, there is a large gap between nutrients applied and nutrients removed leading to depletion of soil nutrients and unsustainable production. This seems to be one of the probable reasons for declining trend in yield of sunflower crop reported/observed in many sunflower-growing areas.

Plant protection constraints

Sunflower is affected by a large number of insect pests and diseases although only a few of them are economically important. Capitulum borer, Bihar hairy caterpillar, tobacco caterpillar, green semilooper, cabbage semilooper, leaf hoppers, aphids, and cut worms are important insect pests. Losses up to 30% from seedling pests, 46% from sucking pests and 50% from inflorescence pests have been reported. Appropriate management practices need to be standardized and practiced to manage different insect pests.

Among diseases like sclerotium rot, alternaria blight, leaf spots and rhizopus head rot are very important. Sunflower is prone to severe damages by diseases especially during rainy season when there is high rainfall and high humidity, and any effort to stabilize crop productivity cannot be successful until suitable disease management practices are followed.

In addition to the above, parrots, doves, crows, rats etc. also cause severe damage on sunflower crop leading to poor yields. When the crop is taken on large scale, the severity of these problems will reduce although in off-season crop production, special efforts need to be made to protect the crops.

Marketing constraints

Due to lack of oil extraction facility from sunflower seed, traders in Nepal are not purchasing the produce. The farmers are not able to sell their surplus produce. Marketing problem is one of the serious bottlenecks in increasing the sunflower area.

Oil extraction constraints

Based on available information, there are no small to medium scale sunflower oil processing industry in Nepal. The farmers producing sunflower have no options than to extract oil in local expellers. The oil recovery in such mills is less and lacks the desired quality. The oil extracted in local mills has short shelf life.

CONCLUSION

The area and productivity of oilseeds in the country is almost stagnant or rather low which can be raised through increasing the cultivation of sunflower. During the winter and spring seasons most of the land remains fallow and in such areas with minimum irrigation facility sunflower could be taken successfully. In order to attract the farmers in sunflower cultivation the small-scale oil mills should be available and the existing oil industries should utilize the domestic raw materials. The industries should also encourage the farmers to cultivate sunflower.

REFERENCES

- Hegde DM. 1998. Integrated nutrient management for production sustainability of oilseeds: A review. *J. Oilseed Research* 15(1):1-17.
NORP. 2001. Annual report 2000/2001. National Oilseed Research Program, Nawalpur, Sarlahi.

Rice Varietal Evaluation and Scaling-up at Chapagaun, Lalitpur

Ramji Khadka, Madhav Joshi, Thaneswar P Pokhrel and Yuga N Ghimire

Outreach Research Division, NARC, Khumaltar

ABSTRACT

Taichung 176 is the most popular rice variety in Kathmandu valley. But it is highly susceptible to blast disease (*Pyricularia oryzae*) that is consistently reducing its yield potential in recent years. Farmers are interested to grow newer, blast tolerant and better yielding rice varieties. Therefore, a set of rice variety evaluation was done at Chapagaun village in the southern side of Kathmandu valley over years, 2001 and 2002, with the objectives of identifying high yielding, location specific and farmers' preferred Taichung 176 typed (*Japonica* type) of improved rice variety for Kathmandu valley and scale-up the adoption process of the preferred ones. For this, six promising lines of normal season rice NR 10375-14, NR 10375-20, Taichung 176, NR 10353-8, NR 10291 (Manjusree), NR 10342-29 and widely adopted farmers cultivar (Taichung 176) were tested. They were tested in 4-5 farms in farmers' management conditions. Among the tested lines, Manjusree produced the highest grain yield of 7.6 t/ha followed by NR 10342-29 (6.6 t/ha) which is 43% and 18% higher grain yield respectively, compared to the existing variety Taichung 176 and Chinung 242 widely adopted by the farmers. In spite of their lower yields, farmers preferred Khumal 11 (NR 10375-14-2-1) and NR 10375-20 because of their quality cooked rice as per the taste liked by the farmers, good for beaten rice preparation, desirable table rice (Bhat) quality, durable while eating, tolerant to blast along with high market price (20%). Also, five sets were distributed for farmers' acceptance test (FAT) to scaling-up as well as to simultaneously multiply for source seeds. The responses from the farmers were highly encouraging which were assessed in terms of saving its source seed and also, distributing to neighbor farmers to popularize it.

Key words: Evaluation, rice, scaling up

INTRODUCTION

General information

Over all, rice (*Oryza sativa* L) is a staple food of Nepalese people. It occupies first position in terms of coverage (1.52 million ha) as well in production (4.17 million ton) with the national average yield of 2.74 Mt /ha against 4.68 t/ha of Lalitpur. The productivity of rice is gradually increasing (Figure 1) in recent year (MOAC, 2001/2002). It is grown in a wide range of agro-climatic situation ranging from the Tarai (60 masl) to high hill of Jumla (2300 masl).

In general, rice is the second important cereal after maize in the mid-hills of Nepal, which is not representative in case of Lalitpur of Kathmandu valley (Shrestha et al 2001), although, it lies in the mid hill. Almost all the rice area of Kathmandu valley is covered by improved varieties. However, the quality of the seeds used by the farmers is not reliable because farmers are used to recycle the same source seeds for more than 10 years. Normally farmers do not purchase improved seeds of rice as far as manageable from their own source seeds.

Farmers have been continuously growing the *Japonica* type like Taichung 176 and Chinung 242 after their released in late 60s. During the early stage of released, they were less affected from the blast disease. The severity of "neck blast" disease appeared in Taichung 176 and Chinung 242 during early 90s. It causes normal yield loss from 5- 25% and in some cases the farmers reported yield losses up to 75%.

Rice area in Kathmandu valley is gradually decreasing because of the fact that some cultivated lands are diverted to use the soils for bricks, buildings by the bricks factories but it does not reflect in the Agricultural Statistics, MOAC, 1997 to 2002.

The productivity of rice of in Kathmandu valley stagnated or increased (Figure 1) which did not agree the farmers of Chapagaun, Lalitpur. They have stated that the yield of rice is decreasing over the year (less than 5t/ha).

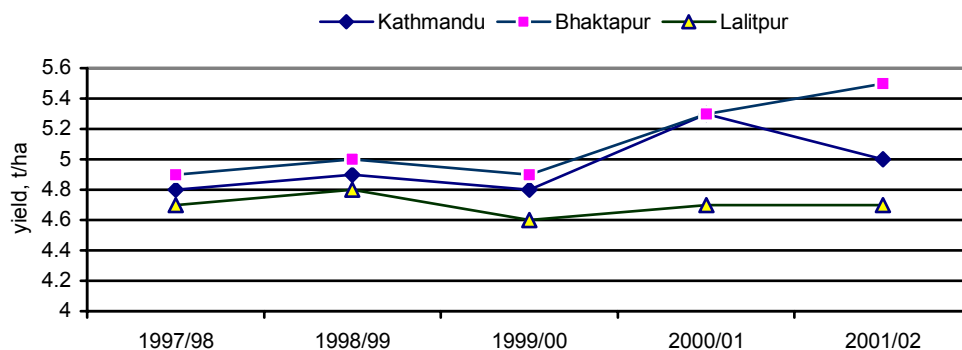


Figure 1. Ricey yield trend in Kathmandu valley over years 1997-2002.

Source: Agricultural Statistics Division, MOAC, 1997-2002.

Crops and cropping patterns

Rice, maize, wheat, mustard, finger millet and soybean are the major crops of Chapagaun. About 80% of the farm families grow improved coarse rice varieties like Taichung 176, Chinung 242 and rest of other fine type (Khumal 4). These varieties are grown in different types of cropping patterns. The major cropping patterns adopted in different land types are performed in table 1.

Table 1. Cropping patterns, coverage (%) and intensity

SN	Cropping pattern	% cover	Cropping intensity
1	Lowlands		206
	Rice- wheat- fallow	45	
	Rice- wheat + mustard- fallow	25	
	Rice- vegetable- vegetable	2	
	Rice- vegetable- fallow	10	
	Rice- potato- fallow	3	
	Rice- fallow- fallow	15	
2	Uplands		225
	Maize- mustard- fallow	50	
	Maize + soybean-mustard- fallow	25	
	Maize / finger millet- fallow	25	

Rice varieties with their quality traits

The dominant rice varieties are being grown are Taichung 176, Chinung 242, Khumal 4, Himali (Chhote masino) and Pokhareli among which Taichung 176 covers more than two-third (70%) of the total rice area of the valley and the rest of other varieties are Khumal 4 and Pokhareli. The popularity of the Taichung 176 is there for preparing several types of special breads (Selroti, Chatamari and Yamari) and other quality food items like beaten rice, local beverage, cooking rice and also it fetches good market price whereas Khumal 4 is a fine rice variety with good taste, suitable for growing in medium soil fertility conditions and is liked by many people. The coarse and sticky type of rice like Khumal 11 is mostly preferred by traditionally tribal group of people called as Matawalis ethnic group for home consumption whereas it is equally preferred by all the people for beaten rice item.

Land types and holding

Land types and the size of holdings are variable according to the topography and locations. There were four types of lands such as khet (46%), bari (50%), pakho (1%) and forest (3%). Khet lands were located in the plain low land areas. Year round irrigation was available only in 50% of the khet lands and rest of the lands are partially irrigated and rain fed.

The average size of land holding was 0.287 ha / family of which 0.14 ha khet land and rest of other Bari lands (0.147 ha). Pakho and forestlands are negligible. About two-third of the farm family relies on cultivation of own lands whereas; the rest of other (35%) cultivated their own land together with leased lands taken from others.

Food situation and marketing

Farming is the main source of food supply. Rice is the principle food item of daily diet. About 80% of the people eat rice twice a day. Rests of other consume maize, wheat along with single diet of rice. Fifteen per cent of the households have surplus food from their production. So this group of people diverted maize and wheat to livestock feeds instead of human consumption. Sixty percent of the household had sufficient food for less than 9 months; the food for deficit period was managed by procuring from the local market. At present context, people did not prefer to buy food grains in the village because of higher price. More than 85% of the farmers sell their locally grown paddy like Taichung 176 at higher price and purchase rice in lower rate from the local market for their home consumption. The price of rice and paddy are almost similar (Rs 20-25/kg) because the rice is imported from Tarai.

Inputs use

In general, farmers were using locally available inputs like seeds, DAP, compost/FYM, poultry litters @ of 52, 30, 10500 and 1500 kg/ha respectively along with urea 180 kg/ha. Nobody was using the pesticides except in epidemic conditions of the disease and insect. Primary sources of rice seeds were farmers themselves. However, exchange of seeds of the same variety also was happening within the community.

Production constraints of rice in Kathmandu valley

The production problems and constraints of rice were reported as follows:

- Neck blast disease was severe in widely adopted Taichung 176 and Chinung 242 rice variety.
- Farmers expressed that the rice yield was low as compared to ten years back in spite of manure and fertilizer application to the same level.
- In Khumal 4 rice variety, foot-rot disease was the common problem in Kathmandu valley. Lodging occurred in high fertile conditions.
- Unavailability of improved seeds of major cereals like rice, wheat and maize.

Objectives

- To identify the high yielding, location specific farmers preferred Taichung 176 type of improved rice variety for Kathmandu valley.
- To scale-up the promising technology identified from the varietal evaluation in Chapagaun of Lalitpur.

MATERIALS AND METHODS

Six promising lines of normal hill rice lines namely NR 10375-14-2-1, NR 10375-20, Taichung 176, NR 10353-8, NR 10291/ NR 10342-29 and Farmers variety (Taichung 176) were planted in the farmers managed conditions in Chapagaun of Lalitpur under rice- wheat systems. They were planted in 4-5 farm locations as replication with RCBD design. The plot size was 20 square meter / variety. The inputs like manure and fertilizers were applied as per farmers practice. Almost all the farmers had applied urea @ of 4-5 kg/ropani during transplanting and 2-3 kg / ropani as a top dress after one month of transplanting. The seed rate used was 50 kg/ha. Nursery bed was raised in dry conditions and one month old seedlings were transplanted at a distance of 20 x 12 cm apart, 2-3 seedling /hill. Irrigation was given continue from transplanting to late milking stages. Single hand weeding was done after one and a half month of transplanting.

Five sets for farmers acceptance test (FATs) of Khumal 11 (NR10375-14) were distributed, each packet contained 2.5 kg seeds provided to the co-operator farmers of Chapagaun during 2001/02. Approximately one ropani of land was the size of the FAT area specified. Inputs were applied as the normal farmers' practice (DAP

30, Urea 180, Poultry litters 1500 and FYM 10500 kg/ha). All the fertilizer inputs were applied during transplanting except FYM and poultry litters, which were given during winter season. The rest of other practices followed were the same as the farmers were doing normally. Structured questionnaire survey of 35 households was conducted to collect the farmers' feedback collection and adoption analysis of the technologies verified at the village. Simple mathematical tools such as averaging and frequency data were used for analysis.

RESULTS AND DISCUSSION

Grain yields of rice varieties over years are presented in Table 2. Among these, six promising lines of normal season rice Manjusree produced the highest grain yield of 7.62 t/ha followed by Khumal 11 (NR 10375-14-2-1) and NR 10375-20 during 2000/01 (Table 3) whereas NR 10342-29 produced the highest grain yield followed by NR 10353-8 and NR 10375-14-2-1 during the summer of 2001/02 (Table 4).

The number of tillers/square meter and panicle length are directly related to the grain yield. About 400- 480 effective tiller/sq. meter and 20 – 25 cm long panicle produced more than 6 t / ha grain yield and vice versa. Statistical analysis of grain yield revealed that these varieties were highly significant at 1 per cent of significance in both the years. Manjusree and Khumal 11 top yielder and it was at par in terms of grain yield during 2000/01 whereas NR10342-29 out yielded other cultivars in 2001/02.

Despite low yields (7.16 and 5.81 t/ha) farmers have preferred Khumal 11 (NR 10375-14-2-1) because its perfect fitting in the rice- wheat systems, high market price, matching with the food habit of the farmers, good for beaten rice, desirable table rice (Bhat) quality, durable Bhat after eating and tolerance to blast. However, the gloomy grain was not desirable and it was affecting market price of the paddy to some extent.

Table 2. Grain yields of different rice varieties over years, 2000/01 to 2001/ 02

SN	Variety	Yield, t/ha 2057/58	Yield, t/ha 2058/59	Mean yield, t/ha
1	NR 10375-14-2-1	7.16a	5.81b	6.485
2	NR 10375-20	6.26b	5.69b	5.975
3	Taichung 176	5.32c	5.62b	5.470
4	NR 10353-8	6.24b	5.88b	6.060
5	NR 10291/ NR 10342	7.62a	6.63a	7.120
6	F Var (Taichung 176)	6.02b	5.3b	5.660
	CV, %	7.51	6.45	
	F test	**	**	

Table 3. Agronomical performance of rice varietal evaluation at Chapagaun, Lalitpur, summer, 2000/01

Trait	NR1037 5-14	NR1037 5-20	Taich17 6	NR1035 3	NR10291	Local variety
No. of hill/m ²	43	39	41	40	39	39
No. of panicle/hill	10	9	10	12	12	10
No. of effective tiller/m ²	431	360	418	475	478	380
Plant height, cm	87	88.5	100	88	81	106
Panicle length, cm	19	21	21	26	25	20
Days to maturity	154	154	154	160	154	154
Grain yield, t/ha (at 14% m)	7.2	6.2	5.3	6.2	7.6	6.0
Straw yield, t/ha (sun-dried)	8.2	8.2	7.0	8.4	8.6	8.5

Scale up of Khumal 11 variety of rice at Chapagaun, Lalitpur

Besides varietal evaluation, the co-operator farmers of Chapagaun during 2001/02 grew five FATs of Khumal 11. Highly encouraging result were observed in terms of grain yields as well as socioeconomic and cultural

values. The grain yield ranged from 5.5–7.5 t/ ha with average yield being 6.62 t/ ha compared to Taichung 176 (5.25 t/ha) at the same level of management conditions (Table 5).

Table 4. Agronomical performance of rice varietal evaluation at Chapagaun, Lalitpur during summer, 2001/02.

Trait	NR103 75-14	NR1037 5-20	Taich176	NR1035 3	NR1034 2-29	Local variety
No. of hill/m ²	41	40	40	41	40	39
No. of panicle/hill	8	8	8	8	7	9
No. of effective tiller/m ²	318	309	322	333	302	342
Plant height, cm	68	68	68	67	69	70
Panicle length, cm	19	20	19	20	20	18
Days to maturity	156	156	156	163	156	156
Grain yield, t/ha (at 14% m)	5.8	5.7	5.6	5.9	6.6	5.3
Straw yield, t/ha (sun-dried)	8.1	8.0	8.2	8.5	8.7	7.8

Table 5. Yield performance of Khumal 11 in Chapagaun, Lalitpur over years, 2002-03 and 2003-04

SN	Description	2002/03	2003/04	Estimated expansion for the next season
1.	Grain yield, t/ha	6.62	7.00	7
2.	Yield increase, %	25	25	25

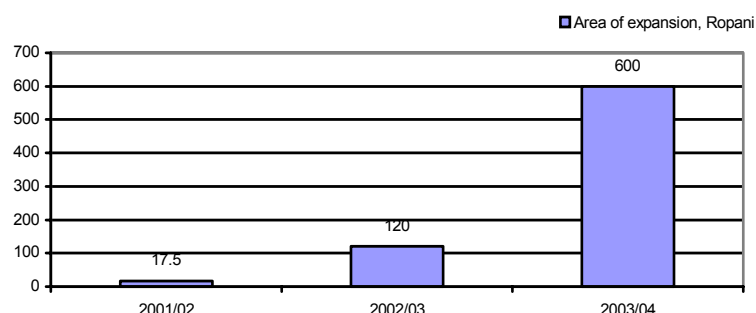


Figure 2. Rate of adoption of Khumal 11.

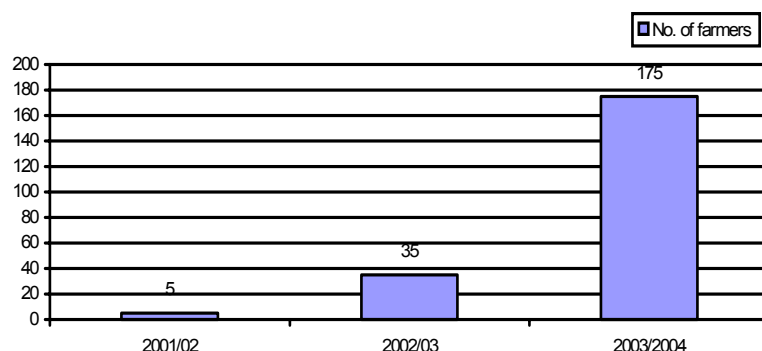


Figure 3. Rate of adoption of Khumal 11.

The co-operator farmers expressed that the variety will be grown continuously thereby multiplying seeds at the site for its fast dissemination because of desirable characters like high grain yield (26%), good quality rice for different food items and better market price (>20%). In the year 2003/04, 35 farmers were growing in 120 ropani of lands, visualizing the present situation, it is estimated that in the next season it could cover at least three times of the present area. The rate of scaling-up or adoption appeared to in the ratio of 1:6. This would substantially cover the area by Khumal 11 because of the availability of its seeds at local level in time. Such a community level seeds production would further trigger the dissemination rate among the farmers at larger scale.

CONCLUSION

Six promising lines including Taichung 176, as a standard check and with an additional locally grown farmers variety (Taichung 176), as a local check were grown in the experiment for two successive year, 2000/01 and 2001/02. Among these, Manjusree (NR10291) and NR 10342-29 produced the highest grain and straw yield 7.62 t/ha and 6.64 t/ha, 8.6 t/ha and 8.7 t/ha respectively over years (2000/01 and 2001/02). In spite of high grain and straw yields, lodging resistance, farmers did not like because of socioeconomic and cultural requirement and reasons of the community.

Despite of low grains and straw yields farmers preferred Khumal 11 (NR10375-14-2-1) because of short and bold grain size, sticky rice quality good for beaten rice, rice pudding, local breads (Selroti and chatamari), local beverage (chhang) and high market price (20%) than Khumal 4. In the Newar community, farming group preferred sticky rice to its capacity to provide energy for longer time " Adilohune " compared to any other fine rice. Apart from it, rice straw remained green till maturity and very much liked by cattle and buffaloes as the fresh fodder. Therefore, Khumal 11 happened to be a good substitute to Taichung 176. All the traits of this variety were similar to Taichung 176 along with neck blast tolerant character that was considered as the top priority by the farmers. Results of varietal evaluation and FATS of Khumal 11 for its quality parameters were highly appreciated by the farmers. The mean average yield of Khumal 11 in varietal evaluation was 7.12 t/ha whereas in FATS it was 6.62 t/ha which was 29% and 26% higher grain yield than that of the farmers own local variety (5.52 t/ha) with the same levels of management.

During interactions with the farmers at standing crop in the field as well as with the present growers (thirty five farmers including ten women farmers), it was found that with Khumal 11 was highly popular from different angles of evaluation both biologically productive; and socio-economically and culturally liked by the people.

Hence, the seed demand of this variety could be met by multiplying seeds at the local level. There was a tremendous scope of its dissemination. It could be popularized to replace the position of the Taichung 176. Therefore, rapid scale-up of this Khumal 11 in community level seed multiplication appears to be very much effective avenue in terms of source seeds production and distribution among farmers in the vicinity. High local demand of quality seeds of Khumal 11 (NR 10375-14-2-1) can be managed thereby multiplying, it at local levels at large. Seeds exchange/ barter among the farmers within the community would help promote for rapid spread of the variety within a short span of the time. Therefore, the seed should be multiply locally as a front line demonstration in close collaboration with the seed grower groups of Agricultural Development Offices of the Kathmandu valley. Such a system of varietal evaluation program should be conducted in farmers' field with the full participation of the farmers. It would help promote ownership feelings and enhance self-confidence of the farmers by initiating "learning by doing " and by making an easy access for its dissemination among other farmers as well. Besides biological, scientists must be aware about the socioeconomic and cultural aspect of the society while promoting the technology. Socioeconomic and cultural role is equally important in technology adoption and dissemination. For example- Taichung 176 released in 1968, for the mid-hills of Nepal is still popular in Kathmandu valley and its neighboring district. But it did not meet the requirements of the society of other mid-hill districts. For a longer sustainability of the community level seed production and marketing systems, a cooperative group of farmers will have to be formed where like minded farmers can join it and scale-up to it further into a commercial seed company.

REFERENCES

- NARC. 1997. *25 years of rice research in Nepal (1972-1997)*. National Rice Research Programme, NARC, Kathmandu, Nepal.
- NRRP. 2002. *Annual report, 2001/2002*. National Rice Research Program, Hardinath, Dhanusha.
- Shrestha B et al. 2001. *Report on baseline survey of outreach site, Bageshwari, Bhaktapur and Chapagaun, Lalitpur*. ORD, NARC.

Rice-Wheat System in Kathmandu Valley: A Socioeconomic Analysis

YN Ghimire, TP Pokhrel, HK Shrestha, NS Thakur, R Khadka, M Joshi, B Shrestha, N Pandey, SM Amatya and S Gautam

Outreach Research Division, NARC, Khumaltar

ABSTRACT

A socioeconomic study was carried out on wheat cultivation in Kathmandu valley with the objectives of analyzing the economic return, farmers' criteria and constraints for adopting the improved technologies of wheat cultivation and utilization of wheat grain in the socioeconomic setup of the valley farmers. Participatory Rapid Appraisal method was employed to select representative villages and to collect general information on the selected villages. The selected villages were Chitpol of Bhaktapur, Nayapati of Kathmandu and Thecho of Lalitpur district. Questionnaire survey was used to assess the farm level detail information of 148 households. The study found B/C ratios of wheat cultivation to be 1.07, 0.94 and 1.09 respectively in the villages. Unavailability of reliable seed of recently released varieties is one of the major constraints in technology adoption. In addition, small size of land holding and small volume of business are discouraging farmers to adopt improved technology. The situation is aggravated by the lack of know-how on available technology options. Among wheat traits, high yield and good taste were some of the important preferences given by the farmers. Wheat produces is mainly used for home consumption and seed, market. Major share of utilization of wheat grain is for the home consumption. About 30% of home consumption goes to feed for their animals. Better access of farmers to available technologies, development of seed supplies mechanism and diversification and efficiency in wheat-food preparation approaches may improve nutrients intake and promote wheat cultivation in the valley.

Key words: Kathmandu, rice-wheat system, socioeconomic analysis

INTRODUCTION

Rice and wheat are the main crops and constitute Rice-Wheat cropping system, which is dominant over the other patterns in Kathmandu valley. This system has been in practice since mid-sixties in a small scale in the valley. Many wheat varieties developed at different periods (1965-2000) were given to the farmers. Their adoption status and farmers' feedback were considered important for the development of more appropriate pre-harvest and post-harvest wheat technologies for the valley and proper management of inputs supply mechanism. This study was conducted for socioeconomic analysis of wheat cultivation in the area incorporating various issues regarding economic efficiency, mode of wheat consumption, level of technology use, constraints for adopting improved technologies of wheat cultivation and preferences of the farmers for different wheat traits.

The study analyzed farm household characteristics (family size, ethnicity, land tenancy and food balance sheet), technology use status (varietal, farm mechanization, soil fortification, pest control), economic efficiency (net return to land and management, labor productivity and employment generation), and utilization of wheat grain, constraints and preferences for farmers. This study was carried out in three Village Development Committees of the valley: Chitpol (Bhaktapur), Nayapati (Kathmandu) and Thecho (Lalitpur) from November 2002 to March 2003.

The general objective of the study was to determine the contribution of wheat cultivation in socioeconomic well being of the wheat farmers in the valley. The specific objectives, therefore, are included to assess the level of technology use in wheat cultivation in Kathmandu valley, to study the production and utilization of wheat grain in the valley, to analyze income, labor productivity and employment generation in wheat cultivation and to identify the constraints and preferences of farmers in wheat cultivation in the valley.

METHODOLOGY

One representative Village Development Committee (VDC) from each of the three districts in the valley were selected by a multidisciplinary team of agronomist, socioeconomist, horticulturist, plant breeders and valley District Agricultural Development Officers. The villages selected were: Chitpol of Bhaktapur, Nayapati of Kathmandu and Thecho of Lalitpur. At the next stage, PRA consisting of local leaders, leader farmers, local NGOs, local cooperatives, extension personnel and multidisciplinary team of scientists were conducted in each selected VDC to identify one study village in each of the selected VDC. PRA selected Ward No. 1 and 3 of Chitpol hereafter called Chitpol, Ward No. 6 of Nayapati hereafter called Nayapati, and Ward No. 1, 2, 8 of Thecho hereafter called Thecho as the study villages.

The technique of stratified random sampling was employed in the selection of representative sample from the population. Firstly, the entire household in each village was listed along with their total land holding including upland (Bari) as well as lowland (Khet). Then, the households were categorized into two strata: Strata I - households with land holding above average and Strata II - households with land holding equal to or below average (Table 1).

Table 1. Household categories based on land holding (households, n)

Village	Average land holding, ha	Number of farm households in Strata I	Number of farm households in Strata II	Total farm Households
Nayapati	0.40	46	54	100
Thecho	0.35	437	713	1150
Chitpol	0.30	28	87	115

Sample size

Based on the proportion, farm households were selected randomly from each stratum so as to make a total sample size of 50 from each village. The results of the sampling distribution following the above procedure are given in Table 2.

Table 2. Sampling distribution (households, n)

Village	Strata I	Strata II	Total
Nayapati	22	28	50
Thecho	23	27	50
Chitpol	20	30	50
Total	65	85	150

Tools for data collection

Necessary information for the study was collected with the combination of two techniques. Overall information of agricultural scenario of the village was assessed in a participatory approach using PRA with the involvement of socioeconomists, agronomists, plant breeders, farmers, village level NGOs, and community based organizations. However, household level detail information was collected using questionnaire survey of sample farm households.

Table 3. Stratification for the analysis

District	Villages	Status	Number of households
Bhaktapur	Chitpol	Below average	38
		Above average	11
		All	49
Kathmandu	Nayapati	Below average	26
		Above average	24
		All	50
Lalitpur	Thecho	Below average	30
		Above average	19
		All	49
Overall		Below average	94
		Above average	54
		All	148

Analytical approach

Simple mathematical tools such as simple average and frequency distribution were used in the analysis to attain the objectives of the study. For uniformity in the analysis of all the villages, the overall mean operational land holding of sample households was used as the basis for stratifying the sample into two broad categories – below average (≤ 0.35 ha) and above average (>0.35 ha). The number of households in each of these groups is given in the Table 3.

Since the number of non-responses was two, the analysis covered only 148 households instead of 150 decided in sampling plan.

FINDINGS

Findings regarding farm household characteristics, level of technology use in wheat cultivation, production and utilization of wheat grains, constraints and preferences have been discussed in this section.

Farm household characteristics of wheat growers in the valley

Family size, ethnicity, land tenure pattern, fragmentation of operational holdings, cropping pattern, cropping intensity and food sufficiency from farmers perspectives have been given in this section.

Family size: Family size for different study villages has been shown in the figure1. Land holding and family size when compared in the study area showed positive relationships, that is, family size is greater in above average group than in below average group.

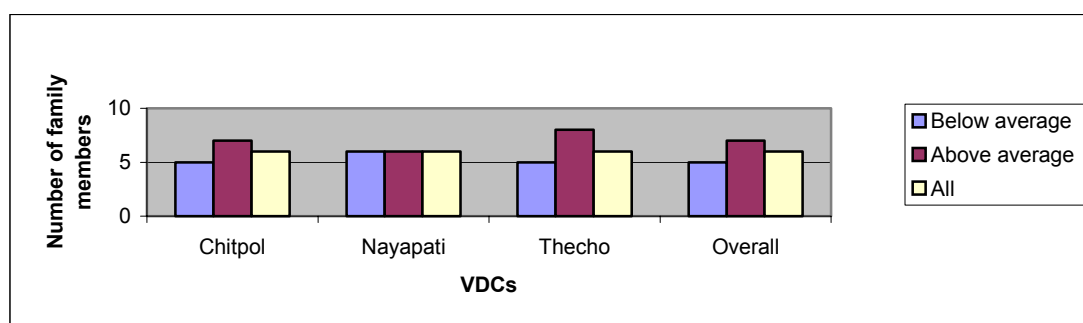


Figure 1. Family size in the sample.

Ethnicity: Results of the ethnicity analysis of the sample are shown in Figure 2-5.

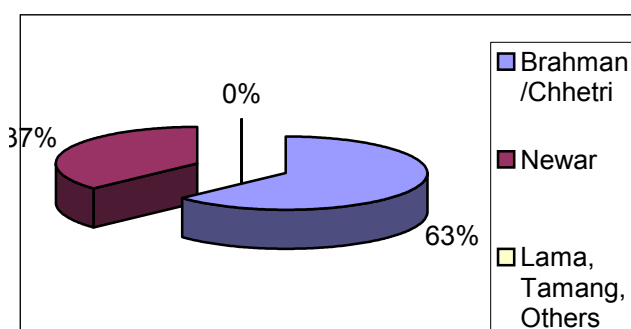


Figure 2. Ethnic composition in Chitpol.

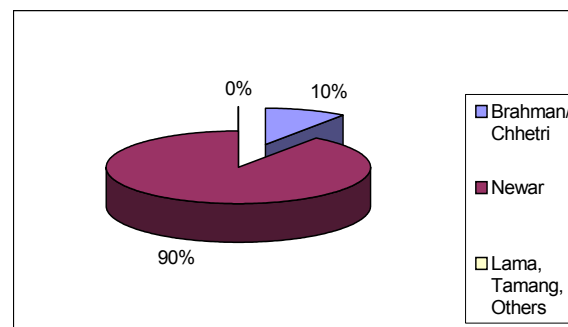


Figure 3. Ethnic composition in Thecho.

Ethnicity composition in the study area shows that, on the whole, Newars constitute 67 % of the population followed by Brahmin/Chhetri with 26%. Lama and others make up the rest of the population. At Chitpol, Brahmin and Chhetri with 63% outnumber Newars (37%). However, Newar is the main caste at Nayapati and Thecho.

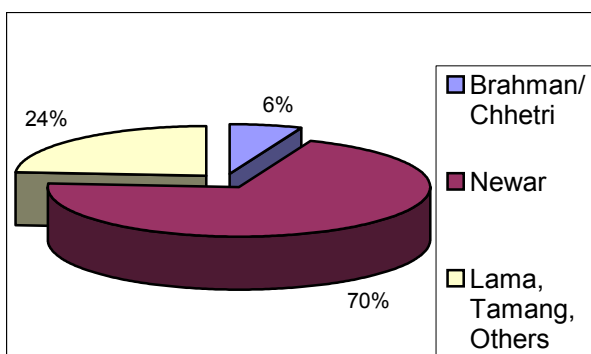


Figure 4. Ethnic composition in Nayapati.

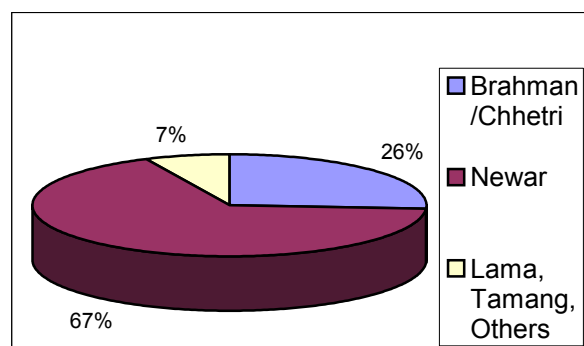


Figure 5. Overall Ethnic composition.

Land tenure pattern: The average Khet is 0.25 ha. The practice of leasing-in and leasing-out is almost absent. The farmers of Nayapati VDC appear to have bigger land holding size than the other two (Table 4).

Table 4. Tenure pattern of Khet land, ha

Village	Status	Self cultivated	Leased out	Leased in	Operated	Land ownership
Chitpol	Below average	0.13	0.06	0.06	0.15	0.13
	Above average	0.25	0	0.25	0.46	0.25
	All	0.16	0.06	0.13	0.22	0.16
Nayapati	Below average	0.16	0	0.0	0.16	0.16
	Above average	0.57	0	0.20	0.61	0.57
	All	0.36	0	0.16	0.37	0.36
Thecho	Below average	0.16	0.17	0	0.16	0.17
	Above average	0.34	0	0.06	0.34	0.34
	All	0.23	0.17	0.06	0.23	0.24
Total	Below average	0.15	0.12	0.06	0.16	0.15
	Above average	0.42	0	0.20	0.48	0.42
	All	0.25	0.12	0.13	0.27	0.25

Fragmentation of operational holding: Degree of fragmentation operational land in Khet land is shown in Table 5. The degree is higher in below average group than in above average

Table 5. Degree of land fragmentation (number of parcels/ha)

Village	Status	Khet
Chitpol	Below average	20
	Above average	9
	All	17
Nayapati	Below average	17
	Above average	8
	All	13
Thecho	Below average	16
	Above average	11
	All	14
Overall	Below average	18
	Above average	10
	All	15

Cropping pattern: Rice-Wheat is the dominant pattern followed by Rice-Vegetable and Rice-Potato (Figure 6-8).

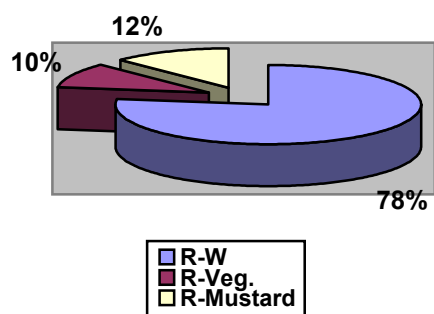


Figure 6. Cropping pattern in Khet in Thecho.

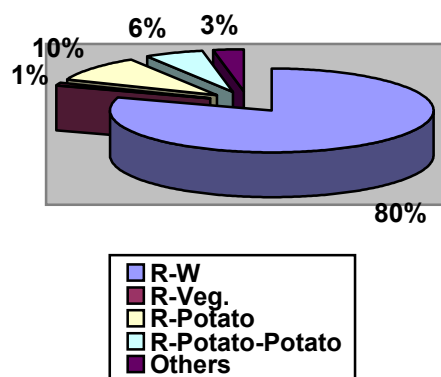


Figure 7. Cropping pattern in Khet in Nayapati.

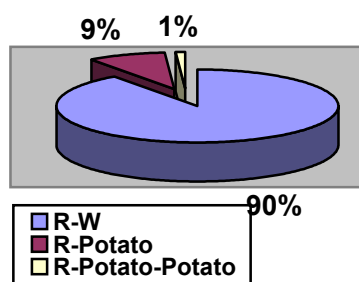


Figure 8. Cropping pattern in Khet in Chitpol

Cropping intensity: Cropping intensity is shown in Table 6. There were more than two crops in Khet land except in Thecho.

Table 6. Cropping Intensity in the study area, %

VDC	Khet	Bari	Total
Chitpol	217	144	194
Nayapati	220	125	173
Thecho	180	105	175
Average	212	135	190

Food sufficiency through farm production: The numbers of households with surplus food production are small in all the three villages. Over 60% of the household at Nayapati and Chitpol to as high as 91.7% at Thecho appear to meet their food requirements for 6 to 12 months. Almost 1/3rd of households at Chitpol and Nayapati are meeting their food need for less than 6 months only.

Table 7. Food sufficiency (households, n)

District	Village	Status	Up to 6 month	6-12 month	Surplus	Total
Bhaktapur	Chitpol	Below average	15	22	1	38
		Above average	1	8	2	11
		All	16	30	3	49
Kathmandu	Nayapati	Below average	12	14	-	26
		Above average	2	19	1	22
		All	14	33	1	48
Lalitpur	Thecho	Below average	4	25	-	29
		Above average	-	19	-	19
		All	4	44	-	48

Level of technology use in wheat cultivation

Status of adoption of different wheat varieties, farm mechanization, use of manures and fertilizers and plant protection are dealt in this sub-section.

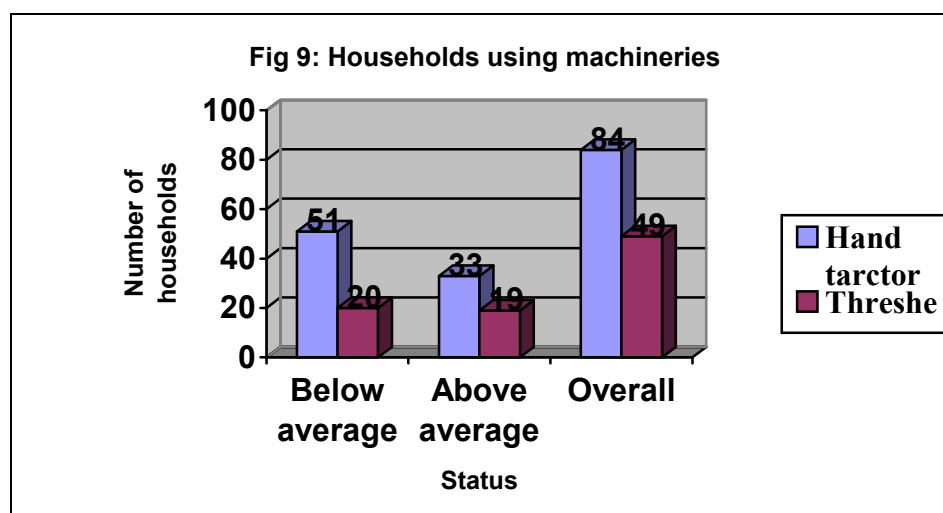
Adoption of different wheat varieties: Lerma 52, Lerma Rojo 64, RR 21, Annapurna 1 and NL 297 are the wheat varieties currently grown in those VDCs. Lerma 52 is successfully grown in slopping land terraces. RR 21 is the leading variety followed by LR 64, NL 297, Annapurna-1 and Lerma 52. The productivity ranges from 2.2 /ha of Lerma 52 to 3.8/ha of Annapurna 1. The most commonly grown varieties namely Lerma Rojo 64, RR 21, and NL 297 have 2.44 t/ha, 2.26t/ha and 2.81t/ha productivity respectively.

Table 8. Area and yield of wheat by variety (area in ha, yield in kg/ha)

Village	Status	LR 52		LR 64		RR 21		Annapurna 1		NL 297	
		Area	yield	Area	yield	Area	yield	Area	yield	Area	yield
Chitpol	Below average	0.10	3560	0.18	2977	0.23	2977	0.10	3850	0.13	3246
	Above average	0.25	4200	0.42	2833	0.10	2833	0.27	3629	0.12	2475
	All	0.17	4117	0.28	2850	0.20	2850	0.19	3589	0.13	3115
Nayapati	Below average	0.25	1400	0.16	2562	0.07	2562	0	-	0.10	3410
	Above average	0	-	0.39	2835	0.41	2835	0	-	0.42	2083
	All	0.25	1400	0.26	2692	0.37	2692	0	-	0.21	2471
Thecho	Below average	0.22	1272	0.14	1807	0.13	1807	0	-	0.06	4083
	Above average	0	-	0.18	2138	0.34	2138	0	-	0	-
	All	0.22	1272	0.15	2006	0.22	2006	0	-	0.06	4083
Overall	Below average	0.20	1575	0.15	2226	0.16	2226	0.10	3850	0.12	3208
	Above average	0.25	4200	0.27	2711	0.37	2711	0.27	3629	0.27	2170
	All	0.21	2200	0.20	2435	0.29	2435	0.18	3788	0.15	2806

The wheat production in the 3 VDC surveyed appears to be satisfactory. Wheat grain yield of 2.4 to 2.5 t/ha is above the national average productivity (1.8/ha).

Status of farm mechanization: Regarding agricultural machineries, they had all the praise for the Chinese tractor primarily used for land preparation hitherto done by the human labor. The status of machineries use in wheat cultivation is shown in Figure 9.



Farmers of Chitpol and Nayapati use hand tractors for land preparation whereas Thecho farmers solely depend up on manual land preparation. 56% of the households used thresher and 33% households use hand tractor in wheat cultivation. Wheat is broadcast both in tractor -prepared land and manually made ridge furrow system.

Use of manures and fertilizers: Urea and DAP are largely used as chemical fertilizers at Nayapati and Chitpol for the wheat crop. At Thecho farmers, however, apply only urea. The application of nitrogenous fertilizer in the form of urea is very high (141 kg/ha) at Chitpol, 90 kg (N/ha) at Nayapati and 107 kg(N/ha) at Thecho. Fertilizers are supplied by private dealers in the localities.

The use of compost is impressive at Chitpol and Nayapati (9 to 11 t/ha/ whereas Thecho uses compost at the rate of 2.5 t/ha. Farmers in all the three VDCs don't apply potassium fertilizer as they feel that compost fulfills its need.

Pest management: With regards to plant Protection chemicals, farmers mostly use Celphos for controlling stored pests in wheat. The major diseases prevailing in wheat field are loose smut, yellow and leaf rust, leaf blights etc. Eight different types of weeds are Commonly found in the surveyed area. These are broadly classified into two groups like narrow and broad leaf. The popular narrow leaf weeds are Leu (*Alepocurous* sp), Ragate (*Phalaris minor*), Beard grass (*Polypogon fugax*) and *Poa annua* Whereas in broad leaf Bethe (*Chenopodium album*), Halhale (*Rumex crispus*), Pirre (*Polygonum hygropiper* L.) and Bhang (*Cannabis sativa*) are the common. Among these weeds, bethe is used for seasonal vegetable and ragate for animal forage. There is no any practice of weed control. Neither do they use any chemicals nor do they manually pull it out.

Production and utilization of wheat grain

Regarding wheat utilization, the total production is not solely used for home consumption. Farmers are not fully aware of its importance. The study found women generally feel cumbersome to make chapatti or puri for tiffin and instead take beaten rice (Chiura). Few reported making roti for tiffin. Some community (Tamang and Maharjans) makes local beer (Jand) from wheat. Pani roti is one of the common dishes made from wheat.

Total production of wheat goes to home consumption, livestock feed and seed. Major share of utilization of grain wheat is for the home consumption and livestock feed. Farmers have reported that about 30%of production goes to animal feed. Very little wheat goes to market and, moreover, farmers do not buy wheat. Thus, the marketing aspect, usually, does not come into consideration.

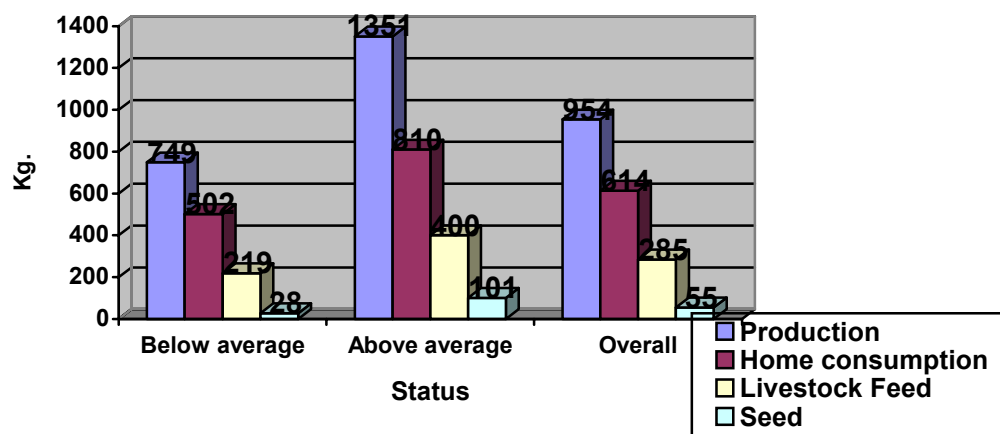


Figure 9. Production and composition of wheat grain

Constraints in wheat cultivation

Unavailability of reliable seed is one of the major constraints in technology adoption. In addition, small size of land holding, thereby, small volume of business is discouraging farmers to adopt improved technology. The situation is aggravated by the lack of technical know-how at the farmer level about available technology option.

Lack of reliable seed supply mechanism: According to farmers wheat is a traditional crop in Kathmandu valley. Farmers have been growing improved wheat varieties since late 60s. The seed replacement by a new variety is negligible. The exchange of seed from farmers to farmers is common. About 79% of the wheat seed is kept by the farmer themselves.

Major seed sources are OS (farmers use their own seed), DADO (district agricultural development office), AIC (agricultural inputs corporation), LC (local cooperatives), FF (fellow farmers) and PT (private traders).

In general, 63 % households keep seed themselves. The second major source of the seed is PT from where 23 % farmers are purchasing the wheat seed required for them (Table 9).

Table 9. Number of farmers reporting sources of wheat seed

District	VDC	Status	OS	DADO	AIC	LC	FF	PT
Bhaktapur	Chitpol	Below average	10	6	1	1	-	25
		Above average	5	-	-	-	-	5
		All	15	6	1	1	-	30
Kathmandu	Nayapati	Below average	15	5	-	-	-	-
		Above average	13	3	-	-	-	-
		All	28	8	-	-	-	-
Lalitpur	Thecho	Below average	23	1	-	-	-	-
		Above average	13	-	-	-	-	-
		All	36	1	-	-	-	-
	Overall	Below average	48	12	1	1	-	25
		Above average	31	3	-	-	-	5
		All	79	15	1	1	-	30

OS = Seed kept by farmer himself, DADO = District Agricultural Development Office, AIC = Agriculture Inputs Corporation, LC = Local Cooperatives, FF = Fellow Farmers, PT = Private Traders.

Small volume of business: Overall size of Khet land of 0.27 ha is very small for a profitable agriculture. This situation led to the low share of income from wheat cultivation in the total income of farmers. This was seen as a cause for less attention of farmers towards improvement in cultivation methods.

Table 10. Size of operational holding

Village	Status	Operated area, ha
Chitpol	Below average	0.15
	Above average	0.46
	All	0.22
Nayapati	Below average	0.16
	Above average	0.61
	All	0.37
Thecho	Below average	0.16
	Above average	0.34
	All	0.23
Total	Below average	0.16
	Above average	0.48
	All	0.27

Lack of up-to-date information: Farmers lack up-to-date information on available techniques of wheat cultivation. Most of the farmers showed their ignorance on the recent wheat technologies.

Preferences for wheat traits

Farmers have been growing RR 21 for over three decades and want replacement by some other high yielding varieties. RR 21 suffers from a host of diseases such as leaf rust, stripe rust foliar bright and loose smut etc (Field observation). All farmers spoke of a variety, which is input efficient that is, responds to input use in terms of higher grain yield than the current varieties. It should have resistance to loose smut and bunt diseases. Farmers

prefer bold and amber grain cultivars but will compromise with small and red grain provided it is well adapted to their conditions. Farmers usually encounter rain during harvest. The presently grown wheat varieties lack dormancy and get sprouted in harvest time when it rains.

Regarding the prioritization for different traits, 90 farmers (out of 135) gave first priority to grain yield, 16 to the test of bread. Storability, grain size, and drought tolerance were the other characteristics getting first priority by the framers. Irrespective of the status, farmers were seen interested in grain yield. Similarly, most important second priority was the test of bread, which was selected by 34 farmers. 22 farmers gave second priority to grain yield. Other important traits getting second priority were tillering ability, grain color, etc. Draught tolerance and grain yield were the most important third criteria for selecting a variety.

Returns from wheat cultivation

Net return to land and management: The benefit cost ratio for the land and management is 1.07, 0.94 and 1.09 at Chitpol, Nayapati and Thecho respectively.

Table 11. Economic benefits from wheat cultivation, Rs

Measures	Chitpol	Nayapati	Thecho
Cost of production	29515	28762	19019
Gross income	31577	27122	20819
Net benefit	2062	-1640	1800
Benefit cost ratio	1.07	0.94	1.09

Negative return in Nayapati resulted due to the high amount of labor and compost use.

Labor productivity: Labor productivity in the sample villages ranges from Rs. 173 to 275 per man day.

Table 12. Labor productivity

Village	Rs/man day
Chitpol	275
Nayapati	258
Thecho	173

Employment generation in wheat cultivation: Wheat cultivation in Kathmandu generated 105-120 man days per hectare.

Table 13. Employment in wheat cultivation (man days per ha)

Sex	Chitpol	Nayapati	Thecho
Male	46	64	73
Female	69	41	47
Total	115	105	120

CONCLUSION

The average operational holding is 5.4 ropani (0.27 ha). It is reported that wheat is being cultivated since time immemorial. They had local land-race (Nepali Gahun) prior to the introduction of the CIMMYT dwarf varieties. Lerma 52, Learn RoJo 64, RR 21, Nepal 297 and Annpurna -1 are the wheat cultivars currently grown in all the three VDCs.

Farmers hardly buy seeds from other sources and they use their own seed. The seed rate is high. Four to five weeds are most common. No weeding is done and no weedicide is applied. The wheat grain yield ranged between 2.4 to 2.5 t/ha. It is stored in plastic/gunny bags. The stored pests are controlled by Celphos. Every household has livestock in variable number. About 33% of the production goes to livestock feed. Farmers face problems in harvest time due to pre-monsoon rain, which causes seeds to germinate in spikes in the field and, moreover, harvesting is difficult.

RECOMMENDATION

1. The participatory research in the form of participatory varietal selection (PVS) in a massive scale and participatory plant breeding in specific area of Kathmandu valley should be carried out to replace the three decade old wheat varieties that are diseased and genetically eroded. It will allow farmers to select the traits they consider important. The scientists while working with the farmers will know the pressing problems faced by the farming commodity and will orient the on- station research program accordingly.
2. Wheat minikits of the new varieties identified through PVS should be widely distributed for scaling up the technology in wheat.
3. The new variety to be released should preferably have dormancy. A short duration variety that escapes pre-monsoon rain is another obvious requirement.

REFERENCE

ORD. 2003. *Rice-wheat system in Kathmandu valley. A baseline study*. Outreach Research Division, Nepal Agricultural Research Council.

Study on Socio-economic Condition of Goat Farming: A Case Study of Command Areas under ARS, Bandipur

Naresh S Thakur, MR Tiwari, Madhav Joshi, Bhawana Shrestha and L Pandey

NARC, Khumaltar, Kathmandu

ABSTRACT

Goat (*Capra hircus*) raising is one of the key components of farm households supporting rural livelihoods in the mid-hills of Nepal. The main objective of this study was to collect the status of socioeconomic on goat production activities in farm household economy. About 30 households each from collaborative and non-collaborative farmers from command areas of Agricultural Research Station (ARS), Bandipur were purposively selected at random. The household data collected by using pre-tested questionnaire covered the areas of socioeconomic attributes, staple crops, livestock herd, income and expenditure, biophysical and socioeconomic constraints and gender involvement. The study revealed that the benefit cost ratios on household of goats, buffalo and cattle were 2.78, 3.42, and 1.34 respectively. High return from goat raising with low investment was observed as compared to other livestock commodities. It was found that about 91.7 percent of the total households were willing to keep exotic goats than the local. An increased trend of stall-feeding was found due to limited availability of pasture areas and increased establishment of community forestry areas. Among biophysical constraints of goat farming, diseases of the goat and availability of fodder and forage were highlighted by the farmers. Emerging socioeconomic constraints were high expenses on medicines, lack of pastureland and lack of training on goat husbandry.

Key words: Cost-benefit, livelihood, socioeconomic

INTRODUCTION

Goat (*Capra hircus*) is one of the key components of livestock farming systems. Majority of rural people depends on goat for cash, meat and manure production. Marginal, landless and small farmers are involved in goat enterprise for sustainable income and gainful employment. Thus, goat farming's are the backbone of livelihoods of rural poor families and landless labors.

Goats are the most demanded common livestock species because of their wide acceptance for goat meat from all religious and ethnic groups. The population of goat and meat production is estimated to be 6.6 million and 0.4 mt respectively, which contributed 19.4% to the total meat production of the country. Livestock sector contributes about 31% to GDP of which small ruminants contribute about 12%. Goats are primarily reared for meat and manure and regarded as the second important animal species for generating cash income of the farmers. A significant amount of Nepalese currencies are drained out to India every year due to inadequate focus on the efficient production of goat for commercial purpose. About 74% of goats are brought from India and 26% from different parts of Nepal in the Kathmandu market (NASA 2000). APP has targeted to enhance the national meat production up by 7%. According to CBS (2002) data, 72% of the goats are located in the hills and mountain regions and most of the goat breeds are reported to be native.

In goat production, it is estimated that 80% of the total losses are from parasite diseases which was estimated to be 0.25 million US\$ at the price of 1995 (Lohani and Rasali 1995). These figures give different value but indicate the importance of the problem on socioeconomics of the farming community at the macro level. About 51% of farming households in Nepal keep 3.9 goats (Aryal et al 2001). It indicates that the environmental degradation in hills and mountains is also alarming for goat farming. Mostly women and children play extremely important role in goat raising system for their household economy. The most challenging issue in rural livelihood

depends on sustainable goat production, which contributes to poverty reduction of rural livelihood. The cause and effect relationships on goat production are summarized in the flow chart below.

The main objective of this study was to collect the information on socioeconomic status of goat production activities, explore the goat farming system and environment management, assess the impact of goat production technology and household income, and examine the status of technology for improving livelihood system

METHODOLOGY

The command area of Outreach Research (OR) sites under ARS (Goat), Bandipur was selected for the study. About 30 households were purposively selected at random as collaborative farmers from Baradi, Village Development Committee (VDC) and other 30 households from non-collaborative farmers covered from Abukhaireni, Khanikhola and Deurali VDCs of Tanahu District.

Available secondary sources of information published by NARC and other related institutions were reviewed to conceptualize the problems. Checklist and structured questionnaire were developed and updated through interaction with experts and knowledgeable persons. A multidisciplinary team of experts (Livestock, Socioeconomic and Agronomy) was involved in the study site. Household interview on focus groups of the farmers was taken. Discussion was held with different types of farmers including women on goat production systems and rationale for adoption of different breeds and their economics. The selected farm households were interviewed based on resource categories and production environments using pretest questionnaire. The data and information were collected on socioeconomic attributes, livestock herds, income and expenditure, biophysical and socioeconomic constraints and gender involvement. Field data obtained through household survey was analyzed using Statistical Package for Social Science (SPSS version 10.0).

An analysis to determine the factors influencing adoption of improved goat breeds was undertaken by probit functions. The probability of adoption (PA) was specified as a function of information about improved breeds, fodder and forage availability, resource constraints and the technology traits.

$PA(\text{improved goats breeds}) = f(\text{info, fod/for, resoac, return, techtr})$

Where PA is the probability of adoption of improved goat breeds. INFO is defined in two ways: a) farmer's knowledge about goat breeds and b) farmers' contact with research, extension and I/NGOs. FOD/FOR is the availability of fodder and forage for goat raising. RESOAC is the availability of capital, which directly influence on health, management, concentrate feed, and labor. RETURN is the return from goat farming. TECHTR is the technology traits that are appropriate in terms of the resource availability of the farmers.

Site description

Collaborative farmers area: Baradi, OR site is situated in Abukhaireni VDC, ward no. 2 and a few areas of under ward no. 3. These areas are situated across the Prithivi High Way about 13 km from Muglin bazaar on the way to Phokhara. The area is been divided into two elevations: river basin along the roadside and terrace land in hill area. It was observed that usually farmers raise Barbari crossbreed of goats on the roadside and Jamunapari crossbreed of goat breeds in the hillsides. The farmers of these areas are getting technical support by ARS (Goat), Bandipur eg various breeds and fodder saplings distributions, training on goat husbandry. ARS (Goat), Bandipur in 1997 at Baradi, Abukhaireni VDC, and ward no.2 formed Chhimkeswari goat-keeping group. The total member of the group was 33 (male 24 and female 9). The meeting of group members has been organized in every 15th day of a month. The main objective of this meeting was to determine the goat price, number of goat sale and discussion on the issues of goat raising.

The group farmers sold the Jamunapari and Barbari crossbreeds from the fiscal year 097/98 to until now. Farmers preferred to sell the goats to the farmers of other districts rather than to NGOs. The price of live goats was fixed at a rate of Rs.140 and Rs105 per kg of live weight. Beside goat raising, production of vegetables and milk are two other major sources of income generating activities of the farmers.

Non-collaborative farmers area: Non-collaborative farmers were selected from Khanikhola, Abukahireni VDC, ward no. 4, about 9 km from Muglin towards Phokhara on the Prithvi High way and Deurali, VDC, ward no. 3 of Tanahu. Most of these areas have never received any technical supports from ARS (Goat), Bandipur.

Most of the farmers have been using local breeds like Khari and they had little knowledge about improved breeds. In Khanikhola, most of the farmers had no land for cultivation but they had access to community forest for livestock raising. Their major sources of fodder and forage were from community forest belts.

RESULTS AND DISCUSSION

Socioeconomic attributes

The total population of the 28 households of collaborative farmers was 184 with an average family size of 6.57 person whereas the non-collaborative farmers (32 HHs) were 209 with an average family size of 6.53 person. It showed that the average family size was not significant. The percentage of the different ethnic groups such as Brahmin/Chhetri, Magar/Gurung, and schedule castes was 75, 17 and 7 respectively among collaborative farmers whereas among non-collaborative farmers, it was 40, 56 and 3. The average family size was found higher in the schedule cast (8.50) in the collaborator and Magar/Gurung (6.78) in the non-collaborator farmers (Table 1).

Table 1. Composition of ethnic communities and their distribution

Ethnic	Collaborative			Non-collaborative		
	HH	Population, %	HH size	HH	Population, %	HH size
Brahmine/chhetri	75 (21)	69	6.05	40 (13)	39	6.31
Magar/gurung	18 (5)	22	8.00	56 (18)	59	6.78
Newar	-	-	-	3 (1)	2	5.00
Schedule cast	7 (2)	9	8.50	-	-	-
Total	100 (28)	100 (184)	6.57	100 (32)	100 (209)	6.53

Figures in the parentheses refer the actual frequency of household (HH)

Land distribution

The sample households have an average holding of 0.8 and 0.5 hectares of collaborative and non-collaborative farmers respectively.

Table 2. Land distribution by farm size

Farm types (ha)	Proportion of HH		Proportion of land			
	Co farmer	Non	Total land in hectares		Average land	
			Collaborator	Non	Collaborator	Non
< 0.5 (marginal)	29	60	2.88	5.23	0.36	0.29
0.5-1 (small)	46	27	9.92	5.53	0.76	0.69
1-2 (medium)	22	13	9.68	5.85	1.38	1.46
2 & more (Large)	-	-	-	-	-	-
Total	100(28)	100(32)	22.47	16.80	0.80	0.55

Among collaborative farmers about 46% of the households were with small farm size whereas 27% of the households among non-collaborative farmers were with small farm size. The proportion of collaborative and non-collaborative was found to be 29 and 60%, respectively (Table 2). The goat raising had a significantly positive relationship with total landholding, total livestock number and active labor force utilization and weak relationship with amount of credit and off-farm income (Thakur 1998)

Livestock

Livestock was an important source of farm incomes to support the livelihoods of farmers. It provides draft power, manure, meat and dairy products for households consumption. Milking buffalo, cow and goats were the main source of farm income.

The households had an average 2.9 and 8.5 heads of local and improved goats among collaborative farmers where as 6.8 and 3.2 heads respectively among non-collaborative farmers. The average head of improved goats possessed by collaborative farmers was found significantly higher than non-collaborative. More than 50% of the collaborative households had small farm size whereas it was 61% of marginal farmers possessed by the non-collaborative farmers (Table 3).

Table 3. Average goat distribution with farm size

Farm types	Collaborative farmers			Non-collaborative farmers		
	Local	Improve	HH, %	Local	Improve	HH, %
< 0.5 (marginal)	2.8	6.6	43	5.2	3.6	61
0.5-1 (small)	4.0	8.7	57	8.7	1.0	29
1-2 (medium)	1.7	10.0	36	9.3	-	10
2 & more (Large)	-	-	-	-	-	-
Overall	2.9	8.5	100 (28)	6.8	3.2	100 (31)

Goat farming had been identified as one of the major activities among both collaborative and non-collaborative farmers. It was found that goat-farming activities have strong relationship to the households' economy among marginal and small farmers in the study area. The average number of goats owned by Magar/Gurung ethnicity (14.4) of collaborative farmers was found to be much higher as compared to Newar ethnic community in the non-collaborative farmers.

Livestock productivity and income

The analyses of production values measure the profitability of the milk, meat and manure, were collected to express in monetary values. The average milk production of buffaloes was estimated to be 8.3 and 4.4 liters/day in collaborative and non-collaborative farmers respectively. The average income from per year milk production was estimated as Rs51,543 and Rs27,080 per households in collaborative and non-collaborative farmers, respectively (Table 5).

Table 5. Livestock Productivity and income

Farmer types	Collaborative			Non-collaborative		
	Production	Av price	Income, Rs	Production	Av price	Income, Rs
Milk (liter/day)						
Buff	8.3	20.7	51543	4.4	20.5	27080
Cow	4.7	17.7	19968	3.5	17.7	14868
Goat meat, kg	124	115	333184	94	107	287314

The average income per annum from goat sale was estimated to be Rs11,299 and Rs9,020 per household in the collaborative and non-collaborative farmers, respectively. The average income from goat sale among collaborative farmers was 25.3% higher than that of non-collaborative farmers (Table 6).

Table 6. Types of goat sale and income (Rs) in 2000

Goat breed	Collaborative farmers				Non-collaborative farmers			
	Goat sale no.	Av. price	Av. weight	Av. Income	Goat sale no.	Av. price	Av. weight	Av. Income
1. Jamunapari	76(18)	116	22.6	11069	9 (2)	107	20	9630
2. Barbari	58(11)	114	19.3	11601	3 (1)	110	17	5610
3. Khari	4 (3)	82	19.3	2110	121(29)	109	20	9096
Overall av.	138			11299	133			9020

Figures in the parentheses refer the household frequency

Cost benefits analysis of herd composition

The important aspect of impact of technology was net profit per household. The net benefit from goats, buffalo, and cattle stood at Rs8, 274, Rs36, 805, and Rs5, 198 per household in the study area. The benefit cost ratios of goats, buffalo, and cattle were 2.78, 3.42, and 1.34 respectively (Table 7). It showed that the low investment with high return from the goats raising was observed as compared to other livestock herds. Labor costs were calculated at the rate of Rs42 per day taking consideration that person involved in buffalo and cattle raising can contribute to the goat raising also. According to the farmers perception they provided approximately 3 kg straw per day to the cattle and buffalo each to feed ingredients.

Household income source

Livestock and vegetables were the major sources of household cash earnings at both the study areas. According to Shrestha (1997), 63% of the farmers responded that earning cash was the main objective followed by 3% for manure, 6% for meat for their own consumption and less than 1% religious purpose. About 96% of the total households were involved in the livestock activities and among them 11% households income was distributed

into the medium income sized farmers (50-75 %) for the collaborative and 53% of the households income was distributed into the marginal income sized farmers (<25 %) for the non-collaborative farmers (Table 8).

Table 7. Cost benefit analysis per household of buffalo, cattle and goat

Source of Income/expenditure	Buffalo	Cattle	Goat
Milk	51543	19966	-
Meat	-	-	11899
Manure	482	452	1015
Total income (Rs)	52025	20418	12914
Expenditure (Rs)*			
Concentrate feed	7200+	7200+	1440**
Straw	1620	1620	-
Labor	6000	6000	3000
Medicines	400	400	200
Total expenditure (Rs)	15220	15220	4640
Net benefit	36805	5198	8274
B/C ratio	3.42	1.34	2.78

+ 2 kg multiplied by 30 days multiplied by 10 months and multiplied by @ of Rs12. ** 200 grams/day multiplied by 30 days and multiplied by @ of Rs12.

Source: Field survey, 2003 and Animal Nutrition Division, NARC.

Table 8. Percent of household distribution pattern by income size

Types of animal	% HH	Collaborative				% HH	Non-collaborative			
		<25	25-50	50-75	75-100		<25	25-50	50-75	75-100
Cereal crop	89	68	32	-	-	78	46	35	19	-
Cash crop	36	100	-	-	-	44	100	-	-	-
Vegetables	96	59	33	7	-	69	86	14	-	-
Fruits	36	60	40	-	-	-	-	-	-	-
Livestock	96	33	56	11	-	100	53	44	-	-
Off-farm	43	67	33	-	-	66	24	24	24	24

About 100 and 97% of the total households were involved in the goat raising activities for the collaborative and non-collaborative farmers, respectively. About 36 and 29% of the total households income was distributed into the large sized farmers income (75-100%) in both the areas, respectively in collaborative and non-collaborative (Table 9). Most of the farmers kept improved breeds of goat for breeding purposes and sale of such breeds to neighboring farmers and adjoining districts was observed to be encouraging for income generating activities.

Table 9. Percentage of households' distribution pattern by livestock income size

Types of animal	HH %	Collaborative				HH%	Non-collaborative			
		<25	25-50	50-75	75-100		<25	25-50	50-75	75-100
Buffalo	100	45	54	-	-	56	28	61	11	-
Cattle	36	90	10	-	-	50	69	25	6	-
Goat	100	-	25	39	36	97	3	39	29	29
Pigs	-	-	-	-	-	-	-	-	-	-
Poultry	7	50	50	-	-	41	92	8	-	-

Farmer's knowledge on goat breeds

The major improved goat breeds available in Nepal are Jamunapari, Barbari and Kiko. All collaborative farmers were familiar with Jamunapari and Barbari breeds whereas among non collaborative farmers 51.6, 48.3 and 4.2% respectively with Jamunapari, Barbari and Kiko breeds in non-collaborative farmers (Table 10). About 66.7 and 28.1% farmers preferred Jamunapari goats for collaborative and non-collaborative groups, respectively because ARS, Bandipur still needs to take proactive role for the dissemination of goat production technology.

Collaborative farmers expressed that the reasons for adopting improved goat breeds were easy to sell (100 %), low cost of inputs (96 %) and high profit margin (72 %) (Table 11).

The sufficient dissemination of technology and information about the improved goat breeds were also important factors in the adoption process. The main sources of information flow about improved breeds were from ARS, Bandipur, neighboring farmers and Heifer International. About 89.3 and 15.6% of the households, respectively

from collaborative and non-collaborative responded that the source of information was ARS, Bandipur in both the sites. It was observed that collaborative farmers who adopted the improved breeds had better contacts with researchers, extension peoples and I/NGO. Non-collaborative farmers received information mainly from neighboring farmers and sparsely from Heifer International for the collaborative (Figure 2). The study revealed that about 91.7% of the total households were willing to keep improved goat breeds than locals.

Table 11. Percent responses on reasons for adopting goat breeds

Reason	Collaborative=28				Non-collaborative=32			
	HH%	I	II	III	HH%	I	II	III
High production	36	10	10	10	47	7	20	33
Kidding rate	36	20	30	10	18	-	20	20
High market price	25	-	29	14	11	33	33	-
Low cost of inputs	96	89	4	4	97	61	10	19
Market ability	28	13	38	13	31	-	30	10
Easy market	100	18	32	29	93	33	30	13
High profit margin	72	5	5	25	72	9	17	39
Social reason	-	-	-	-	31	10	20	20
Faster growth& weight rate	68	14	-	14	62	-	15	15
Easy to adopt	32	11	44	33	18	40	40	-

In the study areas, there are three types of raising systems: stall, semi-stall and open grazing systems. It was observed that collaborative farmers were doing stall-feeding as 51.3 and 58.8% respectively for buffaloes and goats whereas the same for non-collaborative farmers it was 58.7 and 41.2% respectively. Sainju and Shrestha (1991) reported that the animals in the stall feeding system had 17.2% higher daily live weight gain than of animals kept in the open grazing system. Open grazing system for goats was being followed by 33.3 and 66.7% households for collaborative and non-collaborative farmers respectively (Table 12).

Table 12. Buffalo, cattle and goats raising systems

Livestock commodities	Collaborative			Non-collaborative		
	Stall feeding	Semi-stall feeding	Open grazing	Stall feeding	Semi-stall feeding	Open grazing
Buffalo	51.3	-	-	58.7	100	-
Cattle	36.4	25.0	-	63.6	75.0	-
Goat	58.8	42.5	33.3	41.2	57.5	66.7

It seemed that the trend of stall-feeding had been significantly increasing due to the limited availability of pasture areas and increased establishment of community forestry. Only few farmers practiced stall and semi-stall feeding from April to October and open grazing was the usual practice being followed in the rest of the months of the year.

It was revealed that there were no practices of the growing of fodder and forage species except some fodder trees such as bakaino (*Melia azedarach*), napier (*Pennisetum purpureum*), amriso (*Thysalaena maxima*), kimbu (*Morus alba*) and ipil ipil (*Leucaena leucocephala*). Non collaborative farmers were more dependent on forest and collaborative farmers have started developing their fodder grass and tree (Figure 3).

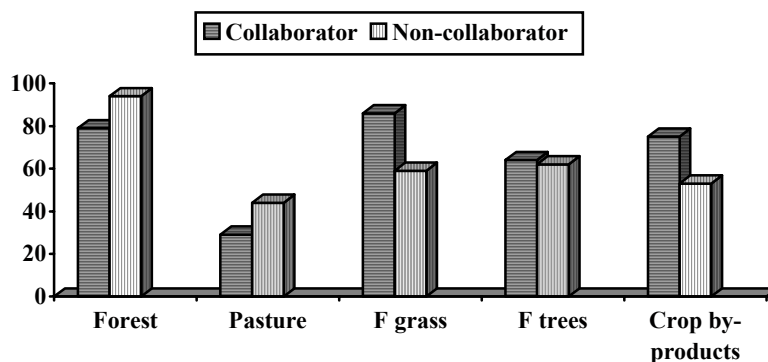


Figure 3. Responses on feed source.

Marketing

It was observed that farmers were selling their male goats of 18-24 months of age with an average body weight of 20.4 kg. About 93% by collaborative and 88% by non-collaborative of the households were selling their goats directly to the consumer (Figure 4). The average price per kg live weight for Jamunapari and Barbari crossbreeds were higher than that of local breeds (Table 6). The price of goat meat has increased by 300% over the last ten years (Kharel and Pradhan 1988) suggesting a high demand of goat meat in the country. Collaborative farmers did not mention the low market price of goats but 12% of the non-collaborative farmers reported it. The major markets for goat sale were Dumre, Mugling, and Narayanghat Bazaars.

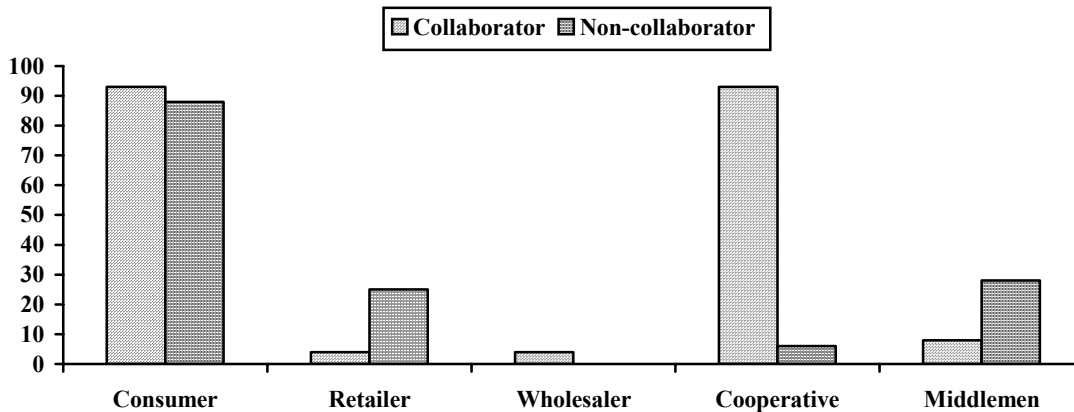


Figure 4. Percent responses in goat marketing channels.

Farmers perception on major constraints

The major constraints stated by the farmers were biophysical and socioeconomic constraints. About 96 and 100% of the total households respectively were of the opinion that the major problem of goat raising was diseases for both the categories of farmers. The study revealed that the major diseases were Anthrax, Tapeworm, Pneumonia and internal and external parasites. Joshi (1994) studied showed that the major symptoms in affected goats were diarrhoea, bottle jaw and loss of appetite and inability to move. Similarly other major problems were unavailability of fodder and forage in both the sites (Table13).

Table 13. Percent perception of the major biophysical constraints and their performance ranking in goat raising

Physical constraint	Collaborative				Non-collaborative			
	Rank				Rank			
	HH, %	I	II	III	HH, %	I	II	III
1. Diseases	96	67	18	15	100	59	25	9
2. Mortality rate	11	-	33	-	9	-	33	33
3. Quality breeding buck	21	-	17	17	69	23	36	32
4. Lack of quality fodder	93	35	31	31	84	22	33	33
4. Low yield of by-products	82	4	52	43	66	9	14	57
5. Low growth rate	-	-	-	-	12	25	50	-

Under the socioeconomic constraints, it was noted that expenses on medicines (89%) and lack of pasture land (89%) were the major problems faced by the collaborative farmers whereas training (81%), expenses on medicines and pasture land (75%) by the non-collaborative farmers (Table 14).

Gender involvement

The survey revealed that both male and female were equally participating in goats farming activities however, the composition of the household size, age and sex of the family members largely were dependant on gender involvement in these activities. Mostly male took decision on animal selling and selection for buying while female contributed to overall goat management activities such as shed cleaning, grazing, fodder collection, feeding and watering. Female members were almost well aware on production and marketing decision of goats (Table 15). Fodder collection was no more a function limited to female domain only in both the locations. It appeared from the study that gender balance in goat management could make it remunerative and sustainable.

Table 14. Percent perception of the major socioeconomic constraint and their performance ranking in goat raising

Socioeconomic constraint	Collaborative				Non-collaborative			
	Rank				Rank			
	HH%	I	II	III	HH%	I	II	III
1. Labor shortage	68	21	10	32	41	-	23	31
2. Low market price	-	-	-	-	12	25	25	25
3. Unavailability of credit	-	-	-	-	-	-	-	-
4. Lack of cash	36	20	10	40	19	-	-	33
5. Lack of pasture land	89	48	28	20	75	33	33	29
6. High inputs cost	-	-	-	-	6	-	50	50
7. High risk	-	-	-	-	-	-	-	-
8. Expenses on medicine	89	20	40	20	75	46	21	17
9. Lack of training	46	15	15	31	81	42	19	27
10. Poor/unmanaged	57	6	31	25	62	5	45	35

Table 15. Gender involvement in percentage

Activity	Decision making					
	Collaborative N=28			Non-collaborative N=32		
	Male	Female	Both	Male	Female	Both
1. Animal selection & buying	17	7	86	19	9	56
2. Animal products selling	21	7	75	22	12	58
3. Stall caring & cleaning	7	14	82	9	22	65
4. Animal grazing	7	14	82	3	25	68
5. Stall feeding /watering	14	14	85	9	22	75
6. Fodder collection	3	14	86	-	25	75
7. Milking cattle & buffalo	7	2	82	9	15	68
8. Marketing	14	3	67	12	12	65

Goat rising is the one of the main activities of the farm households and support for rural livelihoods. The farmers still have hesitation to adopt the improved goat breeds because of high incidence of diseases, unavailability of quality fodder, forage and breeding buck and poor management. However, ARS (Goat), Bandipur are implementing OR activities for improved methods of goat-raising which has limited access to the majority of farmers. Farmers in both locations require technical support to pursue the adoption of improved goat breeds. Farmers have put a great effort to enhance their living conditions but they are confronted with limited resources such as pastureland and fodder, forage and socioeconomic and technical constraints. Efforts should be made to promote goat farming by crossing local goats with improved breeds up to recommended level, goat management system and improved fodder and forage with less degradation of natural resources. Commercialization of improved goat farming generates farm income and increase employment opportunities in the area closed to the Prithivi high way. It is possible to improve economic condition of the people in the OR sites through commercialization of goats husbandry practices without degradation of local natural resources. Due to poor economic condition and poor resource base of the farmers in both the sites, it was necessary to adopt the need-based development approach.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Mr TP Pokherel, Outreach Research Division, NARC for his encouragement in carrying out this study successfully. The authors also acknowledge Dr SR Neupane, Livestock Breeding Division, NARC for their valuable comments.

REFERENCES

- CBS. 2002: *Statistical pocket book, Nepal*, HMG. National Planning Commission Secretariat, Central Bureau of Statistics, Ramshah Path, Thapathali, Kathamandu.
- Devendra C. 1998. Indigenous goat genetic resources: Potential importance in sustainable agriculture. In: *Proceedings of 4th Global Conference on Conservation of Domestic animal Genetic Resources* (JNB Shrestha, ed). 17-21 August 1998, Kathmandu Nepal. Pp.16-22.
- Devendra C and M Burns. 1983. *Goat Production in the tropics*. Technical Communication Bureaux of Animal Breeding and Genetics. Commonwealth Agriculture Bureaux, England.

- Harris RD. 1962. *The distribution and ancestry of the domestic goats*. Proceedings of Linnean Society of London. Pp.79-91.
- Joshi BR. 1994. Effects of parasitic gastroenteritis in goats under sedentary management in a low hill village of Western Nepal: A clinical report. *Veterinary Review* 9(1): 18-20.
- Kharel M and SL Pradhan. 1988: Goat meat production in Nepal. **In:** *Goat meat production in Asia* (C Devendra, ed). Proceedings of a workshop, Tandojam, Pakistan, 13-18 March 1988. IDRC, Canada. Pp.152-160.
- Kharel M and SR Neopane. 1994. *Goat genetic resources*. **In:** *Proceedings of the 1st National Workshop on Animal genetic Resources Conservation and Genetic Improvement of Domestic Animals in Nepal* (JNB Shrestha, ed). 11-13 April 1994. NARC, Kathmandu. Pp.48-54.
- NASA. 2000. *Environmentally sustainable livestock production for poverty alleviation*. Proceedings of the 3rd National Animal Science Convention, October.
- Nozawa K. 1991. Domestication and history of goats. **In:** *World Animal Science B8 Disciplinary Approach 8* (K Maijala ed). Genetic resources of pig, sheep and goat. Elsevier Science Publisher. BV Amsterdam. Pp.391-404.
- Oli KP. 1987. *Goat breed comparison study in Hattikharka panchayat*. PAC Technical Paper No 93. Pakhribas Agricultural Center, Dhankuta, Nepal.
- Pradhan SL and NK Gurung. 1985. Comparative performance of Khari goats and its crossbred with Jamunapari of Central Goat Farm, Bandipur. *Nepalese Journal of Animal Science* 191:35-40.
- Sainju AP and HR Shrestha. 1991. *Effect of stall feeding and open grazing on growth rate of goats*. **In:** *Animal science research and extension in Nepal*. Proceedings of First National Animal Science Convention, 14-15 January 1991. Lalitpur, Nepal. Pp.70-72.
- Shrestha NP. 1997. *Breeding system of local goat in the Eastern hills of Nepal*. PAC Working Paper 219, Pakhrbash, Dhankuta. 15pp.
- Thakur NS. 1998. Alternative strategies of securing livelihoods in the hills of Nepal: A case study of Bhattedada VDC, Lalitpur District. *MSc Thesis*. Asian Institute of Technology, Bangkok, December.
- Zenker FE. 1963. *The origin of domesticated animals*. Span 6. Pp.54-58.

Surface Seeding of Wheat in Wetland: Economics and Scope

Hari K Shrestha and Yuga N Ghimire

NARC, Khumaltar

ABSTRACT

A study was conducted on surface seeding, a best option of crop establishment method in wheat, in the wetland area of Terai in order to analyze its economic return, prospective and constraints in farmers' condition. Group discussion as well as household survey was carried out in farming community for collection of general and individual information. Comparative analysis between two crop establishment methods revealed that surface seeding was more economical with low input cost and higher return as compared to conventional one. The benefit cost ratio was 1.5 in surface seeding whereas it was below 1 in conventional method. A substantial area of wetland in study site went under cultivation in winter after adoption of surface seeding method where land preparation was not possible due to high moisture regime in soil. Although problems vary according to field type excess water logging during rainfall, weed and rat infestation in wheat field were the major constraints associated with this method. Joint effort of research and extension sectors is imperative to expedite the diffusion process in the potential area and at the same time to explore new area for surface seeding all over the country.

Key words: Economics wheat, surface seeding, wetland

INTRODUCTION

Nearly 450,000 hectare of rice area in Nepal is left fallow in winter (NWRP 1997). Most of such fallow lands fall under wetland, which contains excess soil moisture and does not allow timely land preparation for winter crop. Expansion of wheat area has become possible through direct seeding in such type of seasonal fallow land. Despite these fallow lands, a considerable area of wetlands (333,000 ha) is occupied under late sown wheat crop (NWRP 1997). It is estimated that 50-60% of the wheat area is planted in time and rest is planted in late condition (Giri 1998). A substantial increase in wheat production of the country can be achieved by timely sowing of wheat in wetland. Surface seeding has become a best technological option for wheat growing in such domain. As the technology has quite good scope in the lowland area, it has been widely adopted in eastern Dhanusha where the winter crop was either impossible or lately sown due to high moisture regime in the soil.

Socioeconomic research is essential for ex-post evaluation of generated technology in farmers' condition. It is important to understand about adapted technology if researchers have to identify new technological options of interest to farmers, including improvements to current ones. Researchers need to determine whether the new technology has really contributed to increase the well being of intended beneficiaries. Impact studies are worthwhile for policy makers, planners, and stakeholders to present facts and figures on returns of huge investment in agricultural research over the time. In view of assessing the surface seeding practice in wheat in terms of its economics and scope, a survey was carried out in the wetland area of Dhanusha during Sept-Oct of 2001.

METHODOLOGY

Eight villages of eastern Dhanusha adopting surface seeding were purposively selected to carry out the survey. Household survey was carried out through interview with the help of structured questionnaire after pretest in nearly village. Considering the extent of homogeneity found in the farm community, 74 households were interviewed by random sampling. Impact indicators including food sufficiency level, cropping pattern, grain yield and economic return was established for constructing the questionnaire. Impact indicators were the set of

variables, conditions, and/or perceptions that both farmers and scientists expect to change with the adoption of a certain new technology or practice (Bellon 2001).

Interaction with a group of progressive farmers was held in each site in order to collect general information about the site. Transect walk with field observation across the villages was performed. Data processing was carried out using SPSS 10.0. Simple frequency, cross tabulation, mean, median and other descriptive statistics were computed for the main variables of interest.

RESULTS AND DISCUSSION

Food sufficiency level

According to their food availability, the respondents were categorized into three different levels. Due to the small land holding, about 18 percent respondents had food production for less than six months to feed their family. About half of the respondents had food produce enough for six to twelve months for family consumption whereas about one third of the respondents had surplus food production. There was no association between food sufficiency level and adoption of surface seeding, as it was hypothesized that higher the food sufficiency level the less would be the area of adoption. However, the food availability of farm households was substantially increased after the adoption of surface seeding.

Cropping patterns

Among different cropping patterns adopted by the farmers, the most common pattern was rice-wheat. Although some farmers adopted rice-wheat pattern in their whole farmland, on average, farmers covered only half (50%) of their total farmland with this pattern. Similarly, some farmers followed rice-vegetables pattern in half of their total farmland, on average, farmers followed this pattern in one-fifth (21%) of their total farmland. The remaining farmland was covered with rice-potato (13%), rice-linseed (11%) and rice-legumes (5%). Regarding crops grown in past, about half of the respondents used to grow linseed whereas one third of them had no crop in winter previously in the place where surface seeding of wheat was adopted later. About one fifth of the respondents used to grow wheat lately with conventional method in past although the grain yield was poor. About 125 hectare was cropped with surface seeded wheat in surveyed villages whereas a large area ie about 20% of total farmland was reported fallow in neighboring village that can be drawn under surface seeding.

Irrigation facility

Most of the farmers (85%) had direct supply of irrigation with the canals made by Kamala Irrigation Project. Some of the respondents (11%) had installed pumping sets whereas others (4%) had no irrigation facility at all. Regarding the irrigation reliability, the canal irrigation was seasonal and farmers get deprived of supply often at the peak period of wheat (milking stage). There was no need of irrigation in the initial stage, as excess water would hamper the crop with water logging but the irrigation was essential in later stage for surface seeding of wheat.

Cost of cultivation

The average seed rate used in surface seeding of wheat was 120 Kg per hectare that was at par with the recommended seed rate used in conventional seeding. However, some progressive farmers reported surface seeding needs higher seed rate to maintain a good plant population. The average fertilizer dose used in this practice was 39:29:2 (N:P:K), which was far below the recommended dose of fertilizer. Average grain yield increased with the increase in N fertilizer application indicating the responsiveness of the fertilizer in wetland. A major portion of cost in wheat farming was the land preparation cost, which was entirely saved in surface seeding. Land preparation cost in conventional practice was Rs7953 ie 43% of total cost of cultivation. The comparison of input cost between surface seeding and conventional seeding in wheat is given Annex (Table 5).

Benefit cost ratio

The total cost of cultivation in surface seeding (Rs 10095/ha) comprised the total input cost (Rs 3761/ha) and harvesting cost (Rs 6334/ha) with total exemption of land preparation cost. The mean yield of wheat in surface seeding in farmers' condition was found 1914 kg/ha (Table 2) with highest yield 2357 kg/ha under favorable condition. Since the farm gate price of wheat was Rs8 per kg on average, the farmers' gross return was computed as Rs15712 per hectare. This resulted in the average benefit cost ratio of 1.5 in surface seeding. However, there was large variation in grain yield and so in economic return from farmer to farmer in this practice.

The total cost of wheat cultivation with conventional method was found Rs 19135/ha, which was largely contributed by land preparation cost (Rs 7953/ha). The conventional method required larger irrigation cost (Rs 1318/ha) and harvesting cost (Rs6763/ha). The benefit cost ratio (B/C ratio) in conventional practice was found below 1. Since farmers' family labor had no or less opportunity cost instead of cultivating wheat, they might have continued the same although the B/C ratio was less than 1. Comparison between surface seeding and conventional seeding for yield and profitability of wheat is depicted in following diagram.

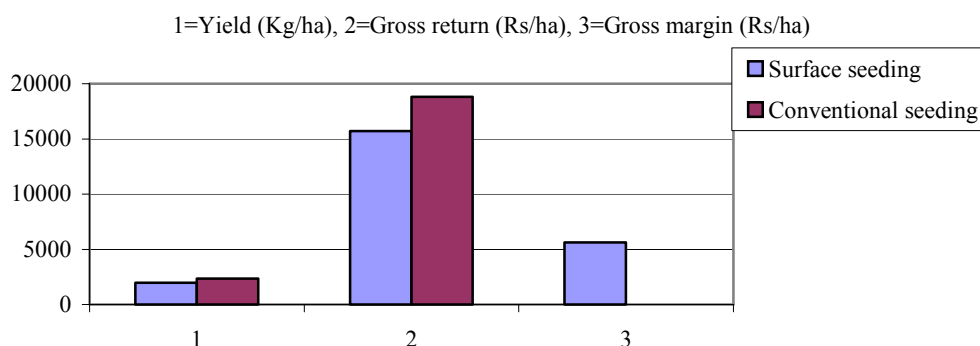


Figure 1. Yield and profitability in surface seeding vs conventional seeding.

Other benefits

Among the immediate benefits, food availability especially for resource poor farmers was increased. A few farmers, who had food deficiency in the past, claimed to be food sufficient after adoption of surface seeding. Large farmers had extra income through low input cost and high profitability. In addition to the increased food availability and income, landowners had also increased land price after the adoption of surface seeding. Although land is a fixed asset, it is a source of cash either for getting loan from moneylenders or for sale to others. It is a common practice of Tarai farmers to sale their land or put it in mortgage for getting loan in marriage function and other ceremonies. As the data showed their land price was higher due to increase in the productivity, farmers were apparently happy with surface seeding technology. The increment in existing land price was from one thousand rupees to ten thousand rupees for one Kathha (333 m²) depending upon road accessibility, land type and distance from market. On average the land price increased by 20% after the adoption of surface seeding in wheat.

Some drawbacks

The problem in this practice was reported as rat infestation in field, which damage the standing crop of wheat. Another drawback of surface seeding is that it creates scarcity of grazing land for dairy farmers who used to graze their livestock in fallow wetland or cut grass there on. After the adoption of surface seeding, the grazing land was reduced which might have adverse effect in their livestock productivity. Stall-feeding practice in livestock was reported as labor intensive as well as expensive for them. The risk of water logging in wetland is high if rainfall occurs in early winter as enough moisture is already there. In such situation, there may be seed rot that reduces plant population causing significant yield loss of wheat and hence farmers may not achieve economic return for at least breakeven point. Therefore, drainage facility is imperative though it may be costlier in wetland. Regarding yield loss due to pest and disease, weed infestation caused yield loss by 5% in conventional seeding and by 3% in surface seeding whereas rats caused yield loss by 3% in surface seeding and by 2% in conventional one. Similarly disease caused 2% yield loss in both practice.

Other crop establishment methods

All of the respondents, who had tried surface seeding at least once, had decided to continue the same practice in future. Minimum drudgery was one of the important reasons for the adoption of this method. However, when they were asked for their interest in zero tillage, most of them replied they were not aware of this technology. Although Outreach program of Rice Research Program, Hardinath demonstrated zero tillage in wheat with Pantnagar Seed Drill last year, most of them were still not familiar with this cultivation method. It indicates there should be some more demonstration programs for Pantnagar Seed Drill in the village. While demonstrated last year, the participant farmers, as well as technicians had realized that the field be well leveled for uniform depth of wheat sowing otherwise the germination of wheat seed would be poor. When respondent farmers were asked

if they were interested in Chinese Seed Drill, they expressed their ignorance on this technology. It indicated that demonstration program for this machine was still needed for the farmers.

Table 1. Food sufficiency level

Duration	Frequency	Respondents, %
< 6 months	13	17.6
6-12 months	38	51.4
>12 months	23	31.0
Total	74	100

Table 2. Area under different cropping patterns

Cropping pattern	Area, %
Rice-Wheat	50
Rice-Vegetables	21
Rice-Potato	13.1
Rice-Oilseed	11.2
Rice-Legumes	3.2

Table 3. Crops grown by respondents before surface seeding of wheat

Crops	Frequency	Respondents, %
Linseed	37	50
Lentil	1	1.4
Wheat (conventional)	13	17.6
Fallow	23	31.0
Total	74	100

Table 4. Farm type with irrigation facility

Farm type	Frequency	Respondents, %
Farms with canal irrigation	63	85.1
Farms with pumping set	8	10.8
Rainfed farms	3	4.0

Table 5. Input cost comparison between surface seeding and conventional seeding

Input	Surface seeding		Conventional seeding	
	Quantity, kg/ha	Cost, Rs/ha	Quantity, kg/ha	Cost, Rs/ha
Seed	120	1221	120	1221
Urea	60.7	597	74.5	744
DAP	61	1196	58	1127
Potash	2.7	9	2.7	9
Irrigation	-	738	-	1318
Land preparation cost	-	-	-	7953
Total cost	-	3761	-	12372

Table 6. Benefit cost ratio in two different crop establishment methods of wheat

Crop establishment methods	Yield, kg/ha	Gross return, Rs/ha	Cost, Rs/ha	Gross margin, Rs/ha	B/C ratio
Surface seeding	1964	15712	10095	5617	1.55
Conventional seeding	2350	18800	19135	-335	0.98

Farm gate price of wheat was Rs8/kg.

Table 7. Land price before and after the adoption of surface seeding

Land price	Minimum, Rs/ha	Maximum, Rs/ha	Mean price, Rs/ha
Before adoption	1,20,000.0	9,00,000.0	5,07,000
After adoption	1,50,000.0	12,00,000.0	6,26,000
Net increase	30,000.0	3,00,000.0	1,19,000

Table 8. Yield loss by pest and disease

Problem	Surface seeding method	Conventional method
Weeds	3	5
Rats	3	2
Disease	1	2

CONCLUSION

Rice-wheat system is inevitable for food security as well as livelihood of small to medium farmers in Nepal. However, wheat farming with conventional method is no more profitable due to high input cost and low food grain price in the market. Since minimum support pricing system is not in practice at present and public organization cannot intervene in competitive food grain market, primary focus of technology development should be into low cost technology. Surface seeding of wheat is not only a proven low cost technology but also one of the best RCTs (Resource Conservation Technology) for timely seeding and getting higher yield in wetland. The possible new area for expansion of surface seeding needs to be explored by joint effort of research and organizations. Further research is imperative to overcome the technical constraints and manage the risk associated with this technology. Potential domains for other RCTs like zero tillage, CHT (Chinese Hand Tractor) and bed planting need to be identified for making wheat farming a profitable one with low input cost.

REFERENCES

- NWRP 1997. *25 years of National wheat research program in Nepal*. National Wheat Research Program, Bhairahawa, Nepal.
- Bellon M. 2001. *Participatory research methods for technology evaluation: A manual for scientists working with farmers*. Mexico, DF: CIMMYT. P. 74.
- NWRP 1997. *Annual report 1999-2000*. National Wheat Research Program, Bhairahawa, Nepal.
- Giri GS. 1998. Surface/ relay planting: An option for planting wheat on time in the lower wetlands of the Tarai, Nepal. **In:** *Proceedings of the Rice-Wheat Research End of Project Workshop*, 1-3 October 1997, Kathmandu, Nepal. NARC and CIMMYT.

SECOND SAS-N CONVENTION

With the theme Agricultural Research for Enhancing Livelihood of Nepalese People the Second Convention of Society of Agricultural Scientists, Nepal (SAS/N) was held in Kathmandu on 30 July-1 Aug 2003. The first convention was held on 29-31 March 1999 in Kathmandu.

The 2nd convention was inaugurated by Hon'ble Vice President, National Planning Commission and the Chief Guest Dr Shankar P Sharma amid a special function chaired by the SAS-N president, Dr Madhusudan P Upadhyay. During the inauguration session theme papers from Mr Shankar L Chaudhary and Dr Fanindra P Neupane were presented. Inaugurating the convention, Hon'ble Member of NPC Dr Sharma spoke on the present growth status of agriculture productivity and emphasized programs and resources mobilization identifying the existing problems. He also suggested to identify the technologies developed in the neighboring countries that can be adopted in the Nepalese condition. At the occasion, Secretary of Agriculture and Cooperatives and special guest of the Convention Mr Purna P Manandhar outlined the need to learn better management technique and conduct need-based research considering the WTO requirements. Mr Raghunath P Sapkota, Executive Director, NARC, at the occasion, expressed his hope that the recommendations made by the Convention would contribute to enhancing the research capabilities. President of the Society, Dr Madhusudan P Upadhyay highlighted the achievements of the Society.

BEST PAPER AWARDS

SAS-N has a tradition of announcing best papers in its convention. Under the chairmanship of Buddhi R Khadge papers of this convention were evaluated on the basis of both content of papers and their presentations made by authors. Evaluation was based on relevance to present context, technical quality, write up and originality in papers. In the presentation, general expression, audio-visual use, punctuality and answering questions were considered. Considering number of papers and disciplinary adjustment in this second convention 5 papers were awarded. Titles of these awarded papers under different categories are:

Category A. Agronomy, Plant Breeding, Soil Science and Agric-Engineering

Assessment of factors responsible for yield decline in Toria, Written by Ghimire (See page 41 for details)

Category B. Plant Protection

Population dynamics of citrus psylla (*Diaphorina citri* Kuwayarna) in the western hills of Nepal and spread of citrus greening disease, Written by Manandhar et al (See page 178 for details)

Category C. Horticulture

Evaluation of cauliflower varieties and their planting dates for commercial production under Jumla agro-ecological condition, Written by Pandey (See page 207 for details)

Category D. Animal Sciences

Diversity of fodder and grasses in Sankhuwasabha, Written by Joshi and Karki (See page 432 for details)

Category E. Socio-economics

Rice-wheat system in Kathmandu valley: A socioeconomic analysis, Written by Ghimire et al (See page 542 for details)

RECOMMENDATIONS

The convention made out recommendations and suggestions on technical, management and policy issues after extensive discussion in different groups. Summary of recommendations is given below.

Plant Breeding, Biotechnology

Transferable technologies

Rice

- Hardening technique for regenerants through embryo rescue (Distant hybridization) Genes from 47 ancestors originating from 12 countries are available in 20 released varieties of Nepal (Rice breeding program in Mid and high hills)

Technology in pipeline

Rice

- NR10288-10J-2J, NR 10288-015J-015J-7 (blast resistance for Jumla)

Wheat

- WK904, WK935, WK930, WK914 (grain production) for Jumla
- WK 921, WK919 (biomass production) for Jumla

Common bean

- PB0001, PB0002, PB0048 for Jumla

Chickpea

- ICCx840508-38, ICCx840508-21 for Tarai

Future Research Issues

- Hybrid rice and maize technology
- Exploitation of biotechnology

Soil Science

- Rice bean - Environmentally friendly technology for maintaining plant nutrient in soil (hills, Tarai)
- Biogas effluent can substitute mineral fertilizer demand to some extent if it is handled carefully and composted properly (low hills and Tarai)
- 50 kg N and 60 kg K₂O/ha for good yield and quality of potato (mid-hills)
- 40 kg Sulphur/ha for good yield of onion bulbs in the acidic soil of Pokhara valley

Agri Engineering

- Tubular corn sheller for reducing time and drudgery (maize growing areas)
- Mini SRR dryer for drying rice during rainy season (early rice growing areas)
- Low cost solar dryer for drying agro commodities (apple, apricot and vegetables) in the remote areas (mid hills and high hills)

Agronomy

- Full package of practices to increase Toria (Tarai and Inner Tarai)
- Double corn plants per hill with 75- x 50-cm spacing to reduce shading effect in maize, soybean or bean intercropping (mid hills and high)
- Gautam, Khumal-11, Chaitya-2 and Saroj- Promising lines for boro (Hiunde) rice cultivation (Tarai and inner Tarai)
- Genetic improvement in Kanchhi Masuli for higher rice yield

- Marketing intermediaries such as rice millers, traders etc should be involved in rice variety development process
- Seed multiplication program be launched at farmer's level (Eastern Tarai)

Future Research Issues

- Micronutrient study in vegetables as well as cereal crops Strengthening laboratory and physical facilities and manpower development.
- Participatory research involving farmers to verify technology
- Organic waste recycling
- Integration of legumes in cropping to reduce leaching losses
- Hedge row intervention to reduce soil loss
- Crop physiological research
- Crop rotation for maintaining soil fertility and profitability
- Development of appropriate technology for resource conservation and reduction of cost of cultivation
- Development of appropriate tools and machines for reduction of drudgery and improvement of efficiency in agricultural operations.
- Development of water management practices and technologies for the efficient water application for maximizing the productivity
- Appropriate post harvest technology to reduce the losses of the perishables and for high value addition in the commodities.
- Resource management (system perspective and indigenous knowledge and techniques)

Horticulture

Transferable technologies

Cauliflower

- Kathmandu Local, planted from 10th of Chaitra to Jestha for maximum yield
- Snow King for early production and Snow Crown for high yield (high hills of eastern Nepal)
- Maize at 150- x 25-cm and cauliflower at 45- x 30-cm spacing for intercropping situation after harvest of potato

Gladiolus

- Vase life of cut spike extended up to 11.3 days in 12% sucrose solution (room condition)

Saffron

- >15 g corm is suitable for bulb production. Artificial cultivation gave a net return of Rs97,700/ropani (Jumla)

Banana

- William hybrid and Jhapali Malbog found better (low hill)
- 300:110:300 g NPK/plant/year in 3 split doses in Feb, May and Aug (low hill)
- Feb-April is the best planting time (low hill)

Potato

- Short dormancy varieties stored in diffused light system found very effective by de-sprouting (>1500 m)

Cabbage

- 60:80:50 kg NPK/ha for rainy season cabbage cultivation

Technology in pipeline

Potato

- Faba bean best for residue incorporation for succeeding potato crops (mid hills)
- SerenaXTPS67 and HPS 11/67 promising for TPS (Tarai)

Bean

- LB-25 and Pant Anupam found suitable in on-station condition (mid hills)

Vegetable type soybean

- AGS-352 superior genotype and resistant to powdery mildew for pre and post monsoon season (mid hills)

Future research issues

- Food security from horticultural crops: Sweet potato, *Colocasia* spp etc
- Environment: ICM on highly commercial vegetable crops
- Agro- biodiversity: Collection and preservation of horticultural crops
- Technology transfer: Action research on horticultural crops
- Resource management: System perspective and indigenous knowledge and techniques.

Animal Science and Fisheries

Transferable Technology

- Local herbs for ecto parasite control
- Quality production of frozen semen
- Commercialization of goat production
- Cold water mountain aquaculture
- Lake fisheries management

Technology in pipeline

- Oat seed production technology
- Reducing cost of broiler production
- Wool blending technology (Angora wool with other)
- Inbreeding control in fish
- Local herbs for endoparasite control
- Cage culture of rainbow trout in stagnant water

Future Research Area

- Improvement of indigenous buffaloes
- Fish health management in cultivated fish species
- Post harvest technology in fish
- Alternative parasite control approaches
- Research on turkey
- Cryopreservation of fish milt
- Low cost production technology in cold water fish

Socioeconomic and Miscellaneous

- Intensive training on control of livestock disease and livestock management to farmers as a group approach.
- Stall feeding of goat and establishment of fruits, orchards and vegetables farming and market oriented high value crops such as mustard and legumes for promoting livelihood.
- Controlled grazing, fodder trees plantation on waste and marginal lands.
- Jamunapari, Barbari cross and Kiko popular
- Diversification in food preparation approaches in Kathmandu valley
- Need of a dormant varieties for Kathmandu valley
- Technologies for commercial production of medicinal and aromatical plants be developed
- Farmers training on off-season vegetable production technologies and marketing
- Participatory seed production and supply mechanism
- Plastic cover technology to reduce the cost of chemical fertilizer.
- Application of 50% organic manure to reduce acidity of the soil caused by the excess use of chemical fertilizer.
- Promotion of resource conservation technologies (minimum tillage, zero tillage, surface seedling) in wheat for soil health
- Promotion of bed planting of wheat for minimization of helminthosporium leaf blight diseases

Cross Cutting

- Covering manures with black plastic sheets for nutrient content (NPK) and crop yield of maize and upland rice
- Diversity study in indigenous crops using biochemical and molecular tools
- Study of molecular markers integrated to breeding programs.
- Study on alternative feeding regimes and cost effective method of raising Pakhribas pig
- Research on poverty reduction aspects through diversification of employment and income from agriculture.
- Research on integrated approach on forward and backward linkage.
- Effort in maize technology generation and dissemination to improve productivity and profitability to maize and feed industries.
- Ethnographic Decision Modeling (EDM) should be incorporated in farming system research.
- Promotion of Farmers' Field School (FFS) for IDM in potato and other crops.
- CO₂ will have positive effect on rice but may not be for C₄ crops due to rise in temperature.

SOCIETY OF AGRICULTURAL SCIENTISTS, NEPAL

Estd 1995

The Society of Agricultural Scientists, Nepal (SAS-N) is a professional organization that serves as a common forum for the agricultural scientists and researchers scattered throughout Nepal in various agricultural and related institutions. SAS-N got officially registered in District Administration Office, Lalitpur on 5 June 1995 with registration no. 490/051/52.

AIM

The SAS-N aims to bring agricultural scientists and researchers of Nepal to a common forum by way of protecting their professional integrity and improving the standard of their research works in order to contribute to a common goal of the country's economic development through the growth of agricultural sector.

OBJECTIVES

- Protect and promote the professional rights, dignity, integrity and welfare of the members of the SAS-N, whilst being fully committed to the democratic norms and fundamental human rights as laid down in the Constitution of the Kingdom of Nepal, 2047 BS (1990).
- Suggest His Majesty's Government of Nepal (HMG/N) in formulating policy and resolving the problems related to agriculture.
- Organize national and international workshops, seminars, conferences etc. on the topics relating to existing status of agricultural science and technology for increasing agricultural production and productivity, making the conclusions and recommendations for resolving various relevant problems in Nepal.
- Publish agriculture related booklets, compendia of research findings and scientific journal that are useful to farmers, extension, scientists and related persons.
- Organize various programs for the SAS-N members with an aim to share their research experiences among themselves and to coordinate their activities with national and international institutions.
- Provide consultancy services to various domestic and foreign institutions as required.
- Exchange cooperation with various organizations of agriculture and other related professional organizations and institutions, maintaining cordial relationship with them.

MEMBERSHIPS

The SAS-N has the provision of following five types of memberships.

1. General Member
2. Life Member
3. Associate Member
4. Benefactor Member
5. Honorary Member

ACHIEVEMENTS

- The SAS-N has been making significant contributions to organizational development of Nepal Agricultural Research Council (NARC) and improvement in its research management systems. The contribution made by SAS-N towards resolving the issue of conversion of HMG/N staff into NARC system was a crucial one.
- The SAS-N has been occasionally organizing seminars and talk programs to provide a scientific forum to the agricultural scientists and researchers. SAS-N has successfully organized two conventions in which significant numbers of relevant scientific papers were presented.
- The SAS-N has been representing to various policy and decision-making forums to contribute in the development of agricultural research systems in the country.
- The SAS-N has hitherto published 4 volumes of a scientific periodical in the name of Nepal Agriculture Research Journal in collaboration with NARC and one proceedings of SAS-N convention.
- The SAS-N has two editorial committees, one for a scientific journal and other for a Nepali periodical especially useful for enthusiastic farmers and entrepreneurs.

FINANCIAL RESOURCES

The SAS-N mobilizes its financial resources being earned from the membership fee, various SAS-N publications, seminars, conferences, symposia, exhibitions, commercial advertisements, consultancy received from individuals, government or non-government organizations both national and international, and other forms of income sources such as donations, grants, etc.

SAS-N EXECUTIVE COMMITTEE 2003-2006

1. Dr Adarsh Pradhan	President
2. Ms Shanti Bhattarai	Vice-President
3. Dr Madhav Joshi	General Secretary
4. Ms Gyanu Manandhar	Treasurer
5. Mr Kamal Shah	Secretary, Administration Management
6. Mr Binesh Man Sakha	Secretary, Coordination
7. Mr Keshav Prasad Shrestha	Secretary, Finance Management
8. Ms Nirmala Pandey	Member, Seminar, Conference Management
9. Dr Hari Prasad Bimb	Member, Publication Management
10. Mr Bishwa Prasad Mainali	Member, Membership Management
11. Mr Yagya Prasad Giri	Member, Planning and Technical Services
12. Dr Madhusudan P Upadhyay	Ex president

AUTHORS INDEX

Aacharya JR	318	KC RB,	196
Acharya BK	515	Khadka R	536, 542
Acharya MR	381	Khanal R	169
Adhikari BH	82, 85, 249	Khanal SK	377
Adhikari C	82, 85	Khatiwada PP	36, 115, 131
Adhikari P	382	Khatiwada SP	222
Adhikari RC	239	Khatrri B	78, 98, 227, 244, 294
Adhikary SK	15	Khatrri BB	121, 126, 502
Amatya SM	542	Kumar S	369
Aryal MP	469	Lama TK	89, 292
Aryal SR	366	Lama TL	302
Baidya S	523	Lamsal GP	412, 418, 422
Bajracharya B	479	Malla S	178
Bajracharya K	427	Manandhar GB	19
Bakker RR	19	Manandhar R	174, 178
Banstola BR	442	Maurice M	153
Barakoti TP	47	Mishra K	346, 370
Basnet SR	412, 418	Mudwari A	222
Batajoo R	382	Neopane M	381
BC BB	82, 85, 249	Neopane SP	345, 346
Bhatiya AK	88	Nepal AP	418, 422
Bhattarai EM	187, 473	Nepali MB	457
Bhattarai KK	153	Neupane D	335
Bhujel RB	462	Neupane FP	6
Bhurer KP	33, 271	Neupane RK	187
Bimb HP	146	Niroula RK	147
Bista JD	382, 406	Oli OB	111
Chapagain TR	502	Osti NP	347, 377, 492
Chaudhari D	121, 126	Pandey L	552
Chaudhary B	222	Pandey N	542
Chaudhary BN	92	Pandey YR	92, 207, 216, 235, 447
Chaudhary C	249	Paneru RB	169
Chaudhary DK	204, 239, 473	Pant BB	457
Chaudhary JN	98, 227, 244, 294	Panthee DR	196
Chaudhary RN	532	Paudel CL	479
Chaudhary SL	1	Paudel KB	98, 227, 244, 294
Deo SN	381	Paudel KP	362, 369
Devkota SR	174	Paudyal KR	492
Dhakal DP	310, 324	Piya S	115, 131
Dhakal RP	382, 406	Pokharel PK	345
Dhaubhadel T	335, 347	Pokhrel BB	111
Dhital BK	67	Pokhrel DN	200
Duveiller E	282	Pokhrel TP	462, 536, 542
Duwadi VR	169	Poon TB	111, 137
Emmett B	97	Pradhan N	398, 422
Gautam DM	196	Prasad JB	279
Gautam IP	28, 78, 98, 227, 244, 294	Prasai HK	154
Ghale MS	82, 85, 249	Pun AB	216, 235, 447
Gharti DB	33, 271, 279, 282	Rai AK	382, 412
Ghimire LP	362	Rai GP	121, 126
Ghimire TB	41	Ranabhat DB	82
Ghimire YN	462, 473, 536, 542, 561	Rasaily R	19, 11, 15
Giri YP	169	Rayamajhi A	393
Guatam S	542	Regmi HB	137
Gurung TB	382, 406, 412	Regmi HN	111, 141
Gyawali S	222	Roy NK	427
Jones JE	105	Rutherford M	282
Joshi BK	222, 252, 265, 432	Sah DN	78, 178, 216, 294
Joshi BR	362, 370	Sah G	33, 279
Joshi KD	222	Sah ML	33
Joshi KR	457, 508	Sah YP	161
Joshi M	536, 542, 552	Sakha BM	88
Joshi PL	382, 412	Shah A	362
Justice S	33	Shah G	282
Karki GB	406	Shah ML	271
Karki KB	265, 330, 432	Shah MP	271
Karki M	347, 442	Sharma A	60
Katuwal RB	485	Sharma BP	318
KC P	469	Sharma D	282

Sharma MD	196	Shrestha SL	121, 126
Sharma PN	174	Shrestha SP	366, 381
Sharma RC	147	Sinclair FL	97
Sharma RR	204	Stevens P	97
Sharma S	282	Sthapit BR	222
Sharma SR	111	Subedi LP	147
Sherchan DP	97	Thakur NK	542
Sherchan K	60	Thakur NS	523, 552
Shrestha B	542, 552	Thakur P	473
Shrestha BS	353, 370	Tiwari MR	377, 552
Shrestha GL	15, 19	Tripathi BP	105, 479
Shrestha HK	222, 462, 473, 542, 561	Upadhyay KP	98, 227, 244, 294
Shrestha K	222	Upadhyay MP	147, 222
Shrestha KB	15	Upreti G	141
Shrestha KP	523	Vaidya ML	187, 211, 214
Shrestha PP	89	Wagle SK	382, 398, 406
Shrestha R	187	Wilcockson SJ	67
Shrestha S	11, 60	Yadav NK	200
Shrestha SB	338	Yadav YP	235, 508
Shrestha SK	324, 422		