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AGRICULTURAL RESEARCH FOR DEVELOPMENT

Proceedings of the Fourth SAS-N Convention

4-6 April 2012, Lalitpur



Nepal Agricultural Research Council
(NARC)



Society of Agricultural Scientists - Nepal
(SAS-N)

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**Nepal Agricultural Research Council
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**Society of Agricultural Scientists, Nepal
(SAS-N)**

Fourth SAS-N Convention

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Cover Page Photos: Left to right – 1. Development of Seed Cleaner, Agri. Engineering Division (Photo: Shreemat Shrestha); 2. Research on native mushrooms, Plant Pathology Division (Photo: Suraj Baidya); 3. Research on citrus fruits, National Citrus Research Program (Photo: Hira Kaji Manandhar); 4. Introduction of Boer buck and production of female Boer herd through artificial insemination at ARS (Goat), Bandipur (Photo: Ram Ghimire); 5. Farmers' participation in rice research, Gene Bank (Photo: Madan Raj Bhatta); 6. Feeding experiment on dual purpose Giriraja chicken at Dolkha Bazar, Swine and Avian Research Program (Photo: Tulsi Paudel); 7. Adoption of resource conservation technology in wheat, Mr. Jaya Kishor Yadav, Parsa (Photo: Shreemat Shrestha); 8. In-vitro plantlet production for pre-basic seed production and research on potato, National Potato Research Program (Photo: Shambhu Prasad Dhital); 9. Participatory research on trout farming, Mr. Kacchyapati and Partners, Melamchi (Photo: Tek Bahadur Gurung).

Foreword

The Society of Agricultural Scientists of Nepal (SAS-N) has successfully organized its Fourth Convention with the theme of "Agricultural Research for Development". I am pleased that the Convention provided an important forum for agricultural scientists and researchers working in different organizations for sharing and interacting on various aspects of agricultural research and development. This proceedings as an outcome of the Convention includes 67 papers, covering almost all sectors and areas of agricultural research for development. I appreciate scientists and researchers for their commendable research works and their findings. I hope the technologies and information presented in this proceedings will be useful and informative to researchers, extension workers, farmers, entrepreneurs, academicians, administrators, policy makers and others involved in agricultural research and development.

Nepal Agricultural Research Council (NARC) has been collaborating with SAS-N in different activities, including the joint publication of 'Nepal Agriculture Research Journal' since the beginning. NARC has started supporting SAS-N for publication of proceedings since its Third Convention. I congratulate SAS-N for bringing this publication in this form and look forward to strengthening the scientific collaboration in the years to come.

Dil Bahadur Gurung, PhD

Executive Director

Nepal Agricultural Research Council (NARC)

Singhadurbar Plaza, Kathmandu, Nepal

Preface

The Society of Agricultural Scientists, Nepal (SAS-N) is a non-profit professional, scientific organization dedicated to the research and development of agriculture in Nepal. It serves as a common forum for the agricultural scientists and researchers scattered throughout the country in various agricultural and related institutions.

SAS-N organized its Fourth Convention from 4 to 6 April, 2012 (Chaitra 24 - 26, 2068) in Lalitpur with the theme of "Agricultural Research for Development". The main objective of the convention was to create a scientific forum for sharing of knowledge and experience of agriculture research and development. Five parallel sessions on (1) crops, (2) horticulture, (3) livestock, (4) Organic Agriculture: Trends and Sustainability, and (5) Advancement in Aquaculture Research in Nepal were organized. Over 150 papers on food security, agro-biodiversity, agronomy, horticulture, plant breeding, crop and soils management, physiology, micro-nutrients, irrigation, livestock improvement, livestock production, animal nutrition, animal health, fodder and pasture, fisheries, agro-forestry, climate change and socioeconomics were presented.

This proceedings include the technical and thematic papers presented in the convention. The authenticity of the papers and the opinion expressed therein are those of the respective author(s). I hope the information and findings presented in the proceedings bear a meaningful and productive impact on agriculture research and development in Nepal. Special thanks are due to the members of the Editorial Board and contributors for their valuable contribution in compiling and editing papers to bring the proceedings in this shape.

I would like to greatly acknowledge the then SAS-N Executive Committee for successful completion of the Fourth SAS-N Convention and express sincere gratitude to all the SAS-N members for active and fruitful participation in making the Convention a success. My special appreciation goes to the International Maize and Wheat Improvement Center (CIMMYT), Regional Office, Kathmandu Nepal for its generous support. Sincere thanks go to Nepal Permaculture Group (NPG), Nepal Horticulture Society (NHS), Nepal Fisheries Society (NFS), Institute of Agriculture and Animal Science (IAAS), Asian network of Organic Farming Technology (ANSOFT) of Asian Food and Agriculture Cooperation Initiatives (AFACI) and Sustainable Agriculture Development Program (SADP) for co-sponsoring different events.

The Convention and publication of this proceedings would not have been successfully accomplished without the financial and logistic support of Nepal Agricultural Research Council (NARC). On behalf of SAS-N, I extend my gratefulness to the Executive Director, Dr. Dil Bahadur Gurung and the NARC management and also expect continued support and collaboration from NARC in the days to come.

Hira Kaji Manandhar, PhD

President

Society of Agricultural Scientists, Nepal (SAS-N)

Video Message from Prof. M. S. Swaminathan

I would like to congratulate Dr. Hira Manandhar and all the members of the Society of Agricultural Scientists of Nepal for their timely initiative in organizing a Convention on Agriculture Research for Development. Because in all over the countries, whether it is Nepal or India, we require accelerated development, which is inclusive in nature in terms of the transmission of its benefits to all sections of their community. In both of our countries, agriculture is a predominant source of rural livelihood and even of urban areas. In fact, in India, even now with population of 1.2 billion, 75% of the population depend on agriculture for their livelihood. Therefore, agriculture in our countries is not just a food producing machine but is the backbone of the livelihood security system of our majority of the women and men in rural areas. This is why I congratulate Society of Agricultural Scientists for choosing the theme 'Agriculture Research for Development'.

We must accelerate development but without any ecological cost, without environmental damage, this is what now called 'Green Economy' and it is particularly appropriate this Convention is being held just before the 20th Anniversary of Rio Conference on Environment and Development popularly known as the 'Earth Summit' held at Rio de Janeiro in Brazil in June 1992. There will be another conference this year to review the progress we made in incorporating the principles of ecology and environmental sustainability in all branches of economic activity like agriculture, industry, energy generation, climate change management and so on.

Agricultural science has been the trigger of major progress in every field endeavour whether crop husbandry, animal husbandry, fisheries, forestry and agro-forestry. They are all science-based and science is prime mode of progress. This is why it is important to look at agricultural research organizations, their priorities and their organizational structures. Also, another unique important feature is we are predominantly countries with young people. In fact, it has been calculated that by 2020 India will be youngest country in the world, so will also be Nepal with a very large young population. Attract and retain youth in farming has become a major challenge. And this would be possible only if the young people get both intellectually stimulated and economically rewarded when they take the agriculture as a profession. Again, I want to repeat, when I say agriculture, I mean crop and animal husbandry, fisheries, forestry, agro-forestry, agro-processing and agri-business. Our young people will take this occupation only when they find, as a result of their education, they are expecting that work will be sufficiently interesting not only economically rewarding but also intellectually stimulating. This is where the technological transformation of agriculture becomes very important.

The early 60s and what we had called Green Revolution, there was a major technological change caused by dwarfing genes in wheat and rice. The dwarfing gene in wheat was first discovered in Japan. Similarly, the dwarfing gene in rice was first discovered in China and later on rice hybrid came and many of the development took place. And more recently, following discovery of the double helix structure of the DNA molecule by Watson and Crick in 1953 at Cambridge, we find the whole science of molecular biology and genetic engineering, recombinant DNA technology, they all blossomed and they opened up common opportunities for new genetic combinations. In other words, novel genetic combinations are possible. For example, my own centre in Chennai which is on the Tamil Nadu

Coast, we have developed very good rice varieties, which have got high degree tolerance to salt, sea water tolerance. These genes have come from mangrove. I myself did my doctorate degree in genetics in 1952 at Cambridge. At that time, I did not even dream that could be possible to transfer genes across sexual barriers in the way we are doing now. In fact, I had to transfer genes from potato species called *Solanum acaule* from the lake Titikaka region of Peru, Bolivia.

To potato, by very complex method, what was known by then 'Swaminathan Artificial Stigma Method'. Today, it is very easy to transfer genes across sexual barriers. Similarly, new technologies in the field of information, communication technology have become available. Mobile phone is one of those transformational technologies. Everybody has access to it today, we can send messages, timely messages on the monsoon, on the market. These are two very important determinants for the farmers' wellbeing. How will the monsoon behave; will there be floods; will there be drought; how will the market behave; what is the price; what is the support price of the Government, what kind of prices people can take. So, the monsoon, market and many other issues of day to day relevance to farm women and men can be communicated to them through the internet, community radio and mobile phone. And the combination of internet, mobile phone and community radio is a very powerful method of combining up to date generic information and we can convert them into location specific information. This is why we called our centres as village knowledge centres. Information is passive, knowledge is interactive, what is important more and more for people is to get together. So, we have the modern information technology, modern biotechnology, and new kinds of technologies like nano technology are coming. The space technology, space applications are opened up. New opportunities for remote sensing for following what is happening to our forest, what kind of damages taking place and so on.

I need hardly mention before this very enlightened audience with so many distinguished scientists from Nepal and from outside, about the common opportunities available today through the fast progress of modern science. But to take all the science, make it relevant to Nepal, to have location specific research, to organize participatory research with farming families, because that is the way to sustainable development. Unless we combine the ecological prudence of the local communities with modern science we will not have sustainability. So, we need participatory research, we need anticipatory research to meet the challenge of climate change, of glacier melting, of snow melting and also of whole questions of drought and floods, and also we need strategic research using modern tools of biotechnology, genetic engineering, nano technology and so on. To create new varieties, to create new growing conditions, new agronomic practices, new methods of feeding the plant, it is not necessary, it is not enough if we just do breeding. We can do breeding for high yield, but we should also feed for high yield. Feeding for high yield and breeding for high yield should go together because unless this is done we will not get the full benefit of the genetic potential for yield.

Ladies and gentlemen, I appreciate this privilege and Dr. Manandhar was kind enough to ask me to come personally. Unfortunately, I am not able to come but I highly value this opportunity to share some thoughts with you. I mentioned the challenges before us in agriculture. One is the conservation and enhancement of the ecological foundation of sustainable agriculture like land, water, biodiversity and the climate change and so on. We must protect the ecological foundation of sustainable agriculture, we must achieve a technological and management revolution of small farm agriculture. Only then, we will be able to attract the young people to come. We must also mainstream the gender

dimension in all of the programmes because increasingly there is a feminization of agriculture and women do much of the work, much of the hard work, much of the back breaking work. It is very important that the role of women in agriculture is not only recognized but technologies for women are exceedingly important.

2014 has been declared by the United Nations as the 'International Year of Family Farming'. Family farming is going out in industrialized countries but in our countries farming is not only a means to livelihoods but it is also a way of life. The International Year of Family Farming should be the turning point in our history, in our agriculture. In paying once more attention in family farms, women, men and children who are working in the family farms; how to equip them to meet the new challenges, how to enable them to increase the productivity, profitability and sustainability of small farms, these are all challenges. To meet these challenges, we require a very good scientific organization. Nepal Agricultural Research Council is there. We must further strengthen them, we must arm them with new possibilities, both financially and also administratively. They must become the flagship of the new agriculture movement in Nepal, of the new family farm movement in Nepal. I request the Honourable Minister and the other authorities present here that give your support to science, develop Nepal Agricultural Research Council, equip them with new equipment with additional investment, and more importantly give them autonomy and the authority necessary for them to help the farmers of Nepal.

I wish the Convention a great success.

Prof. Dr. M. S. Swaminathan

Chairman, M. S. Swaminathan Foundation (MSSRF)

3rd Cross Road, Taramani Institutional Area Chennai (Madras) 600 113 – INDIA

and

Member of Parliament (Rajya Sabha), Republic of India

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Crop Research in Nepal: Present Status and Future Strategies

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ABSTRACT

Crop sector in agriculture has dominant role contributing 50% of agriculture gross domestic product (AGDP) in the national economy. Rice, wheat, grain legumes and industrial crops are dominant in the terai (southern plain) whereas maize, millets and barley in the hills. Compared to the average of base years (1990-1992) with the average of recent three years (2008-2010) the increase in production in rice, maize and wheat was 40, 57 and 97%, respectively. Among several other factors, the technology must have had significant role in the increase. However, this increase is below the expectation given by Agriculture Perspective Plan (1995-2015). A total of 191 crop varieties have been released with package of practices for various production domains. The varieties were mostly identified to have the tolerance for biotic and abiotic stresses of concerned crops with the increased yield in the existing cropping systems compared to the farmers' varieties. The coverage by improved varieties was more than 87% in the major food crops rice, maize and wheat. However, the seed replacement rate is on average 10% for these three crops and only 3-4% for other crops like finger millet, lentil and oilseeds. Besides these, management practices such as dates and methods of planting, management of soil, water, nutrient, disease and pest, and post harvest measures have been developed and promoted. Resource conservation technologies have been developed mostly in rice-wheat system. The level of production, however, was not enough to meet the demand of population growth in the country and the country was in deficit of edible cereal grain production from 1989 to 2010. Especially, the mid and high hill districts were often suffered from food deficits and in recent years some terai districts have also been identified as food deficit. Farmers growing these crops are facing several constraints related to technology and its transfer system and policy concerns. The possible strategies to address the concerned issues are discussed.

INTRODUCTION

Agriculture is the dominant sector in Nepalese economy. It contributes 35% to gross domestic product (GDP), 66% to total employment and 16% to total trade (MOAC 2011). The total cultivated agricultural land area is 3 million hectare and around 40% is irrigated (MOAC 2011) revealing the dominance of rainfed agriculture in the country. The land holdings are very small with average size of 0.8 ha (CBS 2001). Almost 74% of the farm households have less than one hectare of land where as about 26% of the larger farmer (>1.0 ha) occupy more than 60% of the farm land. The growth in agriculture sector is 3.0% and the crop sector accounts almost 50% to agricultural GDP.

The agronomical crops grown in Nepal can be grouped as cereals, legumes, oilseeds and industrial crops. Cereals, consisted of rice, maize, wheat, millet and barley, are the major source of food in the country. The area under cultivation of these food crops are given in table1. Rice, wheat, grain legumes, oilseeds and sugarcane are dominating in the terai where as maize, millets and barley in the hills. Rice, maize and wheat are the three important crops that account over 90% both in area and food grain production contributing 35% to AGDP and are the prioritized food crops visualized by Agriculture Perspective Plan (APP 1995) to meet the growing demand of the food for 20 years (1995-2015). However, the productivity of these crops is quite low i.e., 2.98, 2.28 and 2.27 mt/ha for rice, maize and wheat, respectively in 2010/11 (MOAC 2011). In other cereals, it is 1.1 mt/ha for finger

millet and 858 kg/ha for barley. The poor productivity is due to the cumulative effect of several factors like low fertilizer and other inputs use, poor access of improved seed and inadequate production technologies.

Grain legumes (pulse) are important in terms of their contribution to human nutrition and improving soil fertility. They occupy 10.3% of total cultivated land of the country. Pulse is the essential component of Nepalese diet. The major grain legumes grown in Nepal are lentil, chickpea, pigeon pea, soybean, black gram, grass pea, horse gram, cowpea, mung bean, ricebean and others. They are mostly rainfed crop and grown in marginal land and mostly planted as mixed, inter, sequential or relayed crop. Lentil is the leading pulse crop of Nepal grown throughout the country in rice or maize-based cropping systems. The priority legume crops for the terai are lentil, pigeon pea, chickpea, horse gram, grass pea, mung bean, cowpea and Phaseolus bean; for the mid hills are black gram, soybean, horse gram, lentil and ricebean; and for the high hills are ricebean, Phaseolus bean and field peas. The overall productivity of the grain legumes is 952 kg/ha (MOAC 2011).

Oilseed crops cover about 6.3% of the total cropped areas in the country and overall productivity is 824 kg/ha. They are good source of oils and fats in Nepalese diet. The oilseeds are also good source of minerals, proteins and vitamins compared to cereals. At present, Nepal is importing considerable amount of oil of different sources. The important oilseed crops are rapeseed mustard, linseed, groundnut, sesame and niger. The rapeseed mustard constitutes about 90% of the total oilseed crops.

The major industrial crops in the country are sugarcane, jute, tobacco and cotton. The area of all these four crops is 74827 ha, of which sugarcane alone consist of 62998 ha (Table 1). The national yield of sugarcane is 43.15 t/ha and its cultivation is mainly concentrated in the terai region. The cultivation of jute is concentrated in the eastern terai, tobacco in the central terai and cotton in the mid western terai. The area of jute, tobacco and cotton are 10559 ha, 1135 ha and 135 ha, respectively (MOAC 2011).

Table1. Area of major agronomical crops in different agro ecological regions in 2010/11 (MOAC 2011)

Crops	Total area	High hills		Hills		Terai	
		Area	Percent	Area	Percent	Area	Percent
Paddy	1,496,476	66713	4.46	407037	27.20	1022726	68.34
Maize	906,253	98527	10.87	623176	68.76	184550	20.36
Wheat	767,499	52118	6.79	265435	34.58	449946	58.62
Millet		53879	19.97	206340	76.47	9601	3.56
Barley	28,461	14154	49.73	13055	45.87	1252	4.40
Legumes	334,380	12500	3.74	69008	20.64	252871	75.62
Oilseeds	213,706	3501	1.64	45276	21.18	164929	77.18
Sugarcane	62,998	272	0.43	1331	2.11	61395	97.46

Government plans and policies

The 20-year Agriculture Perspective Plan (APP) for 1995-2015 describes the broader policy for agriculture development in Nepal with emphasis on priority inputs, outputs and outcomes. Technology is one of the important inputs considered by APP. The subsequent periodic plans - the Tenth Five Year Plan (2002-2007), the two Three Year Interim Plans, 2007-2010 and 2010-2013, and the National Agriculture Policy (2004) drive the fundamentals set by APP to achieve poverty reduction and nutritional food security with the focus on commercialization and diversification in agriculture.

This paper presents the status of production of various crops, some of the major available technologies related to these crops, constraints, emerging issues and challenges, and future strategies of crop research in Nepal.

METHODOLOGY

Statistical information published by Ministry of Agriculture and Cooperatives (MOAC) and Central Bureau of Statistics (CBS) in various years were compiled and analyzed. Annual reports of different research stations Nepal Agricultural Research Council, workshops proceedings and other relevant publications were reviewed and discussed.

RESULTS AND DISCUSSION

Poverty, food production and balance

Poverty is the major problem of Nepal. The Millenium Development Goal number one is to reduce the extreme poverty and hunger from 1990 to 2015 is the most challenging for a least developed country like Nepal (Khatiwada 2006). It is to be reduced by halve to the number of people whose income is less than dollar a day and number of people having chronic hunger in this period. Though poverty was reduced from 42% in 1996 to 31% in 2004 (CBS 2005) contribution of agriculture sector in it was not considered significant as it was mainly attributed to remittance. Despite the government's continuous efforts, the increase in production and productivity of the cereal crops were not satisfactory in almost all the cereals in the last two decades (Table 2). On the average of recent three years (2008-2010) data compared with the average of the base three years (1990-1992) the percentage increase in both the production and productivity was higher in all the cereals except millet. The increase in production was from 2.4% in barley to over 101% in sugarcane and productivity ranged from 6% in legumes to 86% in wheat and it was in minus 4.0 % in millet.

Table 2. Status of production and productivity of some agronomical crops over years

Crops	Average of base three years			Average of recent three years			% increase over base three		
	(1990-1992)			(2008-2010)			years (1990-1992)		
		Production (ton)	Yield (kg/ha)	Area (ha)	Production (ton)	Yield (kg/ha)	Area (ha)	Production (ton)	Yield (kg/ha)
Rice	1376363	3103200	2246	1511235	4335931	2868	9.8	39.7	27.7
Maize	762340	1242053	1629	885780	1951125	2202	16.2	57.0	35.2
Wheat	592660	787643	1330	731193	1548737	2113	23.4	96.6	85.9
Millet	199527	232347	1164	268061	298299	1113	34.3	28.4	-4.4
Barley	29650	27697	934	26959	27017	1000	9.0	2.4	7.0
Legumes	308167	250181	812	322374	278701	863	4.6	11.4	6.3
Oilseeds	158707	91223	575	197869	155590	784	24.7	70.5	36.3
Sugarcane	36233	1254390	34620	59803	2522579	42154	65.0	101.0	21.8

Among the three major food crops, wheat ranked first giving 97% of increased production followed by maize (57%) and rice (39.7%). However, the increase in production was low to overcome the population growth rate. The population growth was mostly over 2.0 percent per annum before 2010 and 1.4% in 2010/11 resulting food deficit in most of the years (Fig 1).

The food balance was improved in earlier years of implementation of APP but later it dropped to minus. It could be due to low investment in agriculture (NARC 2010) during the period and long political conflict in the country. The deficit was more pronounced in the hills and the high hills by agro-ecologically (Table 3) and in the central, mid and far-western by development region-wise (Table 4).

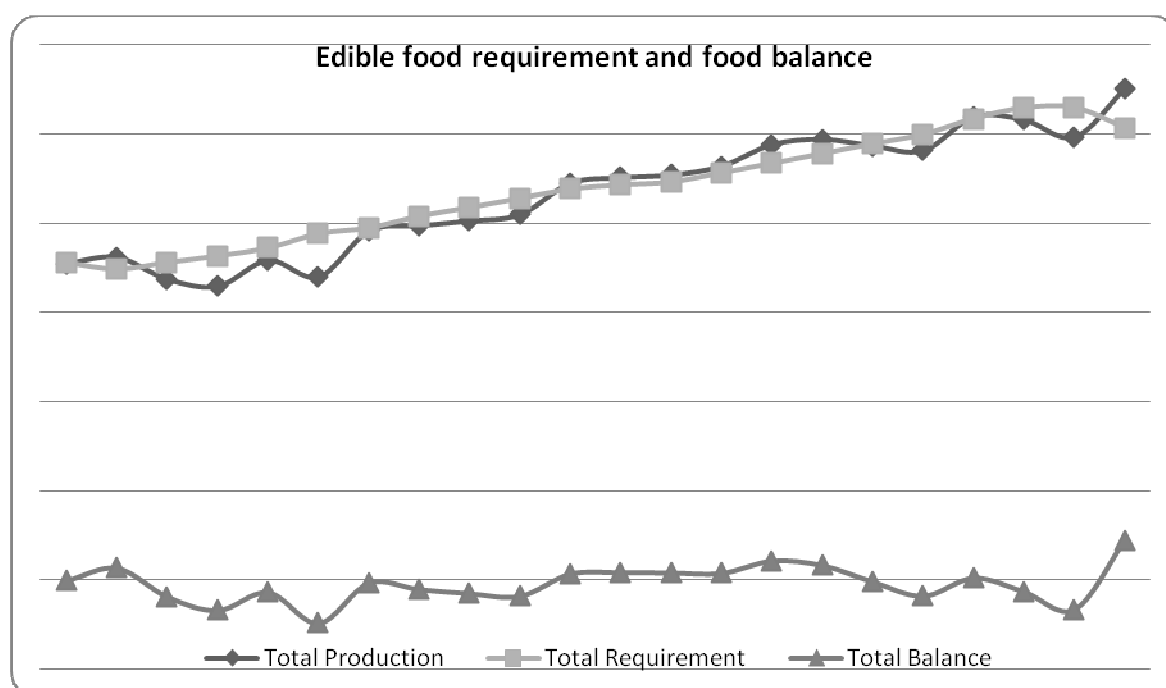


Fig 1. Edible cereal grain production and requirement of Nepal (mt), 1989/90-2010/11

Table 3. Agro-ecological region-wise total food requirement and balance of cereals in metric ton (2008/09-2010/11)

Regions	Total available edible food	Total requirement	Balance (+,-)
High hills	910154	10,89,594	(-179440)
Hills	6377519	71,84,187	(-806667)
Terai	8353079	73,86,797	(966285)
Total	15640752	15660578	(-19826)

Source: MOAC (2011)

Statistics of 2009/10 (MOAC 2010) showed the food deficit in 37 districts in the country. Recently, the food deficit has been observed even in some of the terai districts. Similarly, the increase in production in overall legume crops was very low (11%) in the last two decades. The increase in production in oilseed crops was 70% which was much higher than legumes, rice and maize but still not enough to fulfill the demand of the country. Similarly, the production increase in sugarcane over two decades was 101% but still a lot to do to meet the growing demand of sugar in the country. Technology generation and transfer have to play a vital role to meet this national challenge for fulfilling the food requirement in the country.

Table 4. Development region-wise total food availability and balance of cereals (2008/09-2010/11) (MOAC 2011)

Development region	Total available edible, mt	Total requirement, mt	Balance (+,-), mt
Eastern	39,39,653	34,44,516	4,95,137
Central	44,17,139	56,07,023	-11,89,881
Western	39,09,349	30,30,365	8,78,984
Mid Western	21,30,471	20,69,658	60,813
Far Western	12,44,137	15,09,016	-2,64,879
Total	1,56,40,750	15,66,0578	-19828

Available agricultural technologies and status of research in agronomical crops

A total of 191 different crop varieties have been released for cultivation in different agro-climatic regions of the country till 2011 (NARC 2012) which are summarized in table 5. Among 191 crop varieties, there are 132, 34, 17 and 8 varieties for cereals, grain legumes, oilseeds and industrial crops, respectively.

Table 5. Number of crop varieties released for various domains till 2011

Crops	High hills	Hills	Terai	Total
Total(all crops)	10	61	120	191
Cereals	10	43	69	132
Rice				
Spring	0	0	11	11
Main season	5	19	33	57
Total(Rice)	5	19	44	68
Maize	3	10 (2*)	10	23
Wheat		11 (**)	21	32
Finger millet	1(**)	2 (1*)	0	3
Barley	1	1	4	6
Grain legumes	0	17	17	34
Lentil	0	7 (5*)	3	10
Chickpea	0	2 (*)	6	8
Pigeonpea	0	0	2	2
Soybean	0	5 (1*)	3	8
Blackgram	0	1	0	1
Cowpea	0	2*	2	4
Mungbean			1	1
Oilseeds		1	16	17
Rape seed(Tori)		1	5	6
Mustard (Rayo)			2	2
Sesame			1	1
Niger			2	2
Groundnut			6 (4*)	6
Industrial crops(sugarcane, jute, cotton and tobacco)			8	8

*Indicates suitable for terai, inner terai and mid hills. ** indicates suitable for mid hills and high hills.

In rice, 68 varieties have been recommended with package of practices, including various cultural management and plant protection measures. The varieties are non-sensitive to photoperiodism and fit for various cropping systems. The popular varieties for various domains are given in table 6. The predominance of some of these popular varieties has also been discussed by Khatiwada and Upreti (2008). Several of them are resistant or moderately resistant to major diseases like blast and bacterial blight but susceptible to major insect pests like brown plant hopper, gall midge and stem borer and abiotic stresses like drought and submergence. Farmers mostly prefer the local varieties than the improved varieties for grain quality parameters and they need the low cost technologies. The future research should focus on these aspects.

Along with the varieties technologies like proper age of seedling, planting time, nutrient and water management, weed control and crop establishment practices etc have also been developed (NRRP 1997, NARC 2009 and 2010). Bacterial blight and sheath blight are the major diseases of rice in the terai and inner terai and blast is the major disease in the hills. Recommended varieties are mostly resistant to bacterial blight and blast. Chemical control (Validamycin @ 2ml / lit.) recommended for

Table 6. The popular rice varieties for various domains

Agro-ecological region	Domain/Season/Area	Varieties
Terai, inner terai and foot hills	Spring rice	Hardinath 1, Chaite 2
	Irrigated normal rice	Sabitri, Makawanpur 1, Rampur Mansuli, Mithila, Ram
	Rainfed Low Land Rice	Radha 4, Radha 7, Radha 11, Radha 12, Loktantra
	Rainfed lowland and climate resilient	Sukkha 1, Sukkha 2, Sukkha 3, Tarhara 1 and Hardinath 2 for drought prone rainfed and Swarna sub1 and samba mahasuri sub1 for submergence prone areas.
	Upland rice	Ghaiya 1, Ghaiya 2
Mid hills	Aromatic rice	Lalka Basmati, Sunaulo Sugandh
		Khumal 4, Khumal 8, Taichung 176, Chainung 242, Khumal 11, Pokhrela Jetho Budho (Aromatic), Khumal 10, Khumal 13
High hills		Palung2 (Palung Area), Chandannath 1 & Chandannath 3 (Jumla Area), Chhamrung and Machhapuchhre1 (Western Hill Area)

sheath blight. IPM technologies for most of the major insects (brown plant hopper, stem borer, rice bug, mealy bug).

In maize, there are number of early to medium duration open-pollinated varieties but there is lack of hybrid ones. Altogether 23 maize varieties have been released so far including one hybrid "Gaurav". The major popular varieties are given in table 7. Hybrid Gaurav could not get commercialized due to some technical problems. The demand of hybrids is high, especially in the terai and inner terai. NARC has given priority for development of maize hybrid and some other promising hybrid combinations are in pipeline. The combination RML 4/NML 2 is ready for release (NMRP 2010). Research work is going on quality protein maize which is equally important for both food and feed purpose in terms of nutrition and one variety "Poshilo Makai" has been released. There are varieties resistant to downy mildew, northern leaf blight and stem borer. Other maize production technologies like optimum plant population, weed control, integrated nutrient and water management practices have been developed. Management technologies for major diseases (leaf blight) and insect pests (stem borer, cut worm, army worm) and biological control for white grub are also available (NMRP 1997, NARC 2009 and 2010). Maize planter (jab seeder) identified suitable and commercial production promoted and Suitable technology for baby corn production also identified. Community based seed production program for hills is very effective. The maize grown under rainfed conditions often suffers from drought when rainfall is not adequate. Future research areas are hybrid maize, quality protein maize, early duration and breeding for tolerant to drought and major biotic stresses.

Table 7. The popular maize varieties for various domains

Agro-ecological region	Season	Varieties
Terai, inner terai and foot hills	Spring maize	Arun 2, Arun 4
	Barkhe season maize	Rampur Composite
	Winter maize	Mid hill varieties
Mid hills	Barkhe season maize	Mankamana 3, Mankamana 4, Deauti, Khumal yellow
High hills	Barkhe season maize	Ganesh 1, Ganesh 2

The research in wheat has significant impact in Nepalese agriculture. A total of 32 varieties have been released for various domains. A number of wheat varieties have been identified and developed as resistant to leaf rust, yellow rust and foliar blight diseases. Some of the varieties are also tolerant to terminal heat stresses. The available and popular varieties are Vijaya, Gautam, Aditya, NL 971, Bhrikuti, BL 1473 and NL 297 for terai, inner terai and foothills. Similarly, Annapurna 3, Annapurna 4 and WK 1204 are among the presently available and recommended popular varieties for hills. WK 1204 is the most popular and resistant to yellow rust. Attempts are being done to breed rust resistant wheat varieties especially leaf rust for terai and yellow rust for hills. Recently, the significant work has also been done in identifying, developing and promoting the resistant varieties to black rust pathogen, especially Ug99 race in terai, inner terai. The Ug99 has not been entered in the region yet but if entered Nepal is ready to cope with that pathogen. Bijay, resistant to UG 99 race has recently been released for this purpose. The other promising genotypes are also in pipeline to release. Work on drought tolerance is yet to achieve at required level. Control measures for seed borne diseases and major weeds are developed. Some achievements have been made for generating the technologies on integrated soil fertility management practices including zinc, boron and sulfur deficiencies (NWRP 1997), resource conservation (zero tillage, reduced tillage, surface seeding, bed planting) and management of leaf blight and foliar leaf diseases in the terai and inner terai (NARC 2009 and 2010).

In the hill crops like finger millet, barley, buckwheat, amaranths (also known as underutilized crops), there is inadequate access to exotic germplasm due to poor linkages with international centers. Altogether nine varieties have been released in finger millet and barley (Table 5). In barley, the variety Bonus has been identified for high malt content, suitable for beer industry. However, not much research work has been done in these crops. Blast and Cercospora leaf spot in finger millet and yellow rust in barley and low input use are among the major problems in these crops.

In grain legumes (pigeon pea, lentil, chickpea, soybean and black gram), there are 34 varieties released for the farmers. Sagun, Maheshwar Bharati and Sital of lentil, Tara and Avrodhi of Chickpea, Puja and Tarkari Bhatmas 1 of soybean and Malepatan 1 of vegetable cowpea are some of the new and important varieties for farmer's cultivation. Integrated disease management practices for pigeon pea and lentil have been developed (NGLRP 2010). Similarly, in oilseed crops there are 17 varieties developed for farmers to grow in their field (NARC 2012). The major oilseed crops are groundnut and rapeseed (Tori) and mustard (Rayo). Some of the new varieties are Baidehi and Rajarshi in groundnut and Preeti and Unnati in Rapeseed (NARC 2009 and 2010). Integrated crop management practices including diseases and weeds have been developed in these crops. Alternaria blight, white rust, stem blight and downy mildew are the major diseases of these crops.

Among the four industrial crops, sugarcane is the major one in terms of area as well as its contribution in national economy. Four varieties have been developed and recommended in this crop for various production domains like irrigated high fertility management, rainfed, lowland water logging and late planting conditions (SRP 1997, NARC 2009 and 2010). Crop management practices like intercropping, proper planting time, optimum plant population, method of planting, ratoon

management, integrated weed and nutrient management technologies have been developed. Integrated pest management for borer complex is also available for this crop.

Constraints

Lack of improved varieties tolerant to different biotic and abiotic stresses: Both the biotic and abiotic stresses are major factors causing poor yield of the crops and are crop specific. The biotic factors in rice include blast, bacterial leaf blight, plantoppers, stem borer and gall midge. Similarly, Turcicum leaf blight, ear rot, stem borer, grey leaf spot in maize and rusts and foliar blight in wheat are the major biotic stresses. In minor cereals, finger blast and Cercospora leaf spot in finger millet and yellow rust in barley are the major biotic stresses declining the crop yield. In grain legumes, pod borer and wilts are problems in chickpea and pigeon pea. There are several virus diseases in soybean, cowpea and mungbean. Alternaria blight and aphid are major pests in rapeseed and mustard. Red rot is the major disease of sugarcane.

Insect biotypes and pathogen races/pathotypes causing various diseases of the crops change over time and space. Identification of insect biotypes and plant pathogenic races of most of the insect and diseases in all the crops have not been done yet except for some crops and pathogens and that have been affecting the efficiency of resistant breeding program.

Among abiotic stresses drought is the common stress in all three major crops rice, maize and wheat. The submergence in terai rice, cold in hill rice and terminal heat in terai wheat are the specific problems. The factors causing abiotic stresses are also complex and vary over locations.

In overall, the present available crop varieties are not sufficient to address all these stresses. Some of the crop specific constraints were also discussed by many authors in the past like in rice by Adhikari (2004 and 2010), in maize by Sherchand (2005), in wheat by Bhatta (2005), in grain legumes by Srivastava (2010) and in hill crops by Prasad (2010).

Declining soil fertility and low fertilizer use: Researches on soil and plant nutrients have shown that soil fertility in Nepal is declining (Regmi et al 2004, Srivastava and Baidya 2004, Sah and Adhikari 2010 and Bista et al 2010). The use of fertilizer is very low and far below the general recommendations made by research. The status of fertilizer use found for rice in a study given in table 8.

Table 8. Use of fertilizer in rice

Growing conditions	Average recommended rate*			Average use rate**		
	FYM (t/ha)	NPK (kg/ha)*	Total (kg/ha)	FYM (t/ha)	NPK (kg/ha)	Total (kg/ha)
Irrigated	6	100-30-30	160	2.4	40-19-4	63
Un-irrigated	6	60-20-20	100	-	-	-

*Source: DOA, STSD 2057; **MOAC/DFID Household survey

Inadequate access of improved seeds: The coverage of improved varieties is very high (>87%) especially in major three crops. However, the seed replacement rate (SRR) is quite low. It is 11.4% in rice, 9.0 % in maize, 11.0% in wheat and 2.3% in millet, 3.3% in lentil and 2.8 % in oilseeds (MOAC, 2011). The remaining demand has been met by farmer's own saved seed or farmer to farmer exchange. The expected SRR for rice, maize and wheat visualized by seed vision 2025 (MOAC, 2011) is 24.25, 31.57 and 22.5 % respectively.

Higher cost of cultivation and low market price for the farmer's production: Major part of the country lacks good road facilities and the transportation cost for inputs is high. Prices for fuel, energy, labor is increasing high every year. The government subsidies is almost absent in seed and was

removed in fertilizer too from late nineties. Some limited subsidies have been reintroduced recently. Mechanization of agriculture is at very low level in the country. All these factors are contributing for higher cost of cultivation in all crops and it more pronounced in wheat. The farmers in general get lower price for their product as there is no proper marketing mechanism in the country. Also, the prices go down when the production is high and that has been discouraging farmers for using high production technologies and inputs.

Limited technology for crop management practices: Packages of management practices are not sufficient for all the crops. It is very low especially in industrial crops like sugarcane, cotton, jute etc. Access to germplasm of industrial crops is also very limited. Technologies for water, nutrient and postharvest management are limited in most of the crops.

Weak policy support and coordination system: The government policies are weak and inconsistent in input and credit support facilities. Support for mechanization is poor. The coordination between research and extension, and also between government and private sector agencies is weak.

Emerging issues and challenges

The national agricultural system has to face the emerging issues and challenges in the present international and national context. Some of these issues and challenges are as follows. NARC vision (2010) has also conceptualized some of these aspects.

Food security: Food sovereignty has been recognized as a fundamental people's right in the interim constitution of Nepal (2006). Consequently, the Government of Nepal included the food security plan in both the Three Year Interim Plans (TYIPs), 2007/08-2009/10 and 2010/11-2012/13 for securing the right to food security for all the citizens. The main objective is to increase production and be "self-reliant". The followings are some of the features considered in both the first and second TYIPs.

- Increase the country's self reliance for basic food stuff
- Improve nutrition situation
- Enhance standards and safety of food stuffs which are available in markets
- Enhance capacity for managing food insecurity that arise from emergency conditions and
- Improve food insecurity prone groups /people's access to foods.

The TYIP has targeted to attain 4.5% of agricultural growth by the end of the last year of the plan period. The expected crop yields visualized by APP (1995) for different cereal crops were 4.0 t/ha for rice, 3.5 t/ha for maize, 3.0 t/ha for wheat, and 2.0 t/ha for millet and 2.0 t/ha for barley. The current crop yield of these crops seems that the target will not be achieved by 2015.

Globalization: Nepal is one of the signatory members of various international agreements related to globalization in agriculture. Among them membership to World Trade Organization (WTO) is the prime concern. There are possibilities of increase in private sector investment both from internal and external sources in agriculture sector and need to address the intellectual property right issues. It also influences the cross border markets and raise the value of product competitiveness.

Climate change: Agriculture heavily depends on natural resources particularly water, soils and forests. Climate changes have adversely affected food and water security, water quality, health, energy resources and sustainable livelihoods of rural communities (MOE 2010b). Followings are some of the important impacts noticed in Nepalese agriculture.

- A shift of adaptation of crops/varieties from terai/inner terai to hills (AEU 2009)
- Occurrence of diseases in the hills from terai (eg, bacterial leaf blight and sheath blight in rice)
- Land degradation due to soil erosion, flooding, siltation etc frequently observed in some parts of the country affecting the crop production and food security in the region.

- Declining trend of river discharge in some area affecting supply of water for irrigation (Practical Action 2009)
- A decreasing trend of rainfall has been observed in rainy days during the last four decades (Shrestha et al 2000).

Commercialization in agriculture: Presently, lentil is serving as potential export commodity. The potential commercial cultivation of major industrial crops like sugarcane, jute, cotton etc is poorly utilized at present. As described elsewhere earlier policy factors are not encouraging the farmers for increased production and productivity for these crops. Although most of the agronomical crops serve as food crops contributing to food security in the country, the major crops like rice and maize could be enhanced as commercial crops. The research has been unable to address the specific technological requirements of majority of agro-processors, traders, distributors and other agro-entrepreneurs. It is also true that there is no link between research and these stakeholders as the later have not come up with their specific researchable issues and needs. These aspects need to be addressed to commercializing the crops.

Future strategies

The national research system is committed for both food security as well as commercialization in agriculture. These holistic objectives guided by the present context of challenging issues could be achieved by addressing the proper research areas, policy support and organizational management which could be briefed as follows.

Genetic resource management: Although the improved varieties coverage is high in major crops there is lack of the niche specific and stress tolerant varieties. The available diverse crop genetic resources are underutilized to address these limitations. The crop improvement program is presently poor in industrial crops. There is no access to improved germplasm in these crops like sugarcane, jute, cotton and some other underutilized crops. The following steps could be outlined to overcome these problems.

- Germplasm collection, conservation, characterization and genetic enhancement must be fully strengthened using conventional as well as new molecular techniques.
- Emphasis should be given for incorporation of molecular breeding like marker-aided selection along with conventional breeding system for breeding tolerance to biotic and abiotic stresses and quality traits.
- Regional and location specific or niche-based germplasm adaptation should be duly considered in varietal improvement.
- Development of hybrid varieties especially in rice and maize for potential domains.

Natural resource management and climate change: Soil fertility in Nepal is deteriorating every year. Rainfed agriculture which is pre-dominance in Nepal has great potential but with efficient management of soil and water as natural resources. Followings are some of the important research agendas in these areas.

- Conservation agriculture
- Minor irrigation management
- Integrated crop management
- Integrated disease and pest management
- Integrated nutrient and water management
- Precision agriculture with improved long range production technology

Post harvest and value addition: Markets for value-added and processed commodities are consistently increasing for every crop product to have competitive market advantage. Underutilized crops like buckwheat, millets, amaranths etc have great scope for postharvest and value-added

research program. A lot could be done even for major crops like rice, wheat and maize in these areas to boost the agro-based industries which ultimately enhance export promotion and import substitution.

Mechanization: The present status of agriculture mechanization is at very low level. The role of mechanization is important to bring down the cost of cultivation, address the agricultural labour shortage in the villages, support intensification and commercialization in agriculture for the food security as well as for enhancing the socio economic condition of farmers in the country. The increased scope of mechanization must be addressed with research initiation along with policy support.

Biorisk management: Biorisk is increasing in agriculture due to climate change and owing to transboundary insect pests and diseases. Development of effective and integrated risk and disaster management production systems is needed to overcome the problem of biorisks.

Technology transfer systems: The effective delivery mechanism must be created to narrow down the yield gaps in all the crops and have increased production. Coordination between various stakeholders for effective on-farm research and its dissemination by participatory information and communication technology must get emphasized in the future.

Improvement in coordination, linkages and policy support: Coordination and linkages should be strengthened between various national and international institutions. At national level, the public-private partnership concept should be enhanced to support the increased interest of the private sector in the country. Collaborations between various international institutions, including CG centers must be strengthened to increase the germplasm flow of all the important crops including industrial crops and all the necessary technical support. Necessary policies must be formed to address the issues of mechanization and commercialization.

Human resource development and restructuring of the national research system: Nepal Agricultural Research Council (NARC) is presently the responsible government organization to conduct, promote, support, coordinate and evaluate agriculture research. Before NARC, both the national research system and extension services were run by Department of Agriculture (DOA). After its establishment in 1991, NARC is serving as an autonomous organization to generate agricultural technology related to both crops and livestock sector. However, the experiences have shown that its organizational set-up and operational modality have to be reviewed and modified for effective running of the organization. It is facing the lack of trained and qualified human resources for addressing the research problems as per the need of the country.

CONCLUSION

Rice, maize and wheat are the three major crops of the country and play vital role in fulfillment of the food requirement of the country. The growth in production and productivity of all the agronomical crops including the three major crops is not sufficient to meet the countries food demand in spite of the present available technologies. The future research program of these crops must address the prevailing research problems.

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Evaluation of Cold Tolerant Rice Genotypes for High Hill of Nepal

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ABSTRACT

Rice (*Oryza sativa* L.) is the principle food crop of Nepalese people and is being cultivated in a wide range of agro-climatic regions of Nepal from 60 to 3050 meter above sea level. About 4.46% of the total rice land falls in high hill, where cold injury due to low air temperature is the major constraint in the rice production. An attempt was made to develop cold tolerant and high yielding genotype for this region by conducting on-station and on-farm rice varietal research. On-station researches were conducted at Agriculture Research Station (ARS), Jumla and Agricultural Botany Division, Khumaltar involving 10-12 rice genotypes during 2007-2009 in randomized complete block design. Four promising lines were evaluated as on-farm trial in Outreach Research sites of ARS Jumla, ARS Pakhribas and RARS Lumle during 2008-2010. These lines were compared with standard check Chandannath-3. Among them, NR 10479-B-33-2-1-1 and NR 10482-B-10-3-2-2 were promising and preferred by farmers due to their stable higher yield over Chandannath-3 in tested locations. Release and wider dissemination of these genotypes will help to increase the productivity and production of rice in high hill and help in food security in this region.

INTRODUCTION

Rice (*Oryza sativa* L.) is the lifeline of Nepalese people and holds the key role to sustain food security in the country. Food security of the country depends on the rice production as it contributes nearly 21% to the agricultural GDP and 52% to the total food grain. Presently, it is grown in 1.5 million hectare with the production of 4.46 million ton and productivity is about 2.98 t ha⁻¹ (MOAC 2011). It has been cultivated in a wide range of agro-climatic regions of Nepal under varying topography, climates and altitudes. Nepalese farmer prefer to grow this crop whenever possible from 60 meter in terai to 3,050 meter above sea level (masl) in the high hill (NARC 1996).

About 4.46% of the total rice land falls within cool temperate (high hill) region above 1,500 masl. Cold injury caused by low air temperature is the major constraint in the rice production in this region which limits both rice area and length of the growing season (Sthapit 1992). The common symptoms of cold injury are slow growth, leaf discoloration, delayed heading, poor panicle exertion, spikelet degeneration, spikelet sterility and therefore, poor yield. Until now, five varieties for high hills have been released for general cultivation. Out of them Palung-2 can be grown up to lower high hill (<1700 m), Chhomrong and Machhapuchre-3 up to <2000 m (mid-high hill) and Chandannath-1 and 3 can be grown up to 3050 masl (ABD 2010). Therefore, there is very limited varietal option for farmers of the high hill areas. In this context, this paper summarizes the rice varietal research conducted in different environments to select the best genotypes which might fulfill the farmers' need of higher production and productivity and help uplift the livelihood of high hill farmers and curtail the problem of food security.

MATERIALS AND METHODS

The varieties included in the study were selected from the cross of 1996, evaluated in observation nursery from 2005-2007 and replicated yield trial as JSVT from 2007-2010 and on-farm trials 2008-2010. JSVT consisted of 13, 10 and 10 genotypes in 2007, 2008 and 2009, respectively. All the on-station trials were fertilized with 60:30:30 kg N:P₂O₅:K₂O/ha and on-farm trial were evaluated in farmers' management condition. Planting geometry was 20 cm x 15 cm. Depending on location, 25-40 days old seedlings were transplanted with 2-3 seedling/hill. Jumla Selection Varietal Trial (JSVT) was conducted in randomized complete block design (RCBD) with three replications and on-farm trials as farmers field trials (FFT) were replicated 3-6 times i.e. farmer as a replication in each location. An attempt was made to create the similar high hill environment by delaying the planting time by one month in Khumaltar to expose the breeding material for cold stress at reproductive stage. Genotypes were evaluated in Jumla and Khumaltar (late planting conditions) with the name of JSVT. The agro-morphological, yield and yield components were recorded from on-station field experiment conducted at Agronomy Farm Khumaltar and ARS Jumla and on-farm trials conducted at command area of ARS Pakhribas, RARS Lumle and ARS Jumla. The data were analyzed using MSTATC software.

RESULTS AND DISCUSSION

The study revealed that genotypes differed significantly for days to maturity and grain yield except plant height and number of grains panicle⁻¹ at Jumla in JSVT during 2007 (Table 1). NR 10481-B-11-1-1-1 produced significantly higher yield of 4944 kg ha⁻¹ which was at par with NR 10482-B-10-3-2-2 (4833 kg ha⁻¹) and NR 10479-B-33-2-1-1.

Table 1. Performance of genotypes in Jumla selection varietal trial (JSVT), 2007

Genotypes	ARS, Jumla				ABD, Khumaltar			
	Mat	Pht	Grain	Gyld	Mat	Pht	Grain	Gyld
NR 10479-B-33-2-1-1	192	105	142	4572	144	151	161	5974
NR 10481-B-11-1-1-1	192	104	112	4944	147	159	96	3043
NR 10482-B-10-3-2-2	192	107	149	4833	144	147	172	4926
Chadannath-3	194	101	104	4100	142	144	149	5914
CV (%)	0.87	4.5	28.7	20.7				
F-test	*	ns	ns	**				
LSD _{0.05}	2.8	10.5		1755				

Mat, days to maturity; Pht, plant height (cm); Grain, number of grains panicle⁻¹; Gyld, grain yield (kg/ha)

These three genotypes were earlier than Chandannath-3. Same genotypes performed differently while growing at Khumaltar under late planting conditions. Maturity period shortened and plants became taller due to increased temperature during vegetative growth than in Jumla. NR 10479-B-33-2-1-1 produced highest grain yield of 9574 kg ha⁻¹ followed by check Chandannath-3 (5914 kg ha⁻¹) and NR 10482-B-10-3-2-2 produced 4926 kg ha⁻¹.

At Khumaltar during 2008, all the tested genotypes differed significantly for days to maturity, plant height, panicle length and number of panicle hill⁻¹ but showed insignificant results for number of grain panicle⁻¹, 1000 grain weight, grain yield kg ha⁻¹ and straw yield ton ha⁻¹ (Table 2).

Table 2. Jumla selection varietal trial, Khumaltar, 2008

Genotypes	Mat	Pht	Pnl	Pan	Grain	Swt	Gyld	Syld
NR 10482-B-10-3-2	129	141.0	21.7	12	141	26.9	6168	8.4
NR 10479-B-33-2-1	128	149.3	22.5	10	134	4.7	5090	7.4
NR 10682-B-B-B-2	125	138.5	22.1	11	153	7.9	5561	8.0
Chandannath-3	129	151.1	23.1	10	131	8.0	5152	7.8
F-test	**	**	**	**	ns	ns	ns	ns
LSD _{0.05}	1.42	8.55	1.5	1.9	-	-	-	-
CV (%)	0.65	3.72	3.9	9.4	13.7	6.5	14.67	22

Mat, days to maturity; Pht, plant height (cm); Pnl, panicle length (cm); Pan, number of panicles/hill; Swt, 1000 grain weight (g); Grain, number of grains/panicle; Gyld, grain yield (kg/ha); Syld, straw yield (t/ha)

However, NR 10482-B-10-3-2-2 produced highest grain yield of 6168 kg ha⁻¹ followed by NR 10682-B-B-B-2 (5561 kg ha⁻¹) and NR 10479-B-33-2-1-1 (5090 kg ha⁻¹). NR 10482-B-10-3-2-2 and NR 10479-B-33-2-1-1 were earlier than Chandannath-3 with higher number of grain panicle⁻¹.

In 2009, genotypes differed significantly for all traits except grain number panicle⁻¹ in Khumaltar (Table 3). NR 10482-B-10-3-2-2 produced significantly higher grain yield of 5567 kg ha⁻¹ followed by NR 10695-B-B-B-5-3 (4865 kg ha⁻¹), NR 10695-B-B-B-5-1 (4738 kg ha⁻¹) and NR 10479-B-33-2-1-1 (4598 kg ha⁻¹) with Chandannath-3 (4194 kg ha⁻¹). Same genotypes were found insignificant for grain number panicle⁻¹ and grain yield at ARS, Jumla. However, NR 10479-B-33-2-1-1 produced highest grain yield of 6120 kg ha⁻¹ followed by NR 10482-B-10-3-2-2 (5852 kg ha⁻¹). Thus, both genotypes NR 10482-B-10-3-2-2 and NR 10479-B-33-2-1-1 showed better performance than Chandannath-3 in both the locations.

Table 3. Production performance of rice genotypes in JSVT, 2009

Genotypes	ABD, Khumaltar				ARS, Jumla			
	Mat	Pht	Grain	Gyld	Mat	Pht	Grain	Gyld
NR 10482-B-10-3-2-2	132	134	114	5567	198	112.0	86	5852
NR 10479-B-33-2-1-1	133	129	105	4598	197	113.0	110	6120
NR 10695-B-B-B-5-1	132	126	103	4738	197	108.7	110	4861
NR 10695-B-B-B-5-3	134	129	96	4865	201	105.3	84	5111
Chandannath-3	133	133	107	4194	193	105.7	59	5144
F-test	**	**	ns	**	**	**	ns	ns
LSD _{0.05}	1.2	6.7	-	1061	2.3	5.4	-	-
CV (%)	0.55	3.1	14.6	14.3	1.8	3.3	22.3	18.7

Mat, days to maturity; Pht, plant height (cm); Grain, number of grains panicle⁻¹; Gyld, grain yield (kg/ha)

The tested genotypes were found significant for grain yield and plant height and insignificant for days to maturity at Lumle (Table 4). NR 10481-B-11-1-1-1 produced significantly higher yield of 4765 kg ha⁻¹ followed by NR 10479-B-33-2-1-1 (4506 kg ha⁻¹) and NR 10482-B-10-3-2-2 (4358 kg ha⁻¹) than check Chandannath-3 (4022 kg ha⁻¹). Same trend of observations were also found in Khumaltar.

Table 4. Performance of the rice genotypes in high hill FFT, 2008

Genotypes	ABD, Khumaltar			RARS, Lumle		
	Mat	Pht	Gyld	Mat	Pht	Gyld
NR 10481-B-11-1-1-1	119	138	5180	145	127	4765
NR 10482-B-10-3-2-2	122	137	4936	145	122	4358
NR 10479-B-33-2-1-1	120	114	4742	146	127	4506
NR 10562-B-7-5	124	129	3088	146	108	3074
Chandannath-3	121	132	4367	146	119	4022
F-test				ns	**	**
LSD _{0.05}				-	7.9	500
CV (%)		Not analyzed		1.2	3.5	6.4

Mat, days to maturity; Pht, plant height (cm); Gyld, grain yield (kg/ha)

During 2009, none of the genotypes were found superior than Chandannath-3 in terms of grain yield and days to maturity at Khumaltar. NR 10479-B-33-2-1-1 and NR 10482-B-10-3-2-2 showed comparable performance as Chandannath-3 in terms of grain yield and days to maturity. However, these genotypes were taller and gave higher straw yield than Chandannth-3 which is very important for the high hill farmers along with grain yield.

Table 5. Performance of the rice genotypes in high hill FFT, Khumaltar, 2009

Genotypes	Mat	Pht	Pnl	Pan	Grain	Swt	Gyld	Syld
NR 10481-B-11-1-1-1	130	146	20.0	16	79	24.1	3649	9.1
NR 10482-B-10-3-2-2	130	141	22.4	12	58	27.1	4370	8.0
NR 10479-B-33-2-1-1	129	139	23.0	11	97	25.5	4940	8.0
NR 10562-B-7-5	131	128	21.0	13	87	27.1	4390	7.4
Chandannath-3	127	136	23.6	9	104	30.6	5539	6.5

Mat, days to maturity; Pht, plant height (cm); Pnl, panicle length (cm); Pan, number of panicles/hill; Swt, 1000 grain weight (g); Gyld, grain yield (kg/ha); Syld, straw yield (t/ha)

During 2010, NR 10482 and NR 10479 showed better performance than Chandannath-3 in both Khumaltar and Pakhribas locations (Table 6). These genotypes were found almost similar to days to maturity and plant height to that of Chandannath-3.

Table 6. Performance of the rice genotypes in high hill FFT, 2010

Genotypes	ABD, Khumaltar				ARS, Pakhribas (Mean of 2 sites)			
	Mat	Pht	Gyld	Syld	Mat	Pht	Gyld	Syld
NR 10482	140	132	4625	7.6	144	105	3250	7.1
NR 10695	142	122	3294	13.1	138	86	2233	5.4
NR 10479	140	125	4579	7.5	142	112	3250	7.7
NR 10689	144	105	3108	11.6	138	76	1667	5.5
Chandannath-3	142	128	4227	9.9	140	100	2417	6.1

Mat, days to maturity; Pht, plant height (cm); Gyld, grain yield (kg/ha); Syld, straw yield (t/ha)

In Jumla during 2010, genotypes were insignificant for grain yield and panicle length but plant height was significant (Table 7). All the tested lines produced higher grain yield than Chandannath-1. However, K 39-96-1-1-2 produced highest mean grain yield of 3935 kg ha⁻¹ followed by NR 10479-B-33-2-1 (3648 kg ha⁻¹), NR 10482-B-10-3-2-2 (3320 kg ha⁻¹) than check variety Chandannath-1 (3169 kg ha⁻¹). Therefore, these genotypes could be the best option for high hill farmers.

Table 7. Combined analysis of rice genotypes in the outreach site of ARS, Jumla, 2010

Genotype	Plant height (cm)	Panicle length (cm)	Yield (kg/ha)
NR10481-B-11-1-1-1	107.6	18.1	3182
NR10482-B-10-3-2-2	105.5	18.0	3320
NR10479-B-33-2-1-1	106.8	17.7	3648
K 39-96-1-1-1-2	108.0	17.4	3935
Chandannath-1	94.8	17.0	3169
Mean	104.5	17.6	3450.9
F- test	**	ns	ns
LSD	3.5	-	-
CV (%)	6.4	7.8	25.3

**, highly significant; ns, not significant

Evaluation of elite lines over locations and years revealed that NR 10482-B-10-3-2-2 and NR 10479-B-33-2-1-1 were superior to existing high hill varieties Chandannath-1 and Chandannath-3 in terms of grain yield and straw yield. These lines have widely been accepted by the farmers for their yield,

maturity, plant height, straw yield and grain quality. Joint efforts by researcher, extensions, and NGOs are vital for dissemination of these promising genotypes. Adoption of these genotypes will help to increase production and productivity of rice and thus uplift the livelihood of high hill farmers' and reduce the problem of food security in high hill.

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Participatory Varietal Selection on Submergence Tolerant Rice Varieties for Central Terai Region of Nepal

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ABSTRACT

Participatory varietal selection (PVS) is one of the effective methods to select varieties by participating farmers and agricultural scientists and technicians. Mother and baby trials were carried out in Dhanusha, Mahotari and Rautahat in 2009 and 2010 for identification and dissemination of submergence tolerant rice varieties. A total of 65 farmers in 2009 and 118 farmers in 2010 were involved in PVS. Six varieties including three Sub 1 lines in 2009 and eight varieties including three Sub 1 lines in 2010 were evaluated in mother trials and a set of submergence tolerant lines along with local checks were evaluated in baby trials. Submergence tolerant rice lines Swarna Sub1 and Samba Mahsuri Sub1 performed better in both mother and baby trials under flash flood conditions and preferred by farmers in preference ranking. Grain yield potentiality was recorded higher in Swarna Sub1 than Samba Mahsuri Sub 1, however, Samba Mahsuri Sub1 had better taste than Swarna Sub1. Among the non-sub 1 varieties, taller and stiff stem variety like Radha 12 performed better than short statured varieties when transplanted in water logged environment for longer period.

INTRODUCTION

Rice is number one food grain crop of Nepal and is grown in 1.48 million ha (MOAC 2010). Fifty-five percent of rice crop is irrigated that comprises both complete and partial irrigated areas and the rest is under rain fed. About 15% of total rice area is estimated to be under flash flood in both irrigated and rain fed lowland areas in terai and inner terai where floods usually damage rice crop. Lowland area is about 170,820 ha where water stagnates for 5-10 days during rainy season when heavy rain occurs. According to the farmer's knowledge, almost every year flood occurs mostly after transplanting at tillering stage and sometimes during seedling stage before transplanting. If flood occurs in the beginning of season when transplanting is to be done and farmers become unable to do transplanting in time and they do not have enough seedlings for transplanting later and when it occurs after transplanting, the plants remain under water for more than a week and flood affects vegetative growth, tillering ability and photosynthesis process and ultimately kills the plants if submerged for longer duration.

Existing developed varieties are not adapted to this condition, the farmers still grow local landraces with low yield potentiality and that are also affected by submerged water and farmers loose crop. Earlier they do not have alternate and wait for post rainy season crops. Xu et al (2006) found that submergence tolerance is largely controlled by the *SUB1* gene. Due to presence of that gene rice plant can survive even after submergence up to the 15 days and there is no yield penalty. The varieties having that gene also perform well under normal conditions. Results at IRRI showed that Sub1 varieties had an average 1-3 ton higher grain yield than non-Sub1 varieties following 12-17 days of complete submergence (Singh et al 2009, Sarkar et al 2009). The discovery and cloning of *SUB1*

provided great opportunities for enhancing yield in submergence-prone areas. Recent efforts at IRRI resulted in incorporation of *SUB1* into other popular varieties in South and Southeast Asia using marker assisted backcrossing (Neeraja et al 2006, Septiningsih et al 2009). The popular varieties selected were Swarna, Samba Mahsuri and IR64. Indian variety Swarna has a large coverage area of lowland in the eastern India in UP, Bihar, Orissa, Assam, Chattisgarh and West Bengal in India. Swarna alone covers about 6 million ha at national level and it has been considered as a mega rice variety. This variety is also being grown in many terai districts of Nepal by the name of Sona Masuli, Sona masuli/Golden rice/Bangali rice being introduced from India and disseminated from farmers to farmers. Now it is grown extensively in majority of rice growing areas across terai and inner terai districts. Similarly, other Indian variety Samba Mahsuri which is fine in grain quality is popular among farmers and is being cultivated in many districts. IR64 developed by IRRI is grown in large areas in India and other countries as mega varieties. All these three varieties Swarna, Samba Mahsuri and IR64 are farmers' varieties because of popular among a large number of farmers. Therefore, Swarna, Samba Mahsuri and IR64 were introgressed with *SUB1* gene in IRRI and made tolerant to submergence up to 15 days without any change in other attributes except in husk color from golden yellow to white in Swarna and no any change in Samba Mahsuri and IR64. *SUB1* gene incorporated varieties could be grown under submerged conditions as well as normal conditions without any loss in yield and taste rather improvement.

These varieties were introduced from IRRI Philippines with objective to evaluate on on-station and on-farmer PVS trials in rainfed lowland flash flood areas to know farmer's reactions about these varieties. Grain yield and sensory evaluation are the major basis of selection of varieties among the farmers. Sensory evaluation is post harvest evaluation where product is cooked and tasted for aroma, softness, water uptake, taste, sweetness etc. These are the important traits often scored by the rice consumers.

MATERIALS AND METHODS

Submergence PVS trials were conducted on farmers' fields at three locations, Hardinath and Tulsiyahi in Dhanusha district and Bhediya in Rautahat district in 2009 and at Khairia in Mahotari, Tulsiyahi in Dhanusha district and Bhediya in Rautahat district in 2010 to evaluate submergence tolerance varieties developed by IRRI with some existing improved varieties as checks.

A total of six varieties in 2009 and eight varieties in 2010 were evaluated in RCBD in three replications in 50 m². Fertilizers were applied @ 80:30:30 N:P₂O₅:K₂O kg/ha, of which 40:30:30 N:P₂O₅:K₂O kg/ha were used as basal and the rest 40 N kg/ha was used in two splits as top dressing after submergence. Transplanting was done on 20 x 20 cm spacing. Data was taken on plant height, tillers per square meter, panicle length, filled and unfilled grains per panicle, duration of flooding, percentage of damage by submergence and grain yield. Sub1 varieties included in both the years were Swarna Sub1, Samba Mahsuri Sub1 and IR64 Sub1. Non-Sub1 varieties were Radha12, Makwanpur1, Sona Masuli, Basmati, and Sabitri. Baby trials were composed of Swarna Sub1 and Samba Mahsuri Sub1 with local checks carried out on 60 farmer's fields at Suga, Tulsiyahi and Bhediya in 2009 and on 110 farmer's fields in 2010. One farmer was provided one variety only.

Sensory evaluation was conducted on 3rd July at Tulsiyahi, Dhanusha and 1st July at Hardinath, Dhanusha in 2009. The most preferred two Sub1 varieties in preference ranking and one non-Sub1 variety were included for sensory evaluation in each location.

RESULTS AND DISCUSSION

Varieties Swarna Sub1 and Samba Mahsuri Sub1 performed better than non-Sub1 varieties under submerged conditions in 2009. Among non-Sub1 varieties, Swarna has some ability to tolerate submergence in comparison of other non-Sub1 varieties of same height. The trail was submerged for 7 days. Swarna Sub1 when submerged became somewhat late in maturity (Table 1). Among the non-Sub1 varieties, Radha12, a comparatively taller variety, was less affected by submergence than shorter varieties because of exposure to the surface of water earlier as it was noticed at Baidehi. Flood damage was recorded 10% in Swarna Sub1, 12% in IR64 Sub1, 15% in Samba Mahsuri Sub1, 20% in each Makwanpur1 and Radha12 and 30% in Sona Mahsuri. Heading days were recorded a bit late in submerged than non-submerged conditions.

At Tulsiyahi after transplanting there was flood for 5 days, plants were completely submerged for 3 days and no damage was observed in 2009. Thereafter, there was drought during booting and heading stages and no irrigation facility was available. IR64 Sub1 produced higher grain yield (2000 kg/ha) than longer duration varieties because of earliness that helped partially escaping from drought stress. Samba Mahsuri Sub1 produced 1850 kg/ha followed by Swarna Sub 1(1608 kg/ha). Early termination of rainfall created moisture stress during heading and grain filling (Table 2). Similarly, in on-station PVS conducted at Hardinath in 2009, the highest grain yield was obtained by Swarna Sub1 followed by Samba Mahsuri Sub1, IR64 Sub1 and Makwanpur1 (Table 3). Grain yield of Swarna Sub1 was significantly higher than Samba Mahsuri Sub1. Radha 12 produced lower grain yield similar as Swarna. Potentiality of Samba Mahsuri Sub1 was not as high as Swarna Sub1, however, it had very good taste and high milling recovery with low broken percentage. So, farmers were very much interested to grow this variety although it was not resistant to bacterial leaf blight.

Table 1. Performance of the varieties in PVS at Rautahat under submerged conditions in 2009 for 7-10 days

Varieties	Grain yield kg/ha	Days to heading	Plant height (cm)	Damage %
Swarna Sub1	4192	130	87	10
Samba Mahsuri Sub1	3582	121	84	15
IR64 Sub1	3225	103	80	12
Radha12	3543	121	102	20
Makwanpur1	3303	125	94	25
Swarna	2851	125	81	30
Mean	3449	121	88	

Table 2. Performance of genotypes in PVS at Tulsiyahi (Dhanusha) in submerged and normal conditions

Varieties	Plant height (cm)	Panicle length (cm)	Grain yield (kg/ha)
Swarna sub1	67	22	1608
IR64 sub1	63	23	2000
Makwanpur1	82	23	840
Radha12	98	26	1265
Samba Mahsuri sub1	77	23	1850
Sona Masuli	60	22	1082
Mean	75	23	1441

On the basis of results of PVS conducted at NRRP Hardinath and Tulsiyahi of Dhanusha district in 2010, Swarna Sub1 produced highest grain yield (4340 kg/ha) followed by Radha 12 (3936 kg/ha), Makwanpur1 (3826 kg/ha) and Samba Mahsuri Sub1 (3623 kg/ha). Complete submergence was for 7 days, thenafter water level went on decreasing. Period of submergence caused 5% damage in Swarna

Table 3. Performance of genotypes in PVS at Dhanusha (2009) under submerged conditions

Varieties	Head days	Plant height (cm)	Panicle length (cm)	Grain yield (kg/ha)
Swarna Sub1	124	71	22	4196
Samba Mahsuri Sub1	123	74	22	3695
Radha12	128	87	22	2663
Makwanpur1	118	104	24	3206
IR64 Sub1	109	75	22	3330
Swarna	127	68	24	2663
Mean	121	80	23	3292
LSD (5%)	9	14	2	408
CV%	10	15	2	19
F-test	**	**	ns	**

**, highly significant; ns, not significant

Sub1 and 46% damage in Lalka Basmati (Table 4) as found in RARS Tarahara (RARS Tarahara 2010). *SUB1* gene incorporated varieties were of medium plant height.

The results of PVS where there was no flood during crop period (Table 5) showed that Makwanpur1 produced highest grain yield (4496 kg/ha) followed by Radha12 (4428 kg/ha), Swarna Sub1 (4346 kg/ha) and Sabitri (3976 kg/ha). All varieties except IR64 Sub1 were at par with each other in grain yield. Samba Mahsuri Sub1 was earlier than Swarna Sub1 like Radha12 and the heading day of Swarna Sub1 was same as Makwanpur1, Lalka Basmati, Sona Mahsuri.

Table 4. Performance of varieties in PVS at Rautahat and Mahotari during 2010 under submerged conditions

Varieties	Grain yield (kg/ha)	Plant height (cm)	Panicle length (cm)	Tiller/m ²	Heading day	Damage %
Swarna Sub1	4340	101	23	217	125	5
Samba Mahsuri Sub1	3623	97	23	292	122	20
IR64 Sub1	3085	91	22	258	101	15
Makwanpur1	3826	107	23	242	122	25
Radha12	3936	122	24	237	117	20
Lalka Basmati	2723	159	29	229	120	20
Sona Masuli	3517	99	24	258	121	25
Sabitri	3348	107	25	228	115	20
Mean	3550	110	24	245	118	
F test	**	**	**	ns	**	
LSD (5%)	675	10	3	50	2	
SE	234	4	1	18	1	
CV (%)	15	8	8	16	2	

**, highly significant; ns, not significant

Baby trials

Baby trials were conducted for familiarization and dissemination of submerged tolerant rice varieties among farmers and to make available the seed of submerged tolerant varieties at local level for further expansion and increase rice production in submerged prone areas. Flood water stagnation varied from 5-12 days in baby trials carried out on different farmers' fields in 2009. Total 34 farmers were surveyed. Everywhere submerged tolerant varieties performed better than non-Sub1 varieties where there was flood. Maximum mortality was observed 15% in Sub1 and 70% in non-Sub1 variety Makwanpur1 (Table 6). Some farmers re-transplanted where they found gaps or plants died after flood to minimize yield loss in baby trials. Responses were obtained from 26 farmers of Mahottari district who conducted baby trials in 2010. Varieties Swarna Sub1 and Samba Mahsuri Sub1 were

Table 5. PVS conducted at Rautath and Dhanusha in non-submerged conditions in 2010

Varieties	Grain yield (kg/ha)	Plant height (cm)	Panicle length (cm)	Tiller/m ²	Heading day	Filled grain/ panicle	Unfilled grain/panicle
Swarna Sub1	4346	99	25	279	120	154	30
Samba Mahsuri							
Sub1	3733	93	22	320	115	153	20
IR64 Sub1	2716	88	23	244	93	86	32
Makwanpur 1	4494	100	22	238	120	106	41
Radha 12	4428	126	27	225	115	144	29
Lalka basmati	3057	111	25	247	120	143	22
Sona Masuli	3408	130	28	204	120	129	37
Sabitri	3976	108	25	230	112	150	30
Mean	3895	107	25	248	114	133	30
F-test	**	**	**	ns	**	**	ns
SE (N=6)	286	6	1	30	1	13	6
LSD (5%)	816	18	2	86	2	38	18
STD	860.11	19.89	2.68	76.164	8.92	38.29	15.52
CV%	16.5	6.8	4.4	23.5	1.3	22	44.4

**, highly significant; ns, not significant

transplanted along with non-Sub1 varieties. Local varieties that farmers use to cultivate in rainfed lowland like Jaswa, Basmati, Harinker, Rambilash and Nanki were used as check varieties in baby trails. Some farmers could not transplant due to lack of rainfall during transplanting and some could not keep seed bed who thought to keep seed bed later in favorable moisture. The farmers who could transplant the crop harvested good yield of Swarna Sub1 and Samba Mahsuri Sub1 in both normal and flood prone areas where water receded after flood.

Table 6. Performance of Sub1 varieties in baby trials in 2009

Swarna Sub1 (ton/ha)	Samba Mashuri Sub1 (ton/ha)	Non-Sub1 variety	Increase in grain yield	% increase in grain yield	Remarks
	3.96 (10% died)	3.0 (40% died)	962	32	10 days submerged
	3.6 (10% died)	3.25 (30% died)	350	11	8 days submerged
	2.5	3.0			Not submerged and affected by drought in later growing period
3.6		3.50	100	3	Not submerged
5.07 (15% died)		3.05 (45% died)	2.050	67	10 days submerged
	3.65	4.57			Not submerged
	2.15	3.0			Not submerged, affected by drought
4.26		2.5 (60% died)	1.76	70	11 days submerged
	4.0	3.20 (30% died)	0.8	25	10 days submerged
4.4		2.5 (40% died)	1.9	76	12 days submerged
2.07		2080			Affected by drought
4.9		2.90 (40% died)	2.0	69	
4.55		3.0	1.55	52	12 days submerged

Preference ranking

Preference ranking was conducted in PVS at Dhanusha in 2009 and at Bhediyahi, Rautahat in 2010. The trial was partially submerged for 7 days and 37 farmers were participated in ranking in Dhanusha. The most preferred varieties were Swarna Sub1 and Samba Mahsuri Sub1 because of being suitable in

submergence conditions, synchronous flowering and maturity (Table 7). The trail was submerged for 6 days at Rautahat. In total 25 farmers participated in preference ranking. Most of the farmers preferred Swarna Sub1 and thereafter Radha12. The most non-preferred varieties were Sabitri and IR64 Sub1 (Table 8).

Table 7. Preference analysis of mother trail conducted at Hardinath, 2009

Variety	Male farmer (n=17)		Female farmer (n=20)		Total (n=37)		Preference score
	+	-	+	-	+	-	
IR 64 Sub1	2	14	3	22	5	36	-0.21(IW)
Samba sub 1	15	3	14	6	29	9	0.14(IIB)
Swarna Sub 1	16	4	21	0	37	4	0.22(IB)
Swarna (local check)	1	13	2	12	3	25	-0.15(IIW)
Total	34	34	40	40	74	74	0.00

Table 8. Response of various respondents in preference ranking

Variety	Male farmer (n=24)		Female farmer (n=1)		Researchers (n=3)		Total farmers (n=25)		Preference score
	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	
Swarna Sub1	16	0	1	0	3	0	17	0	0.17
IR64 Sub1	0	17	0	0	0	3	0	17	-0.17
Radha 12	11	0	1	0	3	0	12	0	0.12
Makwanpur1	5	7	0	0	0	2	5	7	-0.02
Lalka Bamati	4	1	0	0	0	0	4	1	0.03
Sona Mahsuri	7	0	0	1	0	0	7	1	0.06
Sabitri	0	14	0	1	0	0	0	15	-0.15
Samba Mahshuri Sub1	5	9	0	0	0	1	5	9	-0.04
Total	48	48	2	2	6	6	50	50	

+ve, positive; -ve, negative

Sensory evaluation

Thirty-four farmers participated in sensory evaluated at Tulsiyahi in Dhanusa. Of them, 19 were female and 15 were male. Most preferred varieties IR 64 Sub1, Samba Mahsuri Sub1 and Sona Mahsuri were included for sensory evaluation. Each participant preferred cooked rice of all three varieties. Samba Mahsuri Sub1 was ranked first followed by Sona Mahsuri (Swarna) and IR64 Sub1 in taste, respectively by both male and female farmers. Samba Mahsuri Sub1 gained 53% in total weightage where as Sona Mahsuri obtained 27% followed by IR64 Sub1 (20%). There was no much variation in combined weightage provided by both male and female farmers. Similar trend was also observed in rating and ranking. Samba Mahsuri Sub1 was the most preferred variety with regard to taste (Table 9).

Table 9. Summary of sensory evaluation conducted at Tulsiyahi, Dhanusha in 2010

Variety	Count				Relative weightage				Combined weightage		
	Acceptable		Not Acceptable		Ranking		Rating		Female	Male	Ranking
	Female	Male	Female	Male	Female	Male	Female	Male			
IR64 Sub 1	19	15	0	0	19.3	23.3	17.1	21.1	18.2	22.2	3
Samba Mahsuri Sub 1	19	15	0	0	47.4	47.8	58.7	56.9	53.0	52.3	1
Sona mahsuri	19	15	0	0	33.3	28.9	24.2	22.1	28.8	25.5	2
Total	57	45	0	0	100	100	100	100	100	100	

Swarna Sub1 and Samba Mahsuri Sub1 were found suitable for flash flood areas as well as for normal lowland areas. Tall and strong stem variety like Radha12 also performed better under partially submerged conditions in comparison to other short statured varieties.

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Alternate Wetting and Drying Irrigation System: Water Saving Irrigation Option for Rice Cultivation in Nepal

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ABSTRACT

Alternate wetting and drying (AWD) trial was conducted at National Rice Research Program (NRRP) Hardinath, during summer season in 2007, 2008 and 2009 to study the performance of rice varieties under AWD system and conventional irrigation system. Significant difference was found for days to heading, maturity and unfilled grains/panicles in 2007 among the tested rice varieties under conventional irrigation system and AWD system in 2007. Highly significant difference for grain yield t/ha, tillers m² under all irrigation systems was found in 2008. The mean grain yield was found higher in AWD as compared to conventional system in both the years at NRRP, Hardinath. All traits did not significantly differ except for unfilled grains/panicle under both irrigation systems in 2009. In general, AWD technology was found effective for saving nearly 54.5% water over continuous irrigation with similar rice grain yield at NRRP, Hardinath.

INTRODUCTION

Rice is the staple food in Nepal and a mainstay for the rural population and their food security. Rice is grown in 1.49 million ha with total production of 4.46 million ton in the country. Rice shares 7.5% and 23% in gross domestic product and agricultural gross domestic product, respectively. The total areas under rice in Nepal, about 45% are rainfed and 55% is irrigated. The population growth combined with changes in diet will lead to an increase of grain requirements from 3.97 million ton in 1995 to 8.3 million ton in 2025 (Winrock 1995). A representative site namely, National Rice Research Program (NRRP), Hardinath was selected for research. In rice production systems, the yield becomes low due to erratic nature of monsoon in Nepal. Due to increasing scarcity of freshwater resources available for irrigated agriculture and escalating demand of food around the world, in the future, it will be necessary to produce more food with less water. Since, more irrigated land is devoted to rice than to any other crops in the world, wastage of the resource in the rice field should be minimized (IRRI 2003). The abundant water environment in which rice grows best differentiates it from all other important crops. But, water is becoming increasingly scarce. By 2025, the per capita available water resources in Asia are expected to decline by 15–54% compared with 1990 (Moya et al 2001). Rice grown under traditional practices in the Asian tropics and subtropics requires between 700 and 1,500 mm of water for a cropping season depending on soil texture (Bhuiyan 1992). The actual amount of water used by the farmers for land preparation and during the crop growth period is much higher than the actual field requirement. Paddy farmers often store water in their fields as a back-up safety measure against uncertainty in water supply. Also, there is often field-to-field irrigation. This leads to a high amount of surface runoff, seepage and percolation accounting for about 50 to 80% of the total water input to the field (Sharma 1989). Considering the above mentioned problems, this experiment was carried out to study the water saving options in rice cultivation.

MATERIALS AND METHODS

Alternate wetting and drying trial was conducted at NRRP Hardinath during kharif season in 2007, 2008 and 2009 to study the performance of rice varieties under alternate wetting and drying (AWD) and conventional irrigation systems. The experiment was designed in split-plot with two irrigation systems (I₁-conventional system I₂- AWD system) as main plot factors and four rice varieties; (Sabitri, Mithila, Hardinath-1 and Radha-4) as sub-plot factors in 2007 and 2008 whereas in 2009 two irrigation systems (conventional system and AWD system) as main plot factors and three rice varieties (IR80411-B-49-1, IR78397, Sabitri) as sub-plot factors were used. The plot size was 5x2 m² with three replications. Fertilizers were applied @ 60:40:30 NPK kg/ha. Continuous water of 5 cm was maintained in the plot throughout the crop growth period in conventional irrigation system. The irrigation was provided at 20 days after transplanting, tillering, panicle initiation, heading and milking stages of crop. While in AWD, irrigation was provided when field became hair crack. The transplanting was done on 9th June 2007, 2nd June, 2008 and 4th June, 2009. Genstat was performed for data analysis.

RESULTS AND DISCUSSION

Significant difference was found for days to heading, maturity and unfilled grains/panicles at NRRP, Hardinath in 2007 while, other observed traits did not significantly differ among the tested rice varieties under conventional irrigation system and AWD system in 2007. Interaction between varieties and irrigation systems were also not found significant different in days to heading, maturity, grain yield (t/ha), tillers/m², filled grains/panicle in 2007. The mean days to heading, days to maturity, grain yield (t/ha), tillers/m², filled grains/panicle and unfilled grains/panicle were 100, 125, 3.1, 262, 115 and 22, respectively (Table 1, 2 and 3). AWD technology was found effective for saving 54.6% water over continuous irrigation with similar grain yield in 2007 (Table 4).

Table 1. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2007

Variety (A)	Days to heading		Mean	Variety(A)	Days to maturity		Mean
	Irrigation system (B)				Irrigation system (B)		
	AWD	Conventional			AWD	Conventional	
Sabitri	111	115	113	Sabitri	133	141	137
Mithila	89	110	95	Mithila	120	135	128
Hardinath-1	92	77	89	Hardinath-1	106	119	112
Radha-4	98	104	98	Radha-4	123	126	125
Mean			100	Mean			125
LSD (0.05%)			21.62	LSD (0.05%)			14.30
CV (%)			10.9	CV (%)			5.7
A			**	A			**
B			ns	B			ns
AxB			ns	AxB			ns

**, highly significant; ns, not significant

The statistical analysis showed highly significant difference on grain yield (t/ha), tillers/m² under all irrigation systems, however, among the tested varieties only showed statistically significant difference in filled grains/panicle during 2008. Similarly, significant difference was not found in days to heading and days to maturity among the tested varieties under both AWD and conventional irrigation system (Table 5). Interaction between grain yield, tillers/m², filled grains/panicle and unfilled grains /panicle did not significantly differ in 2008. The mean grain yield (t/ha), tillers/m², filled grains/panicle and unfilled grains/panicle were 3.7, 272, 98 and 31, respectively (Table 6 and 7). Among the tested genotypes, Hardinath-1 had given higher grain yield in both irrigation systems in 2008 (Table 6).

Table 2. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2007

Variety (A)	Grain yield t/ha		Mean (t/ha)	Variety (A)	Tillers/m ²		Mean
	Irrigation system (B)				Irrigation system (B)		
	AWD	Conventional			AWD	Conventional	
Sabitri	3.4	3.3	3.3	Sabitri	262	247	255
Mithila	2.8	2.7	2.8	Mithila	262	253	258
Hardinath-1	3.0	3.1	3.1	Hardinath-1	271	283	277
Radha-4	3.2	3.1	3.3	Radha-4	237	278	258
Mean			3.1	Mean			262
LSD (0.05%)			-	LSD (0.05%)			69.26
CV (%)			0.9	CV (%)			13.2
A			ns	A			ns
B			ns	B			ns
AxB			ns	AxB			ns

ns, not significant

Table 3. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2007

Variety (A)	Filled grains/panicle		Mean	Variety (A)	Unfilled grains/panicle		Mean
	Irrigation system (B)				Irrigation system (B)		
	AWD	Conventional			AWD	Conventional	
Sabitri	105	114	110	Sabitri	35	20	28
Mithila	119	117	118	Mithila	21	19	20
Hardinath-1	116	126	121	Hardinath-1	24	13	19
Radha-4	109	109	109	Radha-4	24	21	23
Mean			115	Mean			22
LSD (0.05%)			-	LSD (0.05%)			14.36
CV (%)			6.7	CV (%)			7.19
A			ns	A			**
B			ns	B			ns
AxB			ns	AxB			ns

**, highly significant; ns, not significant

Table 4. Water saving under conventional irrigation and alternate wetting and drying system in rice cultivation at NRRP, Hardinath, 2007

Treatment	Water applied (mm)			Water saved compared to CSW (%)
	Irrigation	Rainfall	Total	
Continuous standing water (CSW)	245	1086.4	1331.4	
AWD system	134	1086.4	1220.4	54.6

AWD technology was found effective for saving 54.7% water over continuous irrigation with similar grain yield in 2008 (Table 8).

All traits did not significantly differ except for unfilled grains/panicle under both irrigation systems in 2009 (Table 9, 10 and 11). The mean grain yield (t/ha), tillers/m², filled grains/panicle and unfilled grains/panicle were 4.1, 310, 121 and 32, respectively (Table 10 and 11). The mean grain yield (t/ha) was found higher in AWD as compared to conventional system in 2008 and 2009 at NRRP, Hardinath. AWD technology was found effective for saving 54.2% irrigation water over continuous irrigation and had also higher rice grain yield in 2009 (Table 12).

Table 5. Performance of rice varieties in different irrigation system at NRRP Hardinath, 2008

Variety (A)	Days to heading		Mean	Variety (A)	Days to maturity		Mean
	Irrigation system (B)				Irrigation system (B)		
	AWD	Conventional			AWD	Conventional	
Sabitri	108	113	110	Sabitri	139	144	142
Mithila	95	100	98	Mithila	126	130	128
Hardinath-1	86	90	89	Hardinath-1	116	121	119
Radha-4	91	95	93	Radha-4	125	130	123
Mean			98	Mean			128
CV (%)			0.8	CV (%)			18.0
A			NS	A			NS
B			NS	B			NS
AxB			NS	AxB			NS
LSD (0.05%)			-	LSD (0.05%)			-

Ns, not significant

Table 6. Performance of rice varieties in different irrigation system at NRRP Hardinath, 2008

Variety (A)	Filled grains/panicle		Mean	Variety (A)	Unfilled grains/panicle		Mean
	Irrigation system (B)				Irrigation system (B)		
	AWD	Conventional			AWD	Conventional	
Sabitri	104	100	102	Sabitri	21	27	24
Mithila	97	100	99	Mithila	26	30	28
Hardinath-1	108	105	107	Hardinath-1	18	20	19
Radha-4	88	82	85	Radha-4	27	32	27
Mean			98	Mean			31
LSD (0.05%)			16.79	LSD (0.05%)			4.933
CV (%)			8.6	CV (%)			8.2
A			ns	A			ns
B			**	B			ns
AxB			ns	AxB			ns

**, highly significant; ns, not significant

Table 7. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2008

Variety(A)	Grain yield t/ha		Mean (t/ha)	Variety(A)	Tillers/m ²		Mean
	Irrigation System (B)				Irrigation System (B)		
	AWD	Conventional			AWD	Conventional	
Sabitri	3.5	3.7	3.1	Sabitri	253	267	260
Mithila	3.5	3.7	3.6	Mithila	263	274	268
Hardinath-1	4.1	4.1	4.1	Hardinath-1	271	273	272
Radha-4	3.7	3.8	3.7	Radha-4	280	293	287
Mean			3.7	Mean			272
LSD (0.05%)			0.1	LSD (0.05%)			14.77
CV (%)			1.4	CV (%)			2.7
A			**	A			**
B			**	B			**
AxB			ns	AxB			ns

**, highly significant; ns, not significant

Table 8. Water saving under conventional irrigation and alternate wetting and drying system in rice cultivation at NRRP, Hardinath, 2008

Treatment	Water applied (mm)			Water saved compared to CSW (%)
	Irrigation	Rainfall	Total	
Continuous Standing water (CSW)	365	1162	1562.5	
AWD System	200	1162	1376	54.7

Table 9. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2009

Variety (A)	Days to heading Irrigation System (B)		Mean	Variety (A)	Days to maturity Irrigation System (B)		Mean
	AWD	Conven.			AWD	Conven.	
IR80411-B-49-1	90	91	90	IR80411-B-49-1	120	121	120
IR78397-B-B-B-B	93	92	92	IR78397-B-B-B-B	123	122	123
Sabitri	112	113	112	Sabitri	142	143	142
Mean			98	Mean			128
CV (%)			0.2	CV (%)			18.5
A			ns	A			ns
B			ns	B			ns
AxB			ns	AxB			ns
LSD (0.05%)			-	LSD (0.05%)			-

ns, not significant

Table 10. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2009

Variety (A)	Grain yield t/ha Irrigation system (B)		Mean (t/ha)	Variety (A)	Tillers/m ² Irrigation system (B)		Mean
	AWD	Conven.			AWD	Conven.	
IR80411-B-49-1	4.3	4.2	4.3	IR80411-B-49-1	333	297	315
IR78397-B-B-B-B	4.2	3.9	4.0	IR78397-B-B-B-B	325	292	309
Sabitri	4.1	4.2	4.1	Sabitri	301	312	307
Mean	4.2	4.1	4.1	Mean	320	300	310
CV (%)			6.1	CV (%)			11.4
A			ns	A			ns
B			ns	B			ns
AxB			ns	AxB			ns
LSD (0.05%)			-	LSD (0.05%)			-

ns, not significant

Table 11. Performance of rice varieties in different irrigation system at NRRP, Hardinath, 2009

Variety (A)	Filled grains/panicle Irrigation System (B)		Mean	Variety (A)	Unfilled grains/panicle Irrigation System (B)		Mean
	AWD	Conven.			AWD	Conven.	
IR80411-B-49-1	129	113	121	IR80411-B-49-1	25	37	31
IR78397-B-B-B-B	131	123	127	IR78397-B-B-B-B	26	33	30
Sabitri	126	126	126	Sabitri	34	39	37
Mean	129	121	121	Mean	28	36	32
CV (%)			9.4	CV (%)			19.0
A			ns	A			ns
B			ns	B			ns
AxB			ns	AxB			ns
LSD (0.05%)			-	LSD (0.05%)			-

ns, not significant

Table 12. Water saving under conventional irrigation and alternate wetting and drying system in rice cultivation at NRRP, Hardinath, 2009

Treatment	Water applied (mm)			Water saved compared with CSW (%)
	Irrigation	Rainfall	Total	
Continuous standing water (CSW)	415	1055.6	1470.6	
AWD system	225	1055.6	1280.6	54.2

The AWD (alternate wetting and drying) had reduced 54.4% irrigation water with same grain yield t/ha as compared to conventional irrigation system. Therefore, there is a need for wide scale farmer's

field validation of the technology in lift irrigation and tube well command areas before large scale dissemination of the AWD technology.

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Participatory Varietal Selection (PVS): An Approach to Identify Superior Variety and Disseminate Quality Seed for Increased Productivity in Rainfed Lowlands of Nepal

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ABSTRACT

Drought is one of the major constraints to rice production in rainfed areas in the country. In the context of changing climate, increasing irrigation is generally not a viable option for extenuating drought problems in rainfed rice-growing systems. Participatory varietal selection (PVS) trials were carried out to identify drought tolerant rice varieties and distribute their quality seed among farmers to increase rice production in rainfed areas. The statistical analysis showed highly significant differences in grain yield at Sahorwa of Mahottari district and at NRRP in Hardinath in 2009. Of the tested genotypes, especially IR74371-46-1-1 and IR74371-54-1-1 performed better than local checks across the sites during 2009. In the preference ranking, IR74371-46-1-1, IR74371-54-1-1 and IR74371-70 were preferred by a majority of farmers due to a clean and healthy crop stand, good plant type, good grain type, grain color and size with drought tolerance at all sites during 2009. Similarly, the statistical analysis revealed highly significant differences in grain yield at all sites during 2010. Among the tested genotypes, IR779915-B-83-4-3, IR81063-B-94-U3-3 and IR81896-B-B-68-B produced high grain yields of 3926, 4360 and 3957 kg ha⁻¹, respectively in 2010 across sites. They were also preferred by the majority of farmers in the preference ranking due to a clean and healthy crop stand, good plant type, good grain type, good grain color, grain size, and some drought tolerance. IR779915-B-83-4-3, another genotype preferred by farmers, produced the highest grain yield, had a short duration, good panicle length, fine grain type and drought tolerance at Sahorwa village of Mahottari district in 2010.

INTRODUCTION

Rice (*Oryza sativa*) is the most important cereal crop in Nepal. Rice is grown in diverse environments, where a wide range of varieties and production technologies are required. Widespread and persistent rural poverty is a major problem in the country, particularly where farmers grow rice without irrigation, referred to as “rainfed ecosystems.” Rice is dominant in these areas because it is the only crop that can be grown under the prevalent variable rainfall conditions. Drought seems increasingly becoming a problem for millions of rainfed rice farmers probably due to climate change. And in the near future, increasing scarcity of water resources available for irrigated agriculture and escalating demand of food around the world will make it necessary to produce more food with less water. Also, since more irrigated land is devoted to rice than to any other crop in the world, wastage of the resource in rice fields should be minimized (IRRI 2003). Rice is the staple food for nearly half of the world’s population (2.7 billion people), providing 35-60 percent of the calories consumed (Guerra et al 1998). More than 75 percent of the world’s rice is produced in irrigated systems, which are predominantly found in Asia. But water is becoming increasingly scarce. By 2025, the per capita available water resources in Asia are expected to decline by 15-54 percent compared with 1990 (Moya et al 2001). Rice grown under traditional practices in the Asian tropics and subtropics requires

between 700 and 1,500 mm of water for a cropping season depending on soil texture (Bhuiyan 1992). The actual amount of water used by farmers for land preparation and during the crop growth period is much higher than the actual field requirement. Paddy farmers often store water in their fields as a back-up safety measure against uncertainty in water supply. Also, there is often field-to-field irrigation. This leads to a high amount of surface runoff, seepage and percolation, accounting for about 50 to 80 percent of the total water input to the field (Sharma 1989). To achieve the goal of increasing rice production and productivity in rainfed systems in Nepal, participatory variety selection (PVS) trials were carried out to identify superior variety that maintain grain yields better than presently available rice varieties under drought conditions.

MATERIALS AND METHODS

A total of 12 promising drought tolerant rice genotypes, including check varieties Hardinath1, Radha4 and Janaki were tested at NRRP, Hardinath in 2009. Ten promising drought tolerant lines, including local checks were tested at Sahorwa of Mhottari district in 2009. And in 2010, 10 different promising lines, including checks were tested at the National Rice Research Program (NRRP) station Hardinath, Sahorwa and Baluwa of Siraha district. The trials were seeded on 25th May 2009 at NRRP Hardinath, and 4th June 2009 at Sahorwa. In 2010, seeding was done on 29 May at the NRRP station, on 6th June 2010 at Sahorwa, and on 2nd June 2010 at Baluwa. Nutrients were applied at 60:30:30: $\text{NP}_2\text{O}_5\text{K}_2\text{O}$ kg ha^{-1} . Half the N and all P_2O_5 and K_2O were applied basal, and the remaining N was applied as top dressed at 25 days after seeding. The plot size was 5x2 m in both the years at all sites. The layout was randomized complete block design with 3 replications. The establishment was by direct seeding in both years at all sites. The weed management was done with Butachlore at 1.5 kg ai ha^{-1} , followed by one hand weeding 35 days after seeding in both the years at all sites. All other cultural practices were conducted when necessary according to existing recommendations. Preference ranking was done with negative and positive voting on tested genotypes by farmers during farmers' field day.

RESULTS AND DISCUSSION

The statistical analysis showed insignificant differences in all observed traits at NRRP Hardinath in 2009 (Table 1). Of the tested genotypes, IR74371-46-1-1, IR74371-54-1-1, IR55419-04, IR74371-70-1-1, B6144F-MR6 and Radha4 produced high grain yields of 3.9, 3.9, 3.8, 3.8, 3.8, 3.8 and 3.8 t ha^{-1} , respectively. The range of maturity was between 118 to 125 days (Table1). The plant height ranged between 80 and 101 cm. Genotypes IR74371-46-1-1, IR74371-54-1-1 and NR-274-10 were preferred by farmers because of a high grain yield, drought tolerance, good milling recovery, and disease and pests resistance at NRRP Hardinath (Table 2). In contrast, the statistical analysis showed highly significant differences for all observed traits, except days to flowering and panicle length, at Sahorwa of Mahottari district. The genotypes IR74371-46-1-1, IR74371-54-1-1, IR55419-04, IR 78908-193-B-B-B, NR274-10, B6144F-MR6 and Radha4 produced high grain yields of 5.1, 4.6, 4.6, 4.6, 4.6, 4.6 and 4.6 t ha^{-1} , respectively, at Sahorwa in 2009. The range of days to flowering, plant height (cm), and tillers per m^2 were 88-99, 98.5-120.5 and 70-126, respectively (Table 3). In the preference ranking IR74371-46-1-1, IR74371-54-1-1 and Radha4 were preferred by most farmers because of high grain yields, drought tolerance, good milling recovery, disease and pest resistance, and the fit of these rice varieties into the rice-wheat, and rice-chickpea/lentil cropping patterns (Table 4).

Table 1. Grain yield and its ancillary characters in participatory varietal selection (PVS) in Hardinath during 2009

Variety/Entry	A	B	C	D	E	F	G	H
IR74371-54-1-1	92	123	99.1	20.9	135	101	32	3.9
IR74371-46-1-1	92	122	102	22.5	143	113	36	3.9
IR55419-04	91	122	99.9	24.9	131	101	30	3.8
IR74370-70-1-1	94	124	95.8	21.8	132	117	36	3.8
IR 78908-193-B-B-B	89	119	109	24.6	149	103	39	3.1
IR 83614-673-B	89	118	97.8	25.3	139	101	34	3.5
NR274-10	91	121	96	21.5	143	96	34	3.3
B6144F-MR-6	96	125	114	23.7	136	95	28	3.8
Hardinath1	93	123	96.1	23.8	130	102	33	2.8
Radha4	90	121	91.5	22.5	136	113	34	3.8
IR83614-28-1-B	91	121	98.8	23.7	123	91	36	2
Janaki	93	123	91.3	22.7	120	111	33	1.9
Grand Mean	92	122	99.2	23.2	135	104	34	3.3
CV (%)	5.4	4.0	9.3	8.1	13.4	13.8	18	15.5
LSD (0.05%)	8.4	8.15	15.6	3.19	30.7	24.3	10.3	0.87
F-test	ns	ns	ns	ns	ns	ns	ns	**

A, days to flowering; B, days to maturity; C, plant height (cm); D, panicle length (cm), E, tillers/m²; F, filled grains/panicle; G, unfilled grains/panicle; H, grain yield (mt/ha⁻¹); ns, not significant; **, highly significant

Table 2. Preference analysis in participatory varietal selection (PVS) experiments in Hardinath in the 2009 wet season

Variety/Entry	Male		Female		Total	Ranks
	Positive	Negative	Positive	Negative		
IR74371-54-1-1	7	0	7	1	(+13)	I-B
IR74371-46-1-1	5	0	5	0	(+10)	II-B
IR55419-04	0	0	0	1	(-2)	
IR74371-70-1-1	0	1	0	9	(-10)	I-W
IR78908-193-B-B-B	3	0	2	0	(+5)	
IR83614-673-B	0	0	0	0	0	
NR274-10	8	0	2	0	(+6)	III-B
B6144F-MR-6	4	0	0	0	(+4)	
Hardinath1	0	0	0	0	0	
Radha4	0	6	0	3	(-9)	II-W
IR83614-28-1-B	0	4	0	0	(-4)	III-W
Janaki	0	1	0	1	(-2)	

Table 3. Grain yield and its ancillary characters in participatory varietal selection (PVS) in Sahorwa, Mahottari in 2009

Variety/Entry	A	B	C	D	E
IR74371-54-1-1	99	111.7	26.7	77	4.7
IR74371-46-1-1	94	111.3	20.4	86	5.1
IR55419-04	91	98.5	20.7	111	4.6
IR74370-70-1-1	96	110.3	23.2	112	4.6
IR 78908-193-B-B-B	98	97.9	24	83	4.6
IR 83614-673-B	88	103.7	23.3	126	4.5
NR274-10	90	109.8	22.9	117	4.6
B6144F-MR-6	97	120.9	21.7	88	4.6
Hardinath1	90	109.1	22.7	100	4.4
Radha4	90	101.7	22.5	106	4.6
Grand Mean	94	107.5	24.8	101	4.6
CV (%)	5.7	2	14.5	2.1	3.5
LSD (0.05%)	9.077	3.657	4.61	3.66	0.273
F-test	ns	**	ns	**	**

A, days to flowering; B, plant height (cm); C, panicle length (cm); D, tillers per m²; E, grain yield (mt/ha⁻¹); ns, not significant; **, highly significant

Table 4. Preference analysis in participatory varietal selection (PVS) at Sahorwa, Mahottari, during wet season in 2009

Variety/Entry	Male		Female		Total	Ranks
	Positive	Negative	Positive	Negative		
IR74371-54-1-1	8		6		(+14)	II
IR74371-46-1-1	10		8		(+18)	I
IR55419-04	3				(+3)	V
IR74370-70-1-1					0	
IR78908-193-B-B-B	5		3	3	(+5)	IV
IR83614-673-B		2	4		(+2)	VI
NR274-10		3	6		(+3)	V
B6144F-MR-6					0	
Hardinath1				3	(-3)	
Radha4	6	2	4	2	(+6)	III

The statistical analysis showed highly significant differences in days to flowering, maturity days, plant height, grain yield, and biomass yield at NRRP Hardinath in 2010. The genotypes IR779915-B-83-4-3, IR81063-B-94-U3-3 and IR81896-B-B-68-B produced highest grain yields of 3.9, 4.4 and 4.0 t ha⁻¹, respectively at NRRP Hardinath in 2010. The range of days to flowering, maturity days, plant height (cm), panicle length (cm), tillers per m², biomass (t ha⁻¹), harvest index, 1000 grain weight (g), number of filled grains per panicle and number of unfilled grains per panicle were 71-114, 105-143, 101.5-125.8, 21.9-23.9, 199-132, 7.96-13.36, 0.3-0.5, 20.3-34.5, 73-117 and 14-27, respectively. Genotypes Hardinath1 and IR81432-B-B-150 had a high harvest index indicating their tolerance to drought (Table 5). But farmers preferred IR779915-B-83-4-3, IR81432-B-B-150, IR81063-B-94-U3-3 and Radha4 due to drought tolerance, diseases and pests resistance, higher grain yield, clean crop stand, and the fit of these genotypes into their cropping patterns (Table 6). The statistical analysis revealed that all observed traits were significantly different except for the 1000 grains weight, the number of filled grains per panicle, and the number of unfilled grains per panicle at Baluwa of Sirha district in 2010. Genotypes IR81063-B-94-U3-3, IR77298-14-1-2, IR81896-B-B-68-B and Radha4 produced high grain yields of 5.3, 4.8, 4.8 and 4.8 t ha⁻¹, respectively at Baluwa. Again, Radha4 had a harvest index of 0.5 indicating its drought tolerance. The range of days to flowering, maturity days, plant height (cm), panicle length (cm), tillers per m², 1000 grain weight (g), biomass yield (t ha⁻¹), harvest index, number of filled grains per panicle and number of unfilled grains per panicle were 93-116, 121-149, 105.7-136.8, 22.7-26.7, 210-288, 24.1-34.6, 0.7-1.4, 0.3-0.5, 85-118 and 18-30, respectively at Baluwa (Table 7). In the preference ranking, IR779915-B-83-4-3, Radha-4, IR80463-B-39-3 and IR81432-B-B-150 had a high score because of high grain yield, drought tolerance, clean crop and the fit of these genotypes into farmers' prevailing cropping patterns (Table 8).

The statistical analysis showed highly significant differences for all observed traits among the genotypes at Sahorwa in 2010 except for tillers per m², harvest index, and 1000 grains weight. The genotypes producing higher grain yields than the checks were IR779915-B-83-4-3 (3.2 t ha⁻¹), Radha-4 (2.9 t ha⁻¹), IR77298-14-1-2 (2.9 t ha⁻¹) and IR81063-B-94-U3-3 (2.8 t ha⁻¹). The range of days to flowering, maturity days, plant height (cm), panicle length (cm), tillers per m², 1000 grain weight (g), biomass yield (t ha⁻¹), harvest index, number of filled grains per panicle and number of unfilled grains per panicle were 76-105, 110-135, 85.7-117.6, 17.6-22.13, 156-248, 0.6-1.3, 0.2-0.3, 45-100 and 13-68, respectively at Sahorwa in 2010 (Table 9). However, farmers preferred genotypes IR779915-B-83-4-3, Hardinath1 and IR81896-B-B-68-B because of their earliness, grain type and resistance to diseases and pests (Table 10). They also advocated that these genotypes would fit better into the rice-vegetable cropping pattern.

Table 5. Grain yield and its ancillary characters in participatory varietal selection (PVS) in Hardinath during wet season in 2010

Variety/Entry	A	B	C	D	E	F	G	HI	J	K	L
IR80461-B-7-1	91	121	114.1	23.5	3.200	208	11.96	0.3	22.5	83	22
IR779915-B-83-4-3	89	117	114.8	23.9	3.900	230	11.25	0.4	23.3	117	14
IR80463-B-39-3	90	119	121.7	22.5	2.600	215	11.97	0.3	34.5	105	14
IR81432-B-B-150	97	129	113.6	22.3	2.544	199	9.55	0.5	28.2	103	19
IR81063-B-94-U3-3	89	118	112.3	21.9	4.360	211	12.73	0.4	26.4	108	16
IR77298-14-1-2	90	119	101.5	22.7	2.850	205	11.61	0.3	25.2	130	18
IR81896-B-B-68-B	98	128	125.8	22.6	3.957	214	12.49	0.4	24.9	93	19
Radha11	114	143	119.1	23.8	2.381	231	7.96	0.4	20.3	109	19
Radha4	92	123	110.8	22.5	3.364	232	13.36	0.3	25.8	73	16
Hardinath1	71	105	103.0	21.9	3.703	224	9.07	0.5	24.2	101	27
Grand mean	92	122	113.7	22.8	3.229	217	11.2	0.4	25.5	102	18
LSD	1.03	2.73	9.3	1.45	1.304	38.9	3.32	1.1	7.8	44	13
CV (%)	0.2	1.3	4.8	3.7	4.1	10.5	3.6	3.4	9.9	8	6.7
F-test	**	**	**	ns	*	ns	*	ns	ns	ns	ns

A, days to flowering; B, days to maturity; C, plant height (cm); D, panicle length (cm); E, grain yield (kg/ha); F, tiller/m²; G, biomass yield (mt/ha⁻¹); HI, harvest index; J, 1000 grain weight; K, filled grain/panicle; L, unfilled grain/panicle; **, highly significant; *, significant; **, not significant

Table 6. Preference analysis in participatory varietal selection (PVS) in Hardinath during wet season in 2010

Variety/Entry	Male (n=20)		Female (n=12)		Scientist (n=3)		Total (n=35)		Preference score
	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	
IR80461-B-7-1	0	0	0	0	0	0	0	0	0
IR779915-B-83-4-3	18	2	12	0	3	0	33	2	0.18
IR80463-B-39-3	5	15	2	10	0	3	7	28	-0.12
IR81432-B-B-150	10	10	8	4	2	1	20	15	0.03
IR81063-B-94-U3-3	12	8	10	2	2	1	24	11	0.07
IR77298-14-1-2	0	0	0	0	0	0	0	0	0
IR81896-B-B-68-B	8	12	8	4	0	3	16	19	-0.02
Radha11	0	0	0	0	0	0	0	0	0
Radha4	11	9	8	4	3	0	22	13	0.05
Hardinath1	0	0	0	0	0	0	0	0	0

+ve, positive; -ve, negative

Table 7. Grain yield and its ancillary characters in participatory varietal selection (PVS) in Baluwa, Siraha during wet season in 2010

Variety/Entry	A	B	C	D	E	F	G	J	HI	K	L
IR80461-B-7-1	104	136	116	24.3	4.5	268	29.3	1.1	0.4	100	18
IR779915-B-83-4-3	102	123	122.8	26.7	4	218	26.8	1	0.4	95	20
IR80463-B-39-3	96	131	116.9	23.7	3.8	228	24.8	1	0.4	106	30
IR81432-B-B-150	93	122	120.2	22.7	3.25	217	31.2	0.9	0.4	92	28
IR81063-B-94-U3-3	105	133	128.7	26.7	5.25	283	30.1	1.3	0.4	113	20
IR77298-14-1-2	95	124	110.3	25.7	4.833	210	26.9	1.3	0.4	112	18
IR81896-B-B-68-B	111	143	136.8	24.3	4.833	288	24.1	1.4	0.3	118	21
Radha11	116	149	135.7	25.7	3.917	242	34.6	1.3	0.3	87	26
Radha4	102	132	108.3	23.7	4.75	273	28	1.1	0.5	100	23
Hardinath1	93	121	105.7	24.3	3	252	25.4	0.7	0.4	85	25
GM	101.7	131.3	120.3	24.8	4.215	248	28.13	1.1	0.4	100.7	22.9
LSD	6.4	7.77	2.09	1.13	1.126	32.96	7.76	0.28	0.08	30.14	9.97
CV (%)	1.3	3.4	1	2.7	5.4	5.3	4.1	10.3	15.6	17.4	1.7
F-test	**	**	**	**	**	**	NS	**	**	NS	NS

A, days to flowering; B, days to maturity; C, plant height (cm); D, panicle length (cm); E, grain yield (kg/ha); F, tillers/m²; HI, harvest index; J, biomass yield (ton/ha); G, 1000 grain weight; K, filled grain/panicle; L, unfilled grain/panicle

Table 8. Preference analysis in participatory varietal selection (PVS) at Baluwa, Siraha during wet season in 2010

Variety/Entry	Male (n=30)		Female (n=18)		Scientists (n=8)		Total (n=56)		Preference score
	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	
IR80461-B-7-1	6	24	8	10	3	5	17	39	-0.13
IR779915-B-83-4-3	28	2	12	6	8	0	48	8	0.23
IR80463-B-39-3	18	12	12	6	6	2	36	20	0.09
IR81432-B-B-150	22	8	8	10	5	3	35	21	0.08
IR81063-B-94-U3-3	0	0	0	0	0	0	0	0	0
IR77298-14-1-2	12	18	8	10	2	6	26	30	-0.02
IR81896-B-B-68-B	0	0	0	0	0	0	0	0	0
Radha11	6	24	3	15	0	8	9	47	-0.22
Radha4	25	5	10	8	6	2	41	15	0.15
Hardinath1	11	19	5	13	4	4	20	36	-0.09

+ve, positive, -ve, negative

Table 9. Grain yield and its ancillary characters in participatory varietal selection (PVS) at Sahorwa, Mahottari during wet season in 2010

Variety/Entry	A	B	C	D	E	F	G	HI	J	K	L
IR80461-B-7-1	104	134	96	19.8	2400	208	1.1	0.3	20	71	16
IR779915-B-83-4-3	82	112	101.4	22.13	3167	234	1.1	0.3	22.8	100	13
IR80463-B-39-3	105	135	97.5	21.07	2700	218	0.9	0.3	20.8	90	14
IR81432-B-B-150	86	116	99.8	20.87	1967	218	1.2	0.2	26.3	85	15
IR81063-B-94-U3-3	94	124	91.5	20.73	2833	198	1.1	0.3	20.2	85	14
IR77298-14-1-2	76	110	86.9	22.07	2867	181	1	0.3	23.4	74	14
IR81896-B-B-68-B	94	124	95.4	20.8	2467	248	1.3	0.2	25.6	77	15
Radha-11	101	132	117.6	17.6	1133	156	0.6	0.2	27.1	45	68
Radha-4	97	127	85.7	20.53	2867	213	1.1	0.3	21.4	65	17
Hardinath-1	88	118	74.5	20	1767	201	0.6	0.3	19	72	15
GM	92.7	123.2	94.6	20.6	2417	207	1	0.3	22.7	76	20
LSD (0.05%)	4.313	5.102	12.21	1.897	951.5	52	0.4	0.2	6.6	28.4	10.8
CV (%)	1.3	1.1	7.7	3.8	3.1	2	24	39.3	8.2	19	18.6
	**	**	**	**	**	NS	**	NS	NS	*	**

A, days to flowering; B, days to maturity; C, plant height (cm); D, panicle length (cm); E, grain yield t/ha; F, tiller/m²; HI, harvest index; G, biomass yield (mt/ha); J, 1000 grain weight; K, filled grain/panicle; L, unfilled grain/panicle

It is a top priority to produce higher rice yields with less water in rainfed rice environments of Nepal, especially given the changing weather patterns affected by climate change. The genotypes IR74371-46-1-1, IR74371-54-1-1, IR74371-70, IR779915-B-83-4-3, IR81063-B-94-U3-3 and IR81896-B-B-68-B were found outstanding under aerobic and transplanting conditions. They had good grain yields, little disease problems, and considerable pest resistance and drought tolerance. Thus, these genotypes provide new options for cultivation under rainfed conditions in an environment of highly variable and changing climate. The existing network of research, extension, and NGOs should ensure the effective scaling up of identified genotypes in the rainfed areas. These new genotypes should also be used in breeding program for drought tolerance.

Table 10. Preference analysis in participatory varietal selection (PVS) at Sahorwa, Mahottari during wet season in 2010

Variety/Entry	Male (n=32)		Female (n=10)		Scientists (n=3)		Total (n=45)		Preference score
	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	
IR80461-B-7-1	24	8	6	4	1	2	31	14	0.1
IR779915-B-83--4-3	28	4	8	2	3	0	39	6	0.19
IR80463-B-39-3	16	16	8	2	1	2	25	20	0.03
IR81432-B-B-150	10	22	4	6	0	3	14	31	-0.15
IR81063-B-94-U3-3	0	0	0	0	0	0	0	0	0
IR77298-14-1-2	0	0	0	0	0	0	0	0	0
IR81896-B-B-68-B	20	12	6	4	2	1	28	17	0.06
Radha-11	4	28	0	10	0	3	4	41	-0.21
Radha-4	0	0	0	0	0	0	0	0	0
Hardinath-1	20	12	5	5	3	0	28	17	0.06

+ve, positive; -ve, negative

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Agronomical Investigation of Drought Tolerant Rice in Mid Western Terai of Nepal

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ABSTRACT

Field experiments were conducted during rainy season of 2008 and 2009 at Regional Agriculture Research Station, Khajura, Banke to find out nutrient use efficiency and seedling age effect of different rice genotypes. Grain yield obtained at 45:30:20 kg N:P₂O₅:K₂O/ha was significantly superior over control and at par with 90:60:40 kg N:P₂O₅:K₂O/ha. Interaction between nutrients levels and rice genotypes on grain yield was significant. Rice genotypes impacted rice grain yield when averaged over the nutrients levels. IR74371-54-1-1 produced the highest mean grain yield (3266 kg/ha) followed by IR74371-46-1-1 (3262 kg/ha) and standard check Radha-4 (3650kg/ha), respectively. Age of seedling impacted rice grain yield significantly. The mean grain yields obtained from different seedling age revealed a 37.7 kg/ha/day yield loss up to 35 days old seedling whereas 45 days old seedling had 61 kg/ha/day yield loss. IR74371-54-1-1 produced the highest mean grain yield (3479 kg/ha) followed by IR74371-46-1-1 (3278 kg/ha) and IR74371-70-1-1(3235 kg/ha), respectively. The least grain yielder was Hardinath-1 (2649 kg/ha). Rice genotypes interacted with seedling age in producing rice grain yields. Change either in seedling age or in rice genotypes would impact rice grain yields. IR74371-54-1-1 and IR74371-46-1-1 were stable in rice grain yields and seemed to be appropriate for wider seedling age. IR55419-04 and IR74371-70-1-1 were stable in producing grain yields up to 35 days old seedling.

INTRODUCTION

Rice is the lifeline of Nepalese people and holds the key to sustained food sufficiency in the country since it contributes about 57% of the total food grain production. It is grown in nearly 1.48 million ha with a total production of 4.23 million tones and a productivity of 2.9 t/ha. It is regarded as backbone of country's economy contributing approximately one fourth of the AGDP and meets more than 50% of the total calorie requirement of Nepalese people. It is grown under a wide range of agro-climatic conditions from 60 meter above sea level (masl) in the terai to 3050 masl in Jumla, the highest place of rice growing in the world. Rice farming is considered as the prestigious crop in the hill and mountain and farmers prefer to grow rice even in the small piece of land whenever it is possible. Rice-based systems are essential to everyone directly and indirectly for food security, livelihood improvement and cultural heritage. In food deficit areas, people suffer from under nourishment, malnutrition and disease. A large portion of farm is under rainfed systems where the water supply is unpredictable and drought is common. In Nepal, lowland rice contributes 91% and 44.5% of total rice is under completely rainfed conditions, while 55.5% of the rice area is either fully or partially irrigated (MOAC 2009). Most of the regions with low rice productivity and extensive poverty in Nepal are rainfed ecologies where rice is the principal source of staple food, employment and income for the rural population. Rainfed lowland rice dominates the cropping system in Nepal. Shortage of water and inadequate irrigation infrastructure are typical of rural areas. By 2020, total rice production must increase to over 6 million tons to feed the ever increasing population.

Rainfall is highly variable from year to year, season to season and location to location. Frequency and distribution vary with a significant effect on productivity. Excessive rains cause floods, while no or little rain causes droughts. Sometimes both floods and droughts occur during the same growing season. Irregular rainfall at the beginning of the wet season delays rice planting and increase weed growth and insect pest population, resulting in yield loss. Early termination of rain induce drought at reproductive stage leading to grain yield loss.

To a rice farmer, "drought" means not only physical water shortage that affects plant growth and development but also a lack of sufficient water to support land preparation, transplanting, fertilizer application, and weed control operations. Losses from these management disruptions may be as great as those from direct drought damage. Cultivars differ in their sensitivity to these management disruptions and those differences can be exploited in the development of more resilient varieties for drought-prone environments. Transplanting is the management step that is most vulnerable to water shortage. The optimum age of seedlings at transplanting is 2-4 week old, but rainfed farmers are often forced to transplant seedling that are much older due to water shortage. Farmers cannot transplant until sufficient water accumulates in fields to permit puddling (usually 400-500 mm of rainfall); often, this may not occur until seedlings are 60-80 days old. Such delays result in large yield losses because of reductions in both panicle number and weight. In experiments conducted in IRRI in 2005, transplanting 65-day old as opposed to 22-day old seedlings resulted in yield reduction of more than 50% averaged across 125 cultivars. Yield reductions due to delayed transplanting were experienced on this scale in large areas of western Nepal. Therefore, field experiments were conducted with objectives of studying the effects of nutrient level, seedling age, genotypes and interaction effect of different fertilizer doses and different seedling age in drought tolerant genotypes of rice.

MATERIALS AND METHODS

A total of four trails, two of seedling age and two of nutrient use efficiency were carried out in agronomical research project funded by stress tolerant rice for poor farmers in South Asia and Africa at RARS Khajura during 2008 and 2009. The trails were designed in strip-plot with 3 replications. The individual plot size was 4.8 m². The main plots included three seedling ages as (25, 35 and 45-day old seedlings) in 2008 and 2009 while sub-plots included 10 genotypes in 2008 and 8 genotypes in 2009. Similarly in nutrient use efficiency trails in 2008 and 2009, main plots included 3 levels of nutrients: F1 (0-0-0 NPK kg/ha), F2 (45-30-20 NPK kg/ha) and F3 (90-60-40 NPK kg/ha) while sub-plots included 10 genotypes in 2008 and 8 genotypes in 2009. The 10 genotypes included in 2008 were (1) IR74371-54-1-1, (2) IR72667-16-1-B-B-3, (3) IR74371-46-1-1, (4) IR55419-04, (5) IR74371-70-1-1, (6) IR70215-70-CPA-3-4-1-3, (7) Rhada-4, (8) Judi-572, (9) Pusa-834, and (10) Hardinath-1. Likewise, the 8 genotypes included in 2009 were (1) IR74371-70-1-1, (2) IR55419-04, (3) IR75371-46-1-1, (4) IR74371-54-1-1, (5) IR78908-193-B-3B, (6) IR83614-281-B, (7) Radha-4, and (8) Hardinath-1.

Seeding was done in both the years on 15th Shrawan, 21 days late of normal seeding, to synchronize drought at reproductive stage. Transplanting was done with spacing of 20 cm apart in both the seedling age and nutrients use efficiency trials. The water from field was kept to drain continuously for 25 days after transplanting to induce drought in experimental fields.

The daily rainfall data and water table were recorded. For combined analysis of yield parameter only common genotypes were taken, whereas for other parameters all genotypes of 2008 were taken. Data were analyzed using Gene STAT Computer programme.

RESULTS AND DISCUSSION

Grain yield, 2008

Nutrient level effect: Nutrient levels impacted rice grain yield significantly. The overall mean grain yields obtained from different nutrient levels revealed a 257 g yield loss in control plot F1 (0-0-0 NPK) compared to F2 (45-30-20 kg NPK/ha) in 4.8 m² where as there was no significant difference between F2 (45-30-20 kg NPK/ha) and F3 (90-60-40 kg NPK/ha), but significantly different between F1 and F3 (Table 1).

Genotype effect: Rice genotypes impacted rice grain yield when averaged over the nutrient levels. IR74371-54-1-1 produced the highest mean grain yield (1287 g) followed by IR74371-46-1-1(1213 g) and IR70215-70-CPA-3-4-1-3 (1168 g). The least yielder was IR72667-16-1-B-B-3 (891 g) (Table 1).

Interaction between nutrient levels and rice genotypes: Interaction between rice genotypes and nutrient levels was not significant (Table 1).

Table. 1 Performance and interaction of nutrients levels and rice genotypes on grain weight (g/plot), 2008

Genotypes/ Nutrients levels	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
F1	1033	1037	697	888	975	898	785	992	740	728	877
F2	1177	1150	1542	960	1297	995	755	1225	1093	1147	1134
F3	1430	1675	1190	1048	1268	1120	1133	1288	1182	1187	1252
GM	1213	1287	1143	966	1180	1004	891	1168	1005	1021	1088
	Interaction				Genotypes				Nutrients level		
F-test	Ns				**				**		
CV (%)	19.1				12				5.8		
LSD (0.05)					196.4				124.2		

A, IR 74371-46; B, IR74371-54; C, IR 74371-70; D, IR 55419-04; E, Rhada 4; F, Hardinath 1; G, IR 72667-16-1-B-B-3; H, IR 70215-70-CPA; I, Judi 572; J, Pusa834

Grain yield, 2009

Nutrient level effect: Nutrient levels impacted rice grain yield significantly. The overall mean grain yields obtained from different nutrient levels revealed a 1183 kg and 1572 kg yield/ha loss in an control plot (F1) compared to F2 and F3 plots, respectively, where as 389 kg/ha yield loss in F2 plot compared to F3 plot (Table 2).

Rice genotype effect: Rice genotypes impacted rice grain yield when averaged over the nutrient levels. IR74371-46-1-1 produced the highest mean grain yield (3996 kg/ha) followed by IR74371-54-1-1 (3851 kg/ha) and Radha-4 (3519 kg/ha), respectively. The least yielder was IR83614-281 (2708 kg/ha) (Table 2).

Interaction between nutrient levels and rice genotypes: Rice genotypes interacted significantly with each nutrient level (Table 2).

Combined grain yield (kg/ha), 2008 and 2009

Nutrient level effect: Nutrient levels impacted rice grain yield significantly. The highest mean grain yield obtained from F3 (3393 kg/ha) followed by F2 (3064 kg/ha). The overall mean grain yields obtained from different nutrient levels revealed a 868 kg and 1197 kg/ha yield loss in the control plot (F1) compared to F2 and F3 plots, respectively, whereas 329 kg/ha yield loss in F2 plot compared to F3 plot.

Table 2. Performance and interaction of nutrients levels and rice genotypes on grain weight (kg/ha), 2009

Genotypes/ Nutrients levels	Genotypes								Grand mean
	A	B	C	D	E	F	G	H	
F1	2644	2634	2544	1953	2769	2294	2675	1741	2407
F2	4250	4200	3666	2813	3613	3391	3613	3178	3590
F3	5094	4719	4141	3059	4175	3428	4006	3206	3979
GM	3996	3851	3450	2608	3519	3038	3431	2708	3325
	Interaction			Genotypes			Nutrients level		
F-test	**			**			**		
CV (%)	3.9						3.9		
LSD (0.05)	215.2			124.2			76.1		

A, IR 74371-46; B, IR74371-54; C, IR 74371-70; D, IR 55419-04; E, Rhada 4; F, Hardinath 1; G, IR 72667-16-1-B-B-3; H, IR 70215-70-CPA; I, Judi 572; J, Pusa 834

Rice genotype effect: Rice genotypes impacted rice grain yield when averaged over the nutrient levels. IR74371-54-1-1 produced the highest mean grain yield (3266 kg/ha) followed by IR74371-46-1-1 (3262 kg/ha) and Radha-4 (2988 kg/ha), respectively. The least yielder was IR55419-04 (2310 kg/ha).

Interaction between nutrient level and rice genotype: Rice genotypes interacted significantly with each nutrient level (Table 3).

Table 3. Combined performance and interaction of nutrients levels, and rice genotypes on grain yield (kg/ha), 2008 and 2009

Genotypes/ Nutrients levels	Genotypes						Grand mean
	A	B	C	D	E	F	
F1	2398	2397	1998	1902	2400	2082	2196
F2	3351	3298	3439	2407	3158	2731	3064
F3	4037	4104	3310	2621	3408	2880	3393
GM	3262	3266	2915	2310	2988.	2564	2884
	Interaction		Nutrient levels		Genotypes		
F-test	**		**		**		
CV (%)	12.5		13.8		16.0		
LSD (0.05)	202		191		111		

A, IR 74371-46; B, IR74371-54; C, IR 74371-70; D, IR 55419-04; E, Rhada 4; F, Hardinath 1

Straw yield per plot

Nutrient level effect: Nutrient levels impacted rice straw yield significantly. The overall mean straw yield obtained from different nutrient levels in combined analysis revealed a 594 g straw yield loss in the control plot (F1) compared to F2 plot in 4.8 m² where as between F2 and F3 plots, yield loss was 306 g, and between F1 and F3 the yield loss was 884 g. Straw yield/plot was significantly different among different levels.

Rice genotype effect: Rice genotypes impacted rice straw yield when averaged over the nutrient levels. IR70215-70-CPA-3-4-1-3 produced the highest mean straw yield (2562 g) that was comparable to IR72667-16-1-B-B. The lowest straw yielder was IR55419-04 but it was at par with IR7437154-1-1, IR 74371-70-1-1, Judi-572, Pusa-834 Radha-4 and Hardinath-1.

Interaction between nutrient level and rice genotype: Interaction between rice genotypes and nutrient levels was insignificant (Table 4).

Table 4. Combined performance of nutrients levels, rice genotypes and interaction between nutrients levels and rice genotypes on straw yield (g/plot)

Genotypes/ Nutrients levels	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
F1	1917	1843	1777	1231	1637	2127	1553	1670	1259	1515	1653
F2	2130	2435	2415	2237	2107	2590	2038	2187	2182	2150	2247
F3	2245	2708	2560	2387	2613	2970	2490	2340	2683	2370	2537
GM	2097	2329	2251	1951	2119	2562	2027	2066	2041	2012	2146
F-test	Intera	Genot	Nutri								
CV (%)	ction	ypes	ent								
LSD (0.05)	NS	*	levels								
	14.4	--	*								
	535.4	291.2	6.7								
			326.2								

A, IR74371-54-1-1; B, IR 72667-16-13; C, IR 74371-46-1-1; D, IR 55419-04; E, IR 74371-70-1-1; F, IR 70215-70-CPA-3-4-1-3; G, Judi 572; H, Pusa 834; I, Radha-4; J, Hardinath 1

Flowering

Nutrient level effect: The effect of nutrient levels on days to flowering was insignificant (Table 5).

Rice genotypic effect: Rice genotypes impacted days to flowering when averaged over the nutrient levels. Hardinath-1 took minimum days to flowering (75.2) that was comparable to IR74371-46-1-1, IR55419-0-4 and IR74371-70-1-1. Genotypes IR70215-70-CPA-3-4-1-3 (97.3 days) took more days to flowering but it was similar to IR72667-16-1-B-B-3 (Table 5).

Interaction between nutrient level and rice genotype: Interaction between rice genotypes and nutrient levels on days to flowering was not significant (Table 5).

Table 5. Combined performance of nutrients levels, rice genotypes and interaction between nutrients levels and rice genotypes on flowering

Genotypes/ Nutrients levels	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
F1	80.67	104.67	79.67	80.33	78	103.33	81.67	81	85.33	77.33	85.2
F2	80.67	104.67	79.67	80.33	78	93.67	82.67	80.67	87	74.33	82.67
F3	90	96.33	80.67	79.67	81	95	89.67	79.33	89.67	74	85.53
GM	83.78	95	80.33	80.22	80	97.33	84.67	80.89	87.33	75.22	84.47
F-test	Interaction		Genotypes		Nutrient levels						
CV (%)	NS	**	NS								
LSD (0.05)	8.9	--	2.5								
	12.09	7.06	4.761								

A, IR74371-54-1-1; B, IR 72667-16-13; C, IR 74371-46-1-1; D, IR 55419-04; E, IR 74371-70-1-1; F, IR 70215-70-CPA-3-4-1-3; G, Judi 572; H, Pusa 834; I, Radha-4; J, Hardinath 1

Plant height

Nutrient level effect: Nutrient levels impacted rice plant height significantly. The overall mean of plant height obtained from different nutrient levels revealed a 13.33 cm less plant height in the control plot (F1) compared to F2 plot, whereas between F2 and F3 the difference in plant height was 4 cm, and between F1 and F3 it was 17 cm. Plant height was significantly different among different nutrients levels (Table 6).

Rice genotype effect: Rice genotypes impacted rice plant height when averaged over the nutrients levels. IR72667-16-1-B-B-3 was taller (115.33 cm) and that was comparable to IR74371-54-1-1. The shortest plant height was observed in Hardinath-1 but it was similar to IR74371-70-1-1 (Table 6).

Interaction between nutrient level and rice genotype: Interaction between rice genotypes nutrients levels on plant height was not significant (Table 6).

Table 6. Combined performance of nutrients levels, rice genotypes and interaction between nutrients level and genotypes on plant height

Genotypes/ Nutrients levels	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
F1	103.5	103	102.4	102.2	96.9	104.7	96.9	94.6	97.7	98.4	100.3
F2	116.6	122	114	113.2	108.6	115.3	114	114	110.9	104.5	113.3
F3	123	121	118.4	119.5	115.3	116.8	122.7	116.5	115.9	108.3	117.7
GM	114.4	115	111.6	111.6	106.9	112.2	111.2	108.4	108.2	103.7	110.4
	Interaction		Genotype			Nutrient level					
F-test	ns		**			**					
CV (%)	3.1					0.8					
LSD (0.05)	5.527		3.26			1.936					

A, IR74371-54-1-1; B, IR 72667-16-13; C, IR 74371-46-1-1; D, IR 55419-04; E, IR 74371-70-1-1; F, IR 70215-70-CPA-3-4-1-3; G, Judi 572; H, Pusa 834; I, Radha-4; J, Hardinath 1; **, highly significant

Grain yield, 2008

Seedling age effect: Seedling age impacted rice grain yield significantly. The overall mean grain yields obtained from different seedling age revealed a 15 g/day yield loss up to 35-day old seedling planting in 4.8 m² whereas 45-day old seedling planting caused 16 g/day yield loss. Grain yield was significantly different among the three seedling age (Table 7).

Rice genotype effect: Rice genotypes impacted rice grain yield when averaged over the seedling age. IR74371-54-1-1 produced the highest mean grain yield (1411.1 g) followed by IR74371-46-1-1 (1223.7 g) and IR74371-70-1-1(1214.7 g), respectively. The least yielder was IR72667-16-1-B-B-3 (784.4 g) (Table 7).

Interaction between seedling age and rice genotype: Rice genotypes interacted with seedling age in producing rice grain yields. Change either in seedling age or in rice genotypes would impact rice grain yields (Table 7). IR74371-54-1-1 was stable in rice grain yields as no significant reduction in grain yield was seen and seemed to be an appropriate rice genotype to be planted in wider age of seedlings. IR55419-04, IR74371-70-1-1, Judi-572, Pusa-834 and Hardinath-1 were stable in producing grain yields up to 35- day old seedling as no significant reduction in grain yield was seen (Table 7).

Table 7. Performance of seedlings age of different genotypes and interaction of seedlings age and genotypes on grain weight (g/plot of 4.8m²), 2008

Genotypes/ Seedling age	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
SA1	1335	1446.7	1317.5	1235	1101	1340	1241.7	1250	1400	1258.3	1292.6
	1182.7	1413.3	1220	1161.7	630	1073.3	1244	1133.3	1226.	1126.7	1141.2
SA3	1153.3	1373.3	1106.7	931.7	621.7	1083.3	948.3	1143.3	900	458.3	972
GM	1223.7	1411.1	1214.7	1109.4	784.4	1165.6	1144.7	1175.6	1175.	947.8	1135.2
	Interaction				Genotypes				Seedling age		
F-test	**				**				**		
CV (%)	7.3				---				13.8		
LSD (0.05)	47.5				78				98.3		

A, IR 74371-46; B, IR74371-54; C, IR 74371-70; D, IR 55419-04; E, Rhada 4; F, Hardinath 1; G, IR 72667-16-1-B; H, IR 70215-70-CPA; I, Judi 572; J, Pusa 834

Grain yield, 2009

Seedling age effect: Seedling age impacted rice grain yield significantly. The overall mean grain yields obtained from different seedling age revealed a 37.5 kg/ha/day yield loss up to 35-day old seedling planting whereas 45-day old seedling planting caused 61 kg/ha/day yield loss. Grain yield was significantly different among three seedling age (Table 8).

Rice genotype effect: Rice genotype impacted rice grain yield when averaged over the seedling age. IR74371-46-1-1 produced the highest mean grain yield (4092 kg/ha) followed by Radha-4 (4321 kg/ha) and IR74371-54-1-1-1 (4019 kg/ha), respectively. The least yielder was IR83614-281 (2924 kg/ha) (Table 8).

Interaction between seedling age and rice genotype: Rice genotypes interacted significantly with seedling age on grain yield. Change either in seedling age or in rice genotypes would impact rice grain yield (Table 8). IR74371-54-1-1, IR74371-70-1-1, IR 74371-46-1-1 and Radha-4 were stable in rice grain yields as no significant reduction in grain yield up to 35 days, and seemed to be an appropriate rice genotype to be planted in wider seedling age (Table 8).

Table 8. Performance and interaction of seedling age and genotypes on grain weight (g/plot of 4.8m²), 2009

Genotypes / Seedling age	Genotypes								Grand mean
	A	B	C	D	E	F	G	H	
SA1	4750	4121	4792	3354	4754	4896	5458	3500	4404
SA2	4663	4115	4583	3208	4479	4048	4129	2865	4029
SA3	4063	3823	2860	2958	3729	2563	2813	2406	3183
GM	4492	4019	4078	3174	4321	3835	4133	2924	3872
	Interaction			Genotypes			Seedling age		
F-test	**			**			**		
CV (%)	13			11			14.3		
LSD (0.05)	435.4			153.9			251.4		

A, IR 74371-46; B, IR74371-54; C, IR 74371-70; D, IR 55419-04; E, Rhada 4; F, Hardinath 1; G, IR78908-193-B-3B; H, IR83614-281

Combined grain yield, 2008 and 2009

Seedling age effect: Seedling age impacted rice grain yield significantly. The overall mean grain yield obtained from different seedling age revealed a 24.9 kg/ha/day yield loss up to 35-day old seedling planting where as 45-day old seedling planting caused 39 kg/ha/day yield loss. Grain yield was significantly different among three age of seedling (Table 9).

Rice genotype effect: Rice genotypes impacted rice grain yield when averaged over the seedling age. IR74371-54-1-1 produced the highest mean grain yield (3479 kg/ha) followed by IR74371-46-1-1 (3278 kg/ha) and IR74371-70-1-1-1 (3235 kg/ha), respectively. The least yielder was Hardinath-1 (2649 kg/ha) (Table 9).

Interaction between seedling age and rice genotypes: Rice genotypes interacted significantly with seedling age on grain yield. Change either in seedling age or in rice genotypes would impact rice grain yield (Table 9). IR74371-54-1-1, IR74371-70-1-1, IR74371-46-1-1, Radha-4 and IR55419-04 were stable in rice grain yields as no significant reduction in grain yield up to 35-day seedling, and seemed to be an appropriate rice genotype to be planted in wider seedling age. Hardinath-1 had drastically reduced yield after 35-day old seedlings (Table 9).

Straw yield per plot

Seedling age effect: Seedling age impacted rice straw yield significantly. The overall mean straw yields obtained from different seedling age revealed a 142 g straw yield loss in 25-day old seedling compared to 45-day old seedling (Table 10).

Table 9. Combined performance and interaction of seedling age and genotypes on grain yield (kg/ha), 2008 and 2009

Genotype/ Seedling age	Genotypes						Grand mean
	A	B	C	D	E	F	
SA1	3557	3567	3562	3122	3679	3497	3497.4
SA2	3046	3529	3562	3510	3301	2542	3248.333
SA3	3232	3341	2582	3017	2219	1907	2716.333
GM	3278	3479	3235	3216	3066	2649	3154.022
	Interaction		Seedling age		Genotypes		
F-test	**		**		**		
CV (%)	14.2		13.6		17		
LSD (0.05)	325		128		178		

A, IR 74371-46; B, IR74371-54; C, IR 74371-70; D, IR 55419-04; E, Rhada 4; F, Hardinath 1

Rice genotype effect: Rice genotypes impacted rice straw yield when averaged over the seedling age. IR70215-70-CPA-3-4-1-3 produced the highest mean straw yield (2787 g) and the least straw yielder was Radha-4 but it was similar to Judi-572 and IR74371-54-1-1 (Table 10).

Interaction between age of seedling and rice genotype: Interaction between rice genotypes and seedling age was not significant (Table 10).

Table 10. Combined performance of seedling age, genotypes and interaction between age of seedling and genotype on straw yield/plot

Genotypes/ Seedling age	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
SA-1	2312	2327	2503	2647	2144	2543	2545	2330	2520	2783	2465
SA-2	2262	2350	2802	2185	2573	3167	2107	2510	2149	2735	2455
SA-3	2023	2802	2560	2042	2860	2650	2094	2357	1893	1950	2323
GM	2199	2493	2524	2291	2526	2787	2248	2399	2188	2489	2414

A, IR74371-54-1; B, IR 72667-16; C, IR 74371-46; D, IR 55419-04; E, IR 74371-70; F, IR 70215-70-CPA; G, Judi 572; H, Pusa 834; I, Rhada 4; J, Hardinath 1

Flowering

Seedling age effect: Seedling age impacted days to flowering significantly. Twenty-five-day old seedlings flowered 5 and 7 days earlier than 35 and 45-day old seedlings, respectively (Table 11).

Rice genotype effect: Rice genotypes impacted days to flowering when averaged over the days to flowering. Hardinath-1 took minimum days to flowering (81.2). IR70215-70-CPA-3-4-1-3 took maximum number of days (111.4 days) to flower but it was similar to IR72667-16-1-B-B-3 (Table 11).

Interaction between seedling age and rice genotype: Rice genotypes interacted with seedling age in days to flowering. Change either in seedling age or in rice genotypes impacted rice days to flowering (Table 11). Judi-572 was stable in wider age of seedlings. IR74371-54-1-1, IR74371-46-1-1, IR55419-04, IR74371-70-1-1, Rhada-4 and Hardinath-1 were stable in days to flowering up to 35-day old seedling (Table 11).

Rice genotype IR74371-54-1-1 was stable which have no significant reduction in grain yield up to 45-day old seedlings, and seemed to be an appropriate rice genotype to be planted in wider seedling age. IR55419-04, IR74371-70-1-1, Judi-572, Pusa-834 and Hardinath-1 were stable in producing grain yields up to 35-day old seedling as no significant reduction in grain yield was seen. After 35 days, yield was drastically reduced in Hardinath-1. Rice genotypes IR74371-54-1-1, IR74371-46-1-1 and

IR70215-70-CPA-3-4-1-3 produced satisfactory yield even in low nutrient level. Similarly 45:30:20 kg NPK/ha was found economical dose of fertilizer especially for rainfed low land conditions.

Table 11. Combined performance of seedling age, genotypes and interaction between seedling age and genotype on flowering

Genotypes/ Seedling age	Genotypes										Grand mean
	A	B	C	D	E	F	G	H	I	J	
SA-1	83.3	107.0	83.3	81.0	82.3	105.3	85.7	87.7	87.0	77.7	88.03
SA-2	87.3	112.7	88.3	87.3	87.3	113.3	87.7	93.0	92.0	80.3	92.93
SA-3	90.3	106.3	91.3	89.7	90.7	115.7	90.3	95.7	93.7	85.7	94.93
GM	87	108.7	87.7	86.0	86.8	111.4	87.9	92.1	90.9	81.2	91.97
	Interaction				Seeding age			Variety			
F-test	*				*			**			
CV%	3.7				1.3			-			
LSD (0.05)	5.65				2.742			3.223			

A, IR74371-54-1-1; B, IR 72667-16-1-B-B-3; C, IR 74371-46-1-1; D, IR 55419-04; E, IR 74371-70-1-1; F, IR 70215-70-CPA-3-4-1-3; G, Judi572; H, Pusa 834; I, Rhada 4; J, Hardinath 1

Based on overall performance IR74371-46-1-1, IR74371-54-1-1 and IR74371-70-1-1 were the best genotypes. These varieties have already been released as Sukha Dhan-1, Sukha Dhan-2 and Sukha Dhan-3, respectively.

Factors Affecting Adoption of New Modern Varieties of Rice in Eastern Terai of Nepal

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ABSTRACT

The study on factors affecting adoption of new modern varieties of rice released after 1990s was conducted in Sunsari and Mahottari districts of Nepal during 2011. The districts were selected purposively based on the potentiality of rice production and accessibility through outreach sites of Nepal Agricultural Research Council (NARC). Simaria and Ratauli from Sunsari and Mahottari, respectively as experimental Village Development Committees (VDCs) and Sonapur and Soharwa from Sunsari and Mahottari, respectively as control VDCs were selected purposively. The total sample size for the study was 120 farmers with 30 samples from each of the VDCs selected by using simple random sampling. The findings revealed that most of the farmers (>65%) were using their own seed for rice farming. The area covered by the new modern varieties was found 38% of the total rice cultivation. Higher production, higher market price, straw quantity and quality for animal feeding etc are the preferred characteristics of rice varieties for adoption. Econometric analysis employing Tobit model was carried out to analyze factors determining adoption of newer modern varieties using data from household's level. The results indicated that variables like outreach site ($p < 0.01$), endowment of landholding ($p < 0.05$) and participation in training and involvement in local organization ($p < 0.05$) were the significant factors influencing adoption of new modern varieties of rice. This might be due to the higher level of awareness for new modern varieties and high risk bearing capacity of the farmers. It is recommended that number of outreach sites of NARC should be increased and awareness level of farmer need to be raised for increasing adoption of new modern varieties by strengthening coordination and linkage among the related stakeholders.

INTRODUCTION

Rice is a staple food for world's poor people which is grown on more than 155 million hectares and accounts for one fifth of global calorie supply (Pandey 2011). The crop plays a significant role in Nepal's economy contributing 20% of agricultural GDP. In 2009/010, rice is grown in 1,481,289 ha with total production of 4,023,823 million metric tons in Nepal. Up to 2009/2010, total irrigated area in the country was only 1,227,353 ha and remaining area is rain-fed which is about 70% of the total cultivated area. In case of rice, 41.5% of the total area is rain-fed and their productivity is around 2.4 ton/ha (MoAC 2011). The Agricultural Perspective Plan of Nepal envisages an agriculture-led economy growth strategy; such economy growth strategy is expected to reduce poverty and helps in improving food security in the country. Rice accounts for about 50% of the food supply of the country and about 40% of the total daily calorie uptake (NARC 2010). However, during the past 25 years, the average growth rate in rice productivity has been 1.5% per year while the population has continued to grow at the rate of 2% per year. As a result the current per capita production of rough rice is about 146 kg as declined from the previous per capita production of 220 kg per year. Clearly, there is a need to accelerate the growth rate in rice productivity in Nepal to meet the increasing food needs for ever increasing population and increasing income growth of the people. On this background, this study was carried out to find out different rice varieties suitable for Terai and inner Terai released in different time period; the factors influencing the new modern varieties and the different traits of rice varieties preferred by farmers.

MATERIALS AND METHODS

Selection of study site and sample

Sunsari and Mahottari districts were selected purposively based on the potentiality of rice growing and availability of outreach sites of Nepal Agricultural Research Council (NARC). Simaria and Ratuli from Sunsari and Mahottari, respectively as experimental Village Development Committees (VDCs) and Sonapur and Soharwa from Sunsari and Mahottari, respectively as control VDCs were selected purposively. Thirty samples from each of the VDCs were selected randomly irrespective of their landholdings. The only criterium for selection was the farmers cultivating rice for at least the previous two years. Therefore, the total sample size for the study was 120 farmers.

Data collection

Data were collected through interview, group discussion, and informal interaction.

Data analysis

The data were entered in to computer using Excel and Statistical Package for Social Science (SPSS). This analysis was based on tabular analysis using simple statistical methods like frequency, mean, and standard deviation.

Econometric analysis

Econometric Tobit model are employed to study the adoption behavior of the farmers. In the study, rice varieties are categorized into two groups: new and old rice varieties based on their release year. Varieties released on or before 1990 are considered old generation varieties while those released after 1990 are referred to new modern varieties (MVs).

Tobit Model

The censored regression model (Tobit) was used to study the extent of adoption of new MVs. Share of new MVs to total MVs area was used as dependent variable which is continuous and censored at zero (lower limit). Censored regression model is suitable here as there are a number of farmers with zero adoption of new MVs at the limit.

The model is defined as:

$$Y_i = \begin{cases} X_i'G + u_i & \text{if } X_i'G + u_i > 0; \\ 0 & \text{Otherwise} \end{cases}$$

Such that the residual, $u_i \sim N(0, \sigma^2)$,

Where Y_i is the $(n \times 1)$ vector of dependent variable which is expressed as the percentage of total MV rice area of a household under new modern varieties;

G is the $(k \times 1)$ vector of unknown parameter;

and X_i is the $(n \times k)$ vector of exogenous and predetermined variables.

Which are,

X_1 =total population (no.),

X_2 =involvement in training and organization,

X_3 =outreach site and

X_4 =total landholding. The STATA Package was used for its analysis.

RESULTS AND DISCUSSION

In totality, about 97 percent of the land was lowland. In both study districts, the low land existence was more or less similar. The upland was mostly used for their residential and kitchen garden purpose. The details are given in Table 1.

Table 1. Land type by districts

Land category	Sunsari		Mahottari		All	
	Area	%	Sum	%	Sum	%
Lowland ¹ (ha)	111.1	97.1	90.1	97.2	201.2	97.1
Upland ² (ha)	3.3	2.9	2.6	2.8	5.9	2.9
Total land (ha)	114.4	100.0	92.7	100.0	207.2	100.0

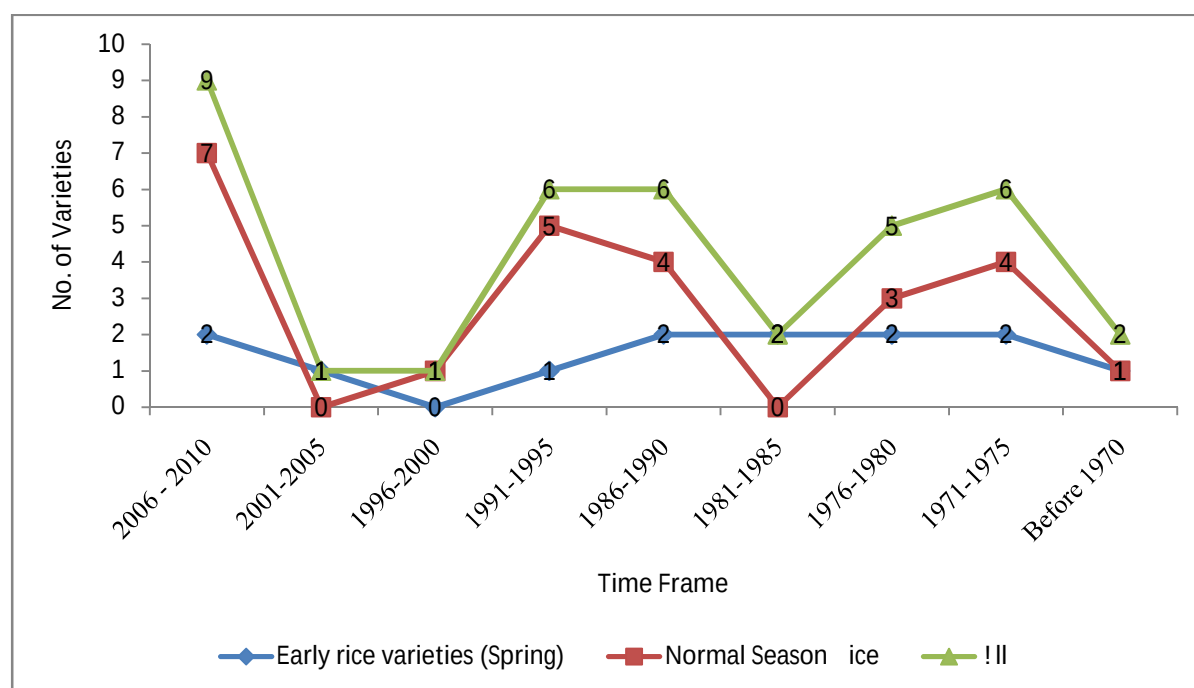
¹It is irrigated and banded land in Nepal is known as *Khetland*, ²It is unirrigated and unbanded land in Nepal as *Bariland*

In the last 50 years, several rice varieties are promoted and adopted in the different parts of the country. Until 2010, the Government of Nepal had developed and released 60 rice varieties for different ecosystems and agro-ecological conditions (NARC 2010). The sources of these varieties were IRRI through INGER (International Network of Genetic Evaluation of Rice) and released directly or used as parents for developing new varieties. Few of them were the selection from popular local landraces of Nepal. Among the total varieties, there were altogether 38 varieties released and registered for Terai and inner Terai until 2010. The number of released early rice varieties was found more after 1990s, whereas the opposite the case was found in normal season rice varieties. In totality, about 54% of the varieties suitable for Terai and inner Terai were released after 1990s (Table 2, Figure 1). Three varieties specifically recommended for central, western and far western Terai were excluded because the study was focused in eastern Terai.

Table 2. Total rice varieties released in different time period for Terai and Inner Terai of Nepal

Period	Early rice varieties (Spring)		Normal season Rice		All	
		%		%		%
Before 1990s	4	31	12	55	16	46
After 1990s	9	69	10	45	19	54
Total	13	100	22	100	35	100

Source: NARC (2010)

**Figure 1. Total rice varieties recommended for Terai and inner Terai released in different time interval**

Area under the crop in 1984/85 was 13,76,860 ha, total physical production was 27,09,430 mt and yield was 1.97 tons per ha. There was a substantial jump in these indicators during 1984/85-2010/2011. Compared to 1984/85, the area increased by about 9%, production increased by 63% and yield increased by 52% in the year 2010/11. Gauchan et al (2011) reported that the important characteristic of rice production system in Nepal is the high level of temporal variability. This is mainly due to rainfall variability since about two third of rice is produced in rain-fed conditions. Rice production increased during favorable monsoon season while during unfavorable years, the area, yield and production reduced sharply. In the same line, yield and production show a smooth trend since 1993/94 throughout the period except in the year 2006/07 and 2008/09 when the crop suffered a severe flood during main planting season and dry spells during the growing season which declined yield and production. It appears that increase in production was mainly due to the increase in yield rather than the increase in area which was growing at the rate of 6,738 ha per year illustrating an inelasticity to time horizon under study. Details are presented in Figure 2.

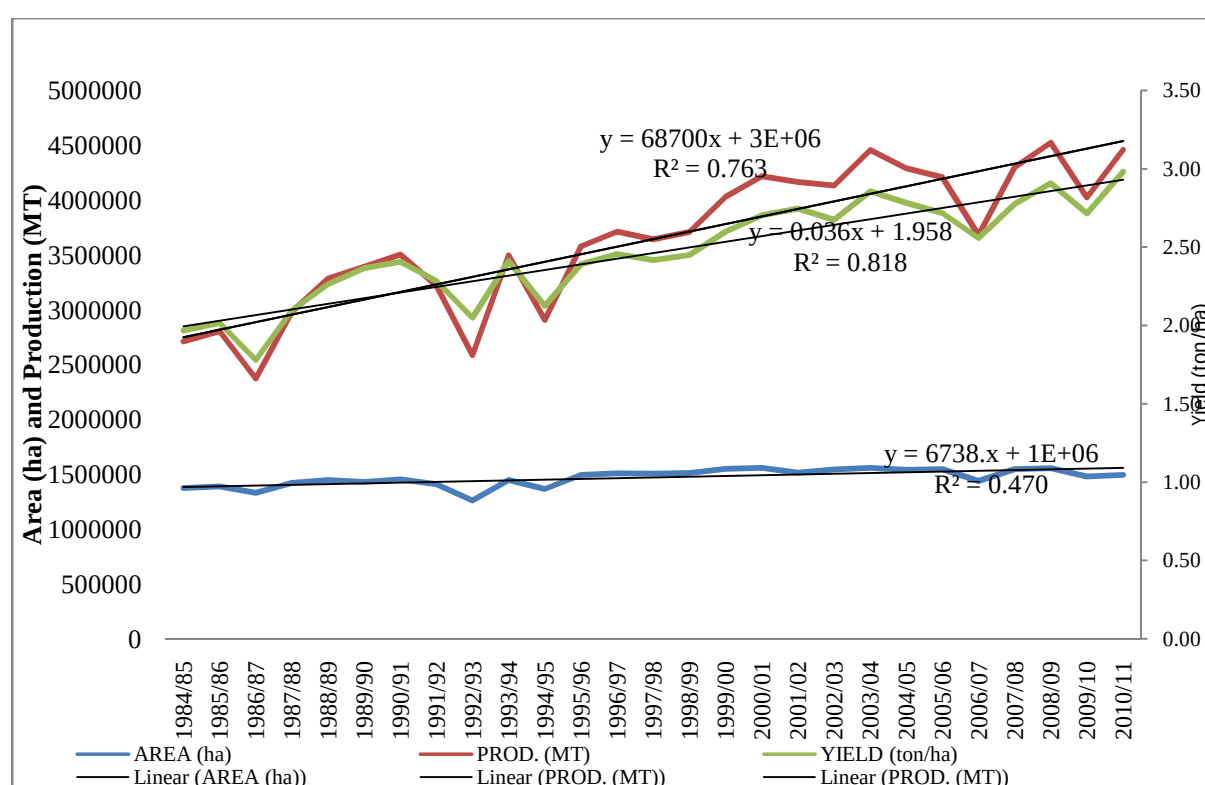


Figure 2. Area, production and yield trend analysis in different time period (Source: MoAC 2011)

Out of 38 varieties released and registered for Terai and inner Tarai of Nepal, about 12 varieties existed in the study area. In totality, about 67% varieties were released after 1990s. There was existence of 3 Indian varieties (Kanchi, Sonamasuli and Ranjit), 6 local landraces (Basmati, Chanachaur, Anadi, Kariya Kamat, Kati and Katarni) and one pipeline varieties (NR-1190). The percentage covered by Indian varieties was also observed higher in the study area.

For new variety (Radha-12), the percentage of taking seed from formal source was higher (35%) than old improved varieties (Kanchi, Sonamansuli and Mansuli) which are about 15-25%. Even in the new improved varieties, the percentage of using their own saved seed is higher (60%). In case of local variety (Basmati) about 92% farmers have been using their own saved seed and remaining farmers were using seed from their neighbors (Table 4).

Table 3. Total rice varieties under cultivation in different time period in study area

Period	Early rice varieties (Spring)	Normal season rice	All	Indian varieties	Local varieties	Pipe line varieties
Before 1990s	1 (33)	3 (33)	4 (33)			
After 1990s	2 (67)	6 (67)	8 (67)			
Total	3 (100)	9 (100)	12 (100)	3	6	1

Table 4. Sources of seed for major varieties (%) in the study areas

Source	Radha-12	Kanchi	Sonamansuli	Mansuli	Basmati
Own saved	60	75	62	65	92
NARC stations	30	0	0	20	0
Agro-vets	5	15	22	5	0
Others	5	10	16	10	8
Total	100	100	100	100	100

The results of Tobit estimation are presented in Table 5. The results show that the presence of outreach sites of NARC has significant contribution at $P=0.001$ for adoption of new MVs. If there is increase in 1 outreach site, then it will result to increase in adoption of new MVs by 19%. This might be due to more exposure on new generation MVs in outreach site with demonstration effects. The awareness on new generation MVs and participation in training and other local organization is another variable influencing significantly at $P<0.05$ for its adoption. This result indicates that the extent of adoption is higher if farmers have better awareness on new MVs and participate in agricultural training programs. This is as expected since increasing awareness of farmers on new MVs reduces fixed cost of adoption and uncertainty of the expected output of the technology (Herdt and Capule 1983). The endowment of landholding was also the influencing factors ($P<0.005$) for the adoption of new MVs. This might be due to the high risk bearing capacity of the farmers for its quick adoption. The socio-economic variables like population size have no statistically significant effect on adoption of new MVs below 5% probability level. This finding is consistent with recent studies carried out by Gauchan et al in 2011. Therefore, there should be well focused and targeted local capacity building programs for farmers through increased training programs, membership to local organizations for farmers and extension demonstration are needed to enhance adoption and likely impact at the farm community.

Table 5. Tobit analysis for adoption of new generation modern varieties

Variables	Coefficient	Std. Err	t	$P> t $
Population (Number)	2.1	1.54	1.4	0.170
Training received and involvement in organization	13.3*	5.98	2.2	0.028
Outreach Site	19.7**	5.58	3.5	0.001
Total Landholding (Kattha)	0.14*	0.066	2.1	0.039
Constant	0.95	8.40	0.11	0.910

No. of obs. = 119, LR $\chi^2(4) = 24.70$, Prob > $\chi^2 = 0.0001$, Log likelihood = 472.42; **, highly significant; *, significant

Radha-12 is a popular new modern variety, especially in the Sunsari district while Kanchi, Sonamansuli and Mansuli are old improved varieties in the study site. Similarly, local Basmati variety is also popular in the study area. Farmers have provided their perception on the traits of specific varieties (Table 6). Among 22 varieties (Annex 3) in the study area, only five including local Basmati, old improved varieties (Kanchi, Sonamansuli and Mansuli) and new improved variety (Radha-12) were selected for the trait study based on area coverage in the study area. Farmers expressed preference for specific modern rice varieties for the traits such as high yield, tolerance to disease and pest, straw yield and suitable for cropping pattern. Most of the farmers responded that high grain

yield, straw yield, straw liked by animals and good tastes are the common and more preferred traits in the study area. Radha-12 was preferred for utility purpose (for making rice popping also called *murai* locally), market access and for straw liked by animals. Farmers continue cultivation and dominance of old modern varieties such as Kanchi, Mansuli and Sonamansuli in the study sites are due to their superior preferred traits such as higher production (Kanchi, Sonamansuli and Mansuli), better taste (Mansuli), more straw (Kanchi and Mansuli), straw liked by animal (Kanchi, Mansuli and Sonamansuli), suitable for cropping pattern (Kanchi). Most of the farmers are still cultivating Basmati for good taste, good market price, more straw and straw liked by animals. In brief, the higher grain and straw yield and straw liked by animals are the major influencing traits in the study area.

Table 6. Farmers' perception for variety-wise traits for its adoption reason (%)

Desirable traits	Radha-12	Kanchi mansuli	Sona mansuli	Masuli	Basmati
High production	61	90	87	80	2
Good taste	10	14	10	80	100
Seed availability	47	46	46	46	31
Good market price	71	12	44	77	94
Low insect pest	13	36	17	2	3
More awareness	15	8	43	7	5
Less shattering after maturity	32	30	68	26	39
Due to more straw	39	78	10	68	78
Due to diff. utility purpose	88	20	18	5	87
Suitable for cropping pattern	28	80	70	61	2
Less breaking	56	14	83	68	31
Straw liked by animal	95	94	76	96	100

Note: The information is the percent response of the farmers, who grows the specific variety. A farmer has a multiple response for more than one trait.

About 65% farmers are satisfied with the rice farming whereas 21% has no response on the rice farming. The numbers of satisfied farmers are more in Sunsari district than Mahottari (Table 7). However, the percentage is more or less similar in both the districts.

Table 7. Satisfaction status of rice farming (Percentage, N=120)

Description	Sunsari	Mahottari	All
Yes	69	58	65
No	8	22	14
Neutral	23	20	21
Total	100	100	100

Until 2010, the government of Nepal had developed and released 60 rice varieties for different ecosystems and agro-ecological conditions. Among the total varieties, there were altogether 38 varieties released and registered for Terai and inner Terai. Out of 38 varieties released and registered for Terai and inner Terai of Nepal, about 12 varieties existed in the study area. Among them, 67% of varieties were released after 1990s. There was existence of 3 Indian varieties (Kanchi, Sonamasuli and Ranjit), 6 local landraces (Basmati, Chanachaur, Anadi, Kariya kamati, Kati and Katarni) and one pipeline variety (NR1190). The percentage covered by Indian varieties was observed higher in the study area. For new improved variety (Radha-12), seed taking from formal source was higher (35%) than old improved varieties (Kanchi, Sonamasuli and Masuli) which are about 15- 25%. Radha-12 is a popular new modern variety especially in the Sunsari district while Kanchi, Sonamansuli and Masuli are popular old improved varieties in the study sites. Similarly, local Basmati is also popular in the study area. Farmers expressed preference for specific modern rice varieties for the traits such as high yield, tolerance to disease and pest, straw yield and suitable for cropping pattern. Most of the farmers responded that high yield, straw yield, straw liked by animals and good tastes are the common and

more preferable traits in the study area. The results of Tobit estimation show that the presence of outreach sites of NARC, the awareness on new modern varieties and participation in training and other local organizations and the endowment of landholding are the major influencing factors for the adoption of new modern rice varieties. Therefore, there should be well focused and targeted local capacity building programs for farmers through increased trainings programs and membership to local organizations for farmers, and demonstration through extension are needed to enhance adoption and likely impact at the farm community. It is recommended that number of outreach sites of NARC should be increased and awareness level of farmer need to be raised for increasing adoption of new modern varieties by strengthening coordination and linkage among the related stakeholders.

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Effects of Zinc Application on Soil Zinc Concentration and Rice Productivity

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ABSTRACT

A soil survey was conducted to know the zinc status of soil in Tanahun district in the year 2067, where the farmers reported the low yield of rice. Then a field experiment in the zinc deficient soil of district was conducted during the year 2068 to study the role of zinc application on the yield of rice and improving the zinc content of the soil. The experiment was laid in RCBD with five treatments. The treatments were control, farmer method, foliar spray, soil application and soil cum foliar application of the zinc. The grain yield of the rice was significantly higher in the treated plots than in the control and the farmer methods. Among the treated plots the highest yield was recorded in the soil cum foliar application. The yield was higher in the foliar application than in the soil application of zinc. The zinc concentration in the soil was not significantly different after experiment but it was highest in the soil application and lower in the foliar application. The soil cum foliar application has lower concentration of soil zinc than the soil application.

INTRODUCTION

Rice is the number one staple crop in Nepal in terms of area and production. It accounts 53% of the total grain production and more than 50% of the agriculture area. It also meets more than 50% of the total calories requirement of the Nepalese people. Rice production is closely linked with the national economic growth. Due to different reasons the productivity of the crop is low in the country. Among several reasons poor nutrients management is one of the main reasons for the low productivity. When the supply of available zinc for plants is inadequate, crop yields are reduced and the quality of crop products is normally damaged. In plants, zinc plays a key role as a structural constituent or regulatory cofactor of a wide range of different enzymes and proteins in many important biochemical pathways. These are mainly concerned with carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens (Alloway 2008). Of the microelements, Zn is thought to be the most widespread (Graham et al 1992). The critical limit of the zinc is 0.6 ppm and the productivity of the rice is drastically reduced below this (Singh 2004). Therefore, in the area where the soil concentration of the zinc is low the plant must be supplied with the nutrients which may be as the foliar application or as soil application.

MATERIALS AND METHODS

Location

The research was conducted in Tharpu Village Development Committee (VDC) of Tanahun which is 11 km west of Damauli and 36 km east of Pokhara. The latitudinal and longitudinal location of the site was 27°59'44.48" N and 84°10'07.48" E and situated at the altitude of 472 meters above sea level.

Cropping pattern of the area

In this site, the farmers used to grow rice for two times in a year, once in Chaitra and other in the rainy season. Some of the farmers even grow maize in addition to these crops. Most of the farmers in the area reported the low yield of the rice crop due to necrosis of leaves and poor grain development. To find out the reasons about 31 soil samples were collected from the rice growing areas and they were analyzed at Regional Soil Testing Laboratory, Pokhara. The analysis showed that the soil was deficient in zinc. Therefore the design was prepared to study the effect of zinc application on the yield of rice in this region.

Experimental design

The experiment was laid out in randomized complete block design with three replications each with five treatment combinations. Three farmers were chosen for the experiment, each of which were treated as a replication and the five treatment combinations included were as follows:.

T1 - Control (recommended dose of fertilizers only)

T2- Farmer's method (recommended dose of fertilizers + high amount of organic manure)

T3- Foliar spray of zinc (solution prepared by mixing 5 gm ZnSO_4 + 2.5 gm lime in a litre of water @ 50 litre of solution per ropani i.e. 500 m²)

T4- Soil application of zinc @ 1 kg ZnSO_4 /ropani

T5- Soil application of zinc + foliar spray of zinc (T3 +T4)

Table 1: Fertility status of the soil before the start of experiment

Rep No.	N%	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)	PH	OM%	Zn ppm	Fe ppm	Cu ppm
1	0.14	23	142	8.1	2.7	0.67	23.5	2.9
2	0.13	8	125	6.9	2.7	0.38	11.4	2.3
3	0.17	12	137	7.6	3.3	0.68	26.2	3.7

Recommended dose of fertilizers

The chemical fertilizers were applied @ 100:30:30 NPK without organic manure in all the plots. But in the farmer's method the organic manure was also applied @ 10 tonnes per hectare.

Foliar spray

The foliar spray was done in the nursery at 15 DAS. The foliar spray was also done after transplanting at the interval of 15 days. The mixture of zinc sulphate was prepared for the spray by mixing 5 gm of zinc sulphate and 2.5 gm lime in a litre of water. While spraying both the sides of the leaves of the plant got fully wet with the mixture.

Soil application of zinc sulphate

The zinc sulphate was applied in the soil during 3 DAT. It was done so in order to reduce the risk that it should not mix with the DAP to form toxic zinc phosphate which harms plant and the animals living in the surrounding.

Transplanting and fertilization

The seedlings were transplanted on the field after the recommended dose of fertilizer and the FYM were applied in the field and the field was puddle.

Harvesting and the grain yield taking

The rice was harvested when the grain were fully riped at 130 DAT. The grains were separated from the straw by threshing in the threshing floor and were weighted by using the weighing machine.

Soil sampling after harvest

The soil samples were taken from each individual plot to find out the nutrients contents in the soil after harvest.

RESULTS AND DISCUSSION

Effects of different methods of zinc application on rice grain yield

The rice grain yields in both the foliar application of zinc and soil application of zinc were significantly higher than in the control (3.80 t ha⁻¹) and the farmer's method of cultivation (3.80 t ha⁻¹) (Table 2). The grain yield in the foliar application (4.03 t ha⁻¹) was higher than in the soil application (3.97 t ha⁻¹). In the soil application cum foliar application (4.23 t ha⁻¹) it was better than the foliar application or the soil application of the zinc alone. The increase in grain yield of the rice due to foliar application, soil application and soil cum foliar application was by 6%, 4% and 11%, respectively. The foliar application of zinc was more effective than the soil application for the increase of the grain yield of the rice. Zinc is very important for the grain formation in rice. In the foliar application the plant can directly absorb the nutrient with the help of the leaf therefore the grain yield is more than that of the soil application. To absorb Zn from soil is time taking process whereas it can be used directly when sprayed on leaf.

Table 2. Effects of zinc application on the rice yield and soil zinc concentration after harvest

Treatments	Rice grain yield (t ha ⁻¹)	Soil zinc concentration after harvest (ppm)
Control	3.80a	0.72a
Farmer's method	3.80a	0.72a
Foliar spray of zinc	4.03b	0.62a
Soil application of zinc	3.97b	0.76a
Soil application of zinc + foliar spray of zinc	4.23c	0.74a
Mean	3.97	0.71
CV%	14.8	9.6
LSD _{0.05}	0.12**	ns
SEm	0.03	0.07

**, highly significant; ns, not significant

Effects of different methods of zinc application on soil zinc concentration

The zinc concentration of the soil didn't increase significantly with the treatments. But the zinc concentration was higher in the soil due to the soil application (0.76 ppm) and soil cum foliar application (0.74 ppm) than on the control plots (0.72 ppm) and farmer's method (0.72 ppm). The zinc concentration was lower on the soil with foliar application (0.62 ppm) than with the control.

The soil application added the zinc on the soil therefore the zinc concentration increased. But in the plot with the foliar application the plant growth is enhanced by the application, so the plant further increase its zinc uptake for its growth and development causing the soil to be low in the nutrients. In brief, the zinc concentration of the soil increases with the soil application and soil cum foliar application. Again by the foliar application, the zinc concentration of the soil decreases and become lower than that of the control. The soil application is beneficial to increase the zinc concentration of soil but the foliar application increases the grain yield of the rice without increasing the soil zinc content. Therefore, to maintain the soil zinc concentration by increasing the yield of the rice the soil cum foliar application of zinc is recommended for the zinc deficient soil.

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Promotion of Agro-biodiversity Conservation Good Practices for Enhancing the Livelihoods of Poor Rainfed Farmers at Mid and Far Western Terai of Nepal

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ABSTRACT

Regional Agricultural Research Station (RARS) Khajura initiated the implementation of agro-biodiversity conservation activities under Western Terai Landscape Complex Project (WTLCP) in mid western terai (Bardia) and far western terai (Kailali and Kanchanpur) during 2008-2011. The main objective of the project was to enhance the livelihoods of the poor rainfed farmers and their role in agro-biodiversity conservation in mid and far western terai through the promotion of agro-biodiversity conservation good practices. This report highlights the major achievements, lesson learned and sharing the field experiences. Four practices i.e. zero till drill (ZTD), pilot demonstration and production of Helicoverpa nuclear polyhedrosis virus (HNPV) in farm level, verification and validation of stress tolerance rice and Ug99 resistant wheat varieties and pigeonpea in degraded lands and agro-forestry system were successfully conducted in collaboration with Biodiversity Conservation Development Committee, farmers groups and local extension offices. Significant achievements were made in identification of suitable stress tolerant rice (submergence and drought tolerance). Seed of Sukha Dhan-3 (6 ton), Sambha Sub1 (1 ton) and Sworna Sub1 (1.4 ton) was produced in Shankarpur and Masuria VDC of Kanchanpur and Kailali districts, respectively. ZTD machine was handed over to farmers in Masuria VDC and this technology is becoming popular in Masuria (110 katha) and Suda VDC (115 katha). Initially ZTD was started cultivating wheat in 10 katha of land and now it has expanded to more than 10 ha of land. All the necessary equipment i.e., a set of freeze, autoclave, grinder machine and 10 pieces of rearing tray were handed over to the Biodiversity Conservation and Development Committee of Belawa in Bardia, Masuria in Kailali and Baisebechuwa in Kanchanpur for HNPV production. A total of 2500 LE HNPV was produced from these sites. Another successful intervention of this project was introduction of Ug99 resistant wheat variety NL1073 which was preferred by the farmers for its high yield, higher number of tillers and disease free traits and the crop covered about 3 ha in Masuria VDC, Kailali and 2 ha in Suda VDC, Kanchanpur. Under capacity building a total of 192 farmers were trained. Most importantly, farmers became familiar with IPM component for effective pest management. This small grant project helps to establishing strong linkage with line agencies and other stakeholders for delivery of suitable agricultural technology to the farming community for agro-biodiversity conservation in the region.

INTRODUCTION

Biodiversity is essential for food security and nutrition and offers key options for sustainable livelihoods. Environmental integrity is critical for maintaining and building positive options for human well-being. Existing knowledge warrants immediate action to promote the sustainable use of biodiversity in food security and nutrition programs. Since agriculture begun some 12,000 years ago, approximately 7000 plant species and several thousand animal species have been used for human food.

Today, certain traditional and indigenous communities continue to use 200 or more species in their diets but the general global trend has been towards diet simplification, with consequent negative impacts on human food security, nutritional balance and health. Biodiversity contributes directly to food security, nutrition and well-being by providing a variety of plant and animal foods from domesticated and wild sources. Biodiversity can also serve as a safety-net to vulnerable households during times of crisis, present income opportunities to the rural poor, and sustain productive agricultural ecosystems.

Agricultural biodiversity performs ecosystem services such as soil and water conservation, maintenance of soil fertility and biota, and pollination, all of which are essential to human survival. In addition, genetic diversity of agricultural biodiversity provides species with the ability to adapt to changing environment and evolve, by increasing their tolerance to frost, high temperature, drought and water-logging, as well as their resistance to particular diseases, pests and parasites for example. This is particularly important regarding climate change.

The Earth's biodiversity is being lost at an alarming rate, putting in jeopardy the sustainability of agriculture and ecosystem services and their ability to adapt to changing conditions, threatening food and livelihoods security. The major challenge for agriculture is to ensure food security, adequate nutrition and stable livelihoods for all, now and in the future, by increasing food production while adopting sustainable and efficient agriculture, sustainable consumption of resources, and landscape-level planning to ensure the preservation of biodiversity. Therefore considering the facts, the main goal of the project is to promote the sustainable use of biodiversity contributing to improving living standard, food security and improved human nutrition by increasing the production and productivity of wheat, chickpea, rice, and pigeonpea in mid and far western region.

This paper highlights the achievement of agro-biodiversity activities (NARC component) implemented by Regional Agricultural Research Station (RARS) Khajura in Bardia, Kailali and Kanchanpur districts from 2008 to 2011. Altogether, four activities were implemented during the period in collaboration with LI-BIRD, WTLCP, Cooperatives, farmers groups and local extension offices. The activities were: zero till drill (ZTD) demonstration to promote resource conservation technology, pilot demonstration of HNPV production for the management of pod borer in chickpea, pigeonpea, cotton and tomato, participatory evaluation and dissemination of Ug99 rust resistant wheat varieties and rice varieties for drought and submerged conditions and promotion of pigeonpea in degraded lands and in agro-forestry system.

Western terai of Nepal especially (Bardia, Kailali & Kanchanpur) is a dry and potential area for grain legumes (*chickpea*, *pigeonpea*), cotton and tomato also. The main constraints for limiting yield and quality of these crops is pod borer (*Helicoverpa armigera*). Due to the multiplicity of host plants and its continuity throughout the year, control of this pest with any single method has been almost impossible. Research conducted in the past has shown the effectiveness of IPM approach (study of pest dynamics, use of bio-control agents including, botanicals, Neem products and need based application of safer chemicals for its management) for the management of pod borer. The main objective of this project was implementation of IPM package on farm level with the main focusing on production and utilization of HNPV locally so as to reduce in the use of chemical pesticides. Long term vision of this activity was to make the BCDC as the reliable source of HNPV bio-pesticides for future application and safe to other natural enemies.

Ug99, *Puccinia graminis* f. sp. *Tritici*, is the most virulent race of stem rust fungus yet to emerge in Nepal. First discovered in Uganda in 1999, the fungus has spread Africa, Asia and the Middle East. Ug99 can wipe out entire wheat fields, resulting in 100 % crop loss. The UN food and agriculture organization (FAO) estimates that 29 countries in East and North Africa, the Near East, Central and

South Asia, accounting for 37 % global production, are already affected by Ug99 or at potential risk. An estimated 80% of the wheat varieties currently being grown in this region are considered susceptible to Ug99. Black stem rust (*Puccinia graminis*) incidences in Nepal is at risk and outbreak of this disease might be more disastrous. Some varieties are found outstanding and resistant to Ug99 rust disease. In this aspect research is always alerted to combat against the Ug99 disease but strategy should be made to go the farmer's level through participatory approach because this disease might be potential to settle in this region and need to verify the suitable varieties of Ug99 rust resistant varieties.

Submerge rice including sub -1 transgenic gene and drought tolerance rice are introduced in Nepal from IRRI/National Rice Research Program, Hardinath with the aim to cope with the climate change and flash flood prone areas. In mid and far western terai, monsoon started delay and early cessation where most of the farmers are depended upon the rainfall for rice transplanting. Drought is a great problem and sometime due to the excess rainfall occurred during the planting season, flooding is another menaces to the rice production. To overcome these problems, NARC/NRRP/RARS, Nepalgunj in collaboration with IRRI, developed Sukha-1, Sukha-2, Sukha-3 varieties for drought condition and Sworna sub-1 gene and Shambha sub-1 gene varieties for submergence condition.

Wastelands referred to as degraded lands which can be brought under vegetation with proper management practices. In fact, farm forestry is a common feature of Nepalese agriculture where crops and tree plants grow together. However the agro-forestry system is not well managed so far. Therefore, the fallow unutilized area between and among the growing trees can be planted to food crops with reasonable effort. Pigeonpea is drought tolerant, hardy and woody perennial crop which can grow in association with fruit trees and /or plantation trees under the agro-forestry system. In an effort to develop adaptation strategies for the agricultural sector, there must be interactions about the constraints created by changing climates in light of other stress factors. Agro forestry can contribute to increasing the resilience of tropical to sub tropical farming systems. In Nepal, pigeonpea (*Cajanus cajan*) is the fourth most important grain legume after lentil, blackgram and soybean. Pigeonpea is grown most intensively along with maize under intercropping system, rice bund and as an alley cropping in between community forest or fruit or fodder trees. Pigeonpea in agro-forestry system which produces food and a little cash may be a candidate for wider adoption

Dissemination of Zero Till Drill (ZTD) in wheat a resource conservation technology in the intervention sites for it's scaling up was another important good practices done at farm level. Similarly, in IPM approach, this program implemented different approaches: establishment of pheromone traps, use of sunflower as a trap crop, preparation and use of both NSKE and HNPV etc. Likewise, in Ug99 rust resistant genotypes NL 1053, NL 1073, Bijay including Gautam as check were disseminated for verification and scaling up. Similarly, stress tolerance rice varieties Sukha-1, Sukha-2, Sukha-3, Sworna sub-1 gene and Shambha sub-1 gene were disseminated for verification and scaling up in intervention sites. Likewise, In integration of pigeonpea in agro-forestry system and degraded lands, pigeonpea genotypes ICPL88039, Rampur Rahar- 1, Bageswori, and ICP 7035 were introduced for verification and scaling up in intervention sites.

MATERIALS AND METHODS

Zero till drill (ZTD)

The project initiated ZTD wheat demonstration at Motipur VDC (Bardia) and Masuriya VDC (Kailali) in 2008 and extended to Gadaria VDC, Kailali in 2009, and Suda VDC, Sundarpur, Kanchanpur in 2010. Problematic areas of above mentioned districts were selected for large plot demonstration of ZTD. Initially required amount of seeds, fertilizer, herbicides (post emergence) were provided to the farmers as a subsidy. Fungicide-treated seed @ 120 kg/ha was used. Orientation

training on ZTD including all aspects was provided by RARS, Khajura. All cultural practices and other management approaches were applied as per recommendation.

Helicoverpa nuclear polyhedrosis virus (HNPV)

The activity was started in 2008 at Motipur and Belawa VDCs of Bardia, involving 19 farmers and 24 farmers, respectively. Chickpea seed of variety Abhrodhi was provided @ 3 kg/farmer. Similarly, the activity was started in 2009 at Masuria of Kailali through the help of Unity Agro-biodiversity Conservation and Development Committee (UACBDC) involving 17 farmers. Chickpea seed of variety Sita was provided @ 3 kg/farmer. Likewise, the activity was started in 2010 at Baisebechuwa VDC of Kanchanpur in collaboration with Mohana Laljhadi Saving and Credit Cooperatives (MLSCC), involving 24 farmers. Chickpea seed of variety Tara was provided @ 3 kg/farmer. Training on production of HNPV was organized for the farmers. Necessary equipment (refrigerator, centrifuge and grinder and trays) were provided. Pheromone traps and bird perches were established in the fields of selected farmers. Neem seed kernel extract (NSKE) was prepared by collecting neem seeds. Five saplings of neem were provided to each farmer. Supervision and monitoring was done as per necessity by RARS Khajura. All cultural and other management practices were applied as per recommendation.

Ug99 resistant wheat and stress tolerant rice

Farmers' selection and group formation was done before intervention of the participatory trials on wheat and rice in Masuria of Kailali and Shankharpur and Sundarpur of Kanchanpur district. Training on Ug99 rust resistant wheat and stress tolerant rice was provided to the participant farmers. Initially, five participatory variety selection (PVS) trials of each crops was conducted in the project areas. Fifteen baby trials in each crops was conducted in the project areas. Data on specific traits was recorded and preference ranking and organoleptic taste was conducted in the project areas. Produced seeds of the rice and wheat varieties were collected in the group and saved for next season. All sorts of cultural and other management practices were applied as per recommendation.

Pigeonpea on degraded land and Agro-forestry

Farmers' selection was done before conducting this activity in Belawa VDC 1, 3 and 9 of Bardia in collaboration with UACBDC and Baisbisawa VDC 7 and 8 of Kanchanpur in collaboration with MLSCC. Training on the integration of pigeonpea and its potential in agro-forestry system and management of degraded land was given to the participant farmers in collaboration with the district forest office. Pigeonpea varieties ICPL88039, Rampur Rahar-1, Bageswori, and ICP7035 were planted as under storey vegetation and trees as over storey vegetation. The spaces left over by the trees were used for pigeonpea planting with recommended management practices. Seeds and fertilizers were provided to the farmers and followed standard IPM package. Pigeonpea was planted in rows between the regenerated tree saplings or fruit trees or fodder trees and the ratoon crop remained stay after harvesting the crop.

RESULTS AND DISCUSSION

Zero till seed (ZTD)

ZTD was initiated in 2008 covering 3 ha of land and 30 farmers participated in Motipur and Masuria. The area expanded to 7.71 ha in Masuria and Gadaria VDC of Kailali in 2009. Further area expanded to Sundarpur in Kanchanpur. In 2011, RARS Khajura conducted large plot demonstration in 4 ha in Kailali and 4 ha in Kanchanpur and now many farmers are following the technology using their own saved seeds. A ZTD machine was handed over to the UACBDC in 2009 and provided training to the local tractor drivers of Kailali and Kanchanpur. Orientation training was organized each year to the participated farmers in each location with discussion, visuals and handouts. Wheat cultivation was

initiated at Monakapur areas of Masuria VDC of Kailali after the introduction of ZTD. Results of ZTD intervention during 2010-11 are given in figures 1 and 2.

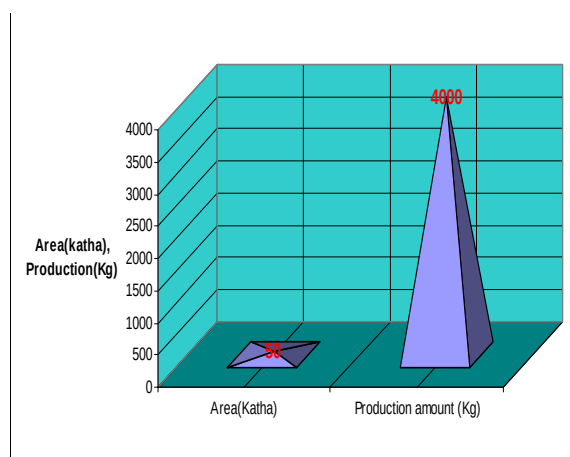


Fig. 1. Total seed production amount of wheat variety Gautam in zero tillage at Masuriya

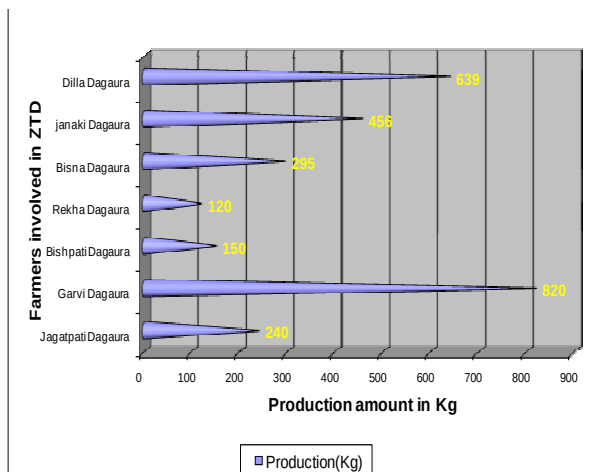


Fig. 2. Total seed production of wheat under zerotillage at farmers level, Kanchanpur

HNPV production and utilization

A total of 125 farmers from Bardia, Kailali and Kanchanpur sites received training on HNPV production and eco-friendly approaches for the management of pod borer. A total of 2000 LE HNPV produced and used at farm level at the intervention sites. A total of 3038 kg chickpea seed was produced during 2010/11 through this activity. A total of 335 Neem saplings were distributed at the intervention sites for making NSKE in future by themselves.

Stress tolerant rice varieties

Before implementation of the activity, RARS Khajura provided one day training on specific technologies for flood and drought tolerant rice to the UABDC farmers of Shankarpur VDC, Balmi in Kanchanpur and Masuria VDC in Kailali. RARS Khajura conducted PVS on submergence tolerant rice varieties (Sworna Sub1, Sambha Mahshuri Sub1 & IR64 Sub1) in 9 farmers' fields. The results revealed that Shambha Mahshuri Sub1 produced the highest average yield (3333 kg/ha) followed by IR64 Sub1 (3278 kg/ha). Likewise, RARS Khajura conducted PVS on drought tolerant rice varieties (Sukha Dhan-1, Sukha Dhan-2 & Sukha Dhan-3) in 6 farmer's fields. The data clearly indicated that drought tolerant genotype Sukha Dhan-3 gave highest mean yield (3800 kg/ha) and farmers preferred it because of its early maturity and high yielding traits. During the period, a total of 54 baby trials of submergence tolerant rice were also distributed to the sites for wider dissemination purposes. Sambha Mahshuri Sub1 recorded the highest average yield (3110 kg/ha) followed by IR64 Sub1 (2935 kg/ha) and Sworna Sub1 (2859 kg/ha). Farmers of both the sites highly preferred Sukha Dhan-3 for its high yielding, medium seed size and far better taste than the coarse type Radha-4 and Sarju-52. A total of 25 farmers in Shankarpur and 17 farmers in Masuria received training on specific technologies of stress tolerant rice.

Ug99 resistant genotypes

In Suda VDC, Sundarpur of Kanchanpur, PVS trials were conducted on Ug99 rust resistant wheat varieties. Wheat genotype NL1073 produced the highest average yield (2672 kg/ha) than the check variety Gautam (2452 kg/ha). Likewise, in Masuria of Kailali, NL1073 produced the highest average yield (3680 kg/ha) followed by NL1053 (3640 kg/ha) compared with Gautam (2880 kg/ha). Baby

trials of Ug99 resistant wheat varieties were conducted in 30 farmers' fields in Kailali and Kanchanpur. Farmers preferred the wheat var. NL1073 because of its high yielding, good taste of bread and good weight for marketing purposes. Farmers themselves saved the seed. UABCD also collected the seed from farmers and sold to other farmers and stakeholders. Mean performance of Ug99 resistant wheat genotypes in Kailali and Kanchanpur are shown in Fig. 3 and 4).



Figure 3. Mean grain yield performances of Ug99 resistant wheat on PVS at Masuriya, Kailali, 2010



Figure 4. Mean grain yield performances of Ug99 resistant wheat on PVS, Suda, Kanchanpur 2010

Integration of pigeonpea in agro-forestry system and degraded land

During 2010, pigeonpea varieties planted in 90 farmers (ICP7035), 80 farmers (Bageswori), 10 farmers (RR-1) and 50 farmers (ICPL88039) in degraded land along the bank of river side and along with the forest or in between forest/orchard. Each farmer planted in 1 katha per variety. A total seed of Pigeonpea genotype ICP7035 (153 kg), Bageswori(348 kg) and Rampur rahar-1 (6 kg) was produced at Baisebechuwa, Kanchanpur under this system. Similarly pigeonpea genotype ICP7035 (63 kg) and Bageswori (163 kg) was produced at Belawa, Bardia. During the project period, RARS Khajura provided one-day training on pigeonpea in degraded land and agro-forestry system to the participant farmers and interacted with the Mohana Laljhadi Saving and Credit Cooperatives, Baisebechuwa and Agri-Biodiversity Conservation Development Committee, Belawa. A total of 20 farmers (8 male and 12 female) participated at Baisebechuwa and 30 farmers (28 male and 2 female) at Belawa. Long duration genotypes (ICP7035 and Bageswori) performed better in agro-forestry system of mid-west and far-west terai and covered about 3.6 ha areas. In 2011, a total of 70 farmers have involved in pigeonpea production covering 112 kattha of land in which Bageswori and ICP 7035 occupies same proportion of area in above mentioned sites.

This small grant project helped to establish strong linkage with line agencies and other stakeholders for delivery of suitable agricultural technology to the farming community for agro-biodiversity conservation in the region. The project activities played pivotal role in nutritional security and biodiversity conservation in the intervention sites of Bardia, Kailali and Kanchanpur districts.

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Agro-forestry Land Use for Sustainable Crop production, Adaptation and Mitigation of Climate Change Effect

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ABSTRACT

Agro-forestry is a collective name for land-use systems and technologies in which woody perennials including trees, shrubs, bamboos etc. are deliberately combined on the same land-management unit with herbaceous crops or animals either in some form of spatial arrangement or temporal sequence. Ecologically sound agro-forestry system such as inter-cropping and mixed arable livestock systems can increase the sustainability of agricultural production. Agro-forestry is a useful path, complementary to chemical fertilizers to enhance soil fertility. This system can contribute to soil fertility improvement through increasing the quality and quantity of fodder and hence livestock manure, providing biomass for composting and slowing the loss of nutrients through run-off. Agro-forestry is a age old practices in Nepal and farmers have been practicing this model in different agro-ecological zones. Home garden is most popular agro-forestry model compared to other practices in Nepal. The demand of fuel wood has increased and energy plantation crops along the boundary of agricultural land would be beneficial. To uplift the livelihood of rural farmers through multi facet income, reducing the drudgery of women in collecting the fodder and fuel wood and introducing climate smart agriculture, agro-forestry land use has become more important in days to come. Research and development efforts are required to sensitize the farming community in more scientific agro-forestry practices. Agro-forestry can solve the problem of declining factor productivity, land degradation, labor shortage and fallow land practices due to migration of people in the cities. This system improves the micro-climate underneath trees and copes up the high temperature stress to the associate components. Besides, agro-forestry land use enhances local biodiversity, conserve natural water resources, reduce the noise and dust pollution and beautify the surroundings. This system also mitigates the climate change effect through carbons sequestration in above and below ground biomass. The gross return obtained from this system is high compared to mono-cropping in addition to other social and ecological benefit.

INTRODUCTION

Maintenance and enhancement of soil fertility is vital for global food security and environmental sustainability (Acharya and Kafle 2009). The increasing dependence of modern agricultural technology on expensive inputs and sub-optimum economic condition have led to renewed awareness of the productive and protective values of trees and realization of the potential of age-old conservation farming techniques. Consequently, efforts are now being made to develop the most appropriate ways to integrate trees and other woody species with agricultural crops and/or livestock either simultaneously or sequentially in the same piece of land for sustainable productivity. Ecologically sound agro-forestry system such as intercropping and mix arable livestock systems can increase the sustainability of agricultural production. Agro-forestry is a collective name for land-use system and technologies in which woody perennials including trees, shrubs, bamboos etc are deliberately combined on the same land management unit with herbaceous crops or animals either in some form of spatial arrangement and/or temporal sequence (Nair 1993). In this system, there are both ecological and economic interactions amongst the different components. Researchers and planners are increasingly recommending agro-forestry systems as a sustainable form of land use for augmentation

of biomass production in agricultural systems. Increase biomass in tree sequestered the substantial amount of carbon and helps to mitigate global warming effect. Similarly, it can contribute to soil fertility improvement through increasing the quality and quantity of fodder and hence livestock manure, providing biomass for composting and slowing the loss of nutrients through runoff (Garforth et al 1999).

Alternate land use system such as agro-horticultural, agro-pastoral and agro-silvipasture are more effective for soil organic matter restoration. Lowering agricultural productivity from loss of nutrients has lowered rural communities' income and supported the livelihood. Organic matter is the main factor which generally determined the soil fertility status of the land. To increase the present productivity level from the existing land resources, soil health has to be improved to support the crop growth and yield. Agro-forestry land use is one of the alternatives for sustainable crop production, environmental protection and local biodiversity conservation. To meet the fodder and fuel wood requirement at household level it is very much important in rural areas. The demand of fuel wood in brick clinks have also increased and energy plantation in farm boundary and waste land has good scope on future earnings. Fallow land may be brought under plantation with suitable tree species (fruits, fodder, fuel etc.) and seasonal labor problem may be sorted out to some extent and household may be benefited from carbon trading in future.

AGRO-FORESTRY

Agro-forestry for soil fertility improvement

Litter fall and decomposition are the two major processes responsible for soil enrichment in agro-forestry systems. Litter fall in 5×4 m spacing of five year old poplar (*Populus deltoids*) plantation recorded upto 5.6 t/ha/year with the addition of 53.1 kg N, 7.3 kg P, 41.7 kg K, 103.5 kg Ca, 15.68 kg S, 473 g Zn, 7767 g Fe, 1053 g Mn and 115.6 g Cu/ha (Singh et al 2007). Decomposition is catalyzed by microorganisms, which constitute part of the soil biomass. The organic matter subjected to microbial decay in soils comes from several sources. Agri-silvi-cultural systems significantly build up soil organic carbon (SOC) and available NPK but decrease in soil pH (Yadav et al 2008). The magnitude of changes in soil properties under trees was generally greater in light soils than in heavy soils (Rao et al 1998) and in less fertile upland areas than in more fertile valley bottoms. Trees with deep roots can take up subsoil nutrients that are beyond the reach of crops and recycle them to the surface through litter fall. The level of increase in SOC may influenced by tree species, as there are marked variations in the quantity and quality of litter fall among the multi-purpose trees (MPTs). The amount and pattern of litter production varies with tree species, their growth pattern, age, density and canopy characteristics and the environment including temperature, water, and mineral nutrient availability, which limit litter production.

It has also been demonstrated that trees can improve soil physical conditions. Improvements are reflected through lower bulk density (Sharma et al 2001), lower surface resistance to penetration, increased porosity and greater aggregate stability. These changes lead to higher rain water infiltration into the soil and higher availability of water to crops. Also, as old tree roots decay, they leave channels that increase water infiltration. Trees improve soil fertility and modify the microclimate both favorably and unfavorably under their canopies depending on tree species. The magnitude of change depends on canopy and root characteristics, age and size of trees, and density. The increased soil fauna plays a significant positive role in litter decomposition, mineralization of nutrients and improvement of soil structure by incorporating SOM into stable soil aggregates. The higher microbial activities in tree rhizosphere as compared to non-rhizosphere soil (Prasad and Merita 2005, Ghimire 2010) is due to increased supply of carbon and nutrients from dead root cells and rhizo deposition.

Agro-forestry for soil conservation

Agro-forestry is a useful path, complementary to chemical fertilizers to enhance soil fertility. It is an age-old practice in Nepal and farmers of Nepal have been practicing different agro-forestry model in different geography and locality. Contour tracing and planting trees and grasses on trace riser is the practice in hill for soil conservation.

Agro-forestry for fodder and fuel supply

Agro-forestry system in Nepal is diversified and integrated with livestock, trees and crops. It supplies fodder to livestock, firewood to household and contributes towards women's time saving for collection of fodder and fuel (Regmi 2003).

Out of different agro-forestry practices, home gardens are well-established land use systems in Nepal, maintained very close to the homestead (Acharya and Kafle 2009). In home garden households manage a small garden around the house where they grow vegetables and fruits on the farmland, while fodder trees are grown around the house. Although home garden covers the small portion of land, its output is very important for sustaining livelihood of the households. Growing trees with crops or crops with trees depends on the farmers' experience. Households plant fodder trees on the underutilized land such as terrace riser and these trees are lopped at low height in order to prevent shading of crops and to provide fodder in short interval for their animals.

Community forest management practices prevent easy access of forest product for the local people especially in hills. As a result, livestock keeping has become difficult and productivity of livestock is also declining due to unavailability of sufficient fodder from forest. The women have to be strived for fodder and fuel wood collection in most of the time. The green fodder is also scares in dry season for the livestock. There is ample opportunity to intervene good agri-pastoral/silvi-pastoral system in mid hills to fulfill the local need of people and maintained ecological balance in the region. The Bhimal, well adapted fodder tree is the main source of fodder in dry season in far-western hill of Nepal and get Rs. 1500 – 2500/trees from seasonal fodder sale. The lopping twig also used for extraction of fiber and fuel wood. *Artocarpus lakoocha* (Badahar) is highly preferred by the household, followed by *Morus alba* (Kimbu), *Leucana spp.* (Ipilipil), *Bauhinia purpurea* (Tanki) and *Ficus hispida* (Khasreto) in central mid hills. The local agro-biodiversity will be improved by the plantation of different tree species with different crops and livestock. Agro-forestry has been intensively used to meet the basic requirement of food, fuel wood, fodder, and small timber (Karkee 2004). The fallow land may be brought for plantation and gives good return in long-run. The inter space for the first 2-3 years may be utilized for the cultivation of cereals, pulses, oilseed, vegetables, sugarcane crop etc. After third year, inter space may be used for shade loving crops like ginger, turmeric, medicinal plants, forage etc. The tree species should be selected based on local adaptation and market demand. In terai, mango, litchi, guava, jack fruit, eucalyptus, sisso, poplar, bakaino, epil-epil, bamboo, Kadam etc. are suitable for plantation. However, eucalyptus is preferred in Terai in low productive land. Along with plantation, dairy animals, goat rearing, poultry keeping, piggyery, fish farming, vegetable farming, medicinal and aromatic plantation, spices cultivation may be combined with tree plantation. In mid hills, mango, litchi, guava, jack fruit, citrus, uttis, siris, chilaune, tuni, koiralo, kutmero, kaneu, nemaro, bhimal, epil-epil, bamboo etc. are the suitable species for plantation. Along with plantation, livestock and crop production activities may be included. In mountain, apple, pear, peach, plum, apricot, walnut, chestnut etc. may be planted in agro-forestry system along with crop and livestock enterprises.

Agro-forestry for adaptation of crops under stresses

The mid and far-western regions are comparatively dry and moisture stress is main problem in the region. Agro-forestry tree component cast shade and protect direct sun on the ground and reduces the evaporation losses of moisture from the crop field. The leaf litter, twigs and tree residues act as mulch material on the ground. Its land use also competes with annual crop production especially for light and

space. The interception of light is more important for dry matter production and assimilation at reproductive stage but deciduous tree do not affect much in winter season. However, the partial shading at grain filling stage is more useful for proper grain filling in wheat by reducing the respiration losses. The heat stress particularly at grain filling stage of wheat is greatly smoother by decreasing the ambient temperature (1.0°C) and raising the atmospheric humidity (1.1%) under poplar tree canopies (Chauhan and Dhiman 2007). Proper management practices viz., pruning of branches can minimize the above ground competition to some extent and below ground competition can be reduced by pruning of roots, providing root barriers and supplementation of plant nutrients. But, many times tree plantation may be complementary with crop production through improvement of microclimate beneath the tree canopies.

Agro-forestry for land degradation management

Tree plantation reduces salinity, improves soil fertility, controls and prevents erosion, controls water logging, reduces catchment eutrophication and checks acidification, increases local bio-diversity and reduces the green-house effect. Trees are grown in scattered manner in agricultural fields for many uses such as shade, fuel wood, fodder, fruit, small timber, vegetable and medicinal uses. Borders around farmlands form significant niches, where trees are planted by small-size holding farmers. Tree planting on farm land borders increases overall farm outputs. Different agro-forestry species are grown by the farmers in their land for different purposes (Table 1). Trees are planted in crop fields for additional advantages as micro-environment improvement, nutrient cycling, and soil conservation. Hedgerow intercropping is a management in intensive system that leads to increase crop yields. This management strategy seeks to maximize trees' role of nitrogen fixation, soil and water conservation, weed control and nutrient cycling. It can lead to soil and micro-environmental improvements directly affecting associated crops. Important genera for hedgerow intercropping include *Albizia*, *Cajanus*, *Caliliandra*, *Gliricidia*, *Leucaena*, *Sesbania*, *Inga*, *Erythrina*, etc (Dhanda 2003). The growing of storied plantation trees and crop in association helps to bind the soil of different depths which protect the soil loss through water erosion in sloppy lands. But, agro-forestry research is required for promoting models for nitrogen fixation, organic matter addition, nutrient cycling, etc.

Agro-forestry for drudgery reduction of farm women

Along with economical services, agro-forestry can also ensure social and ecological services to the people of the community. The intervention of sound agro-forestry system ensures availability of fodder and fuel in their own land and women's burden in collecting the firewood and fodder is greatly reduced. The pressure on community forest lands also decreases. Its role in increasing farm income, tree species diversity and women's time saving for collection of fodder and fuel wood is well recognized by households of hill districts. It has a considerable impact on women and girls, who are responsible for fetching water and collecting fuel wood in rural areas (Regmi 2003). The old springs are drying due to decrease in green vegetation in the region. To maintain the existing natural water resources green vegetation in terms of tree plantation has to be increased. This could be only possible through social agro-forestry practices. The suitable agro-forestry could be agri-horticultural, silvi-pastoral, agri-silvi-pastoral etc.

Agro-forestry for carbon trading

Tree components have capacity to produce maximum biomass within shortest possible time and sequester substantial amount of carbon in above and below ground by utilizing atmospheric carbon. In farm forestry, about 0.5 tonnes of carbon is being sequestered by one cubic meter of wood (Singh et al 2001). One hundred kilograms green poplar tree can sequester about 107.7 kg CO_2 in above and below ground biomass (Khajuria and Chauhan 2005). Similarly, in 8th year rotation, poplar tree produces 28.2 $\text{m}^3/\text{ha}/\text{yr}$ wood biomass with gross tree output of Rs. 83,500/ha/yr in addition to crop yield in winter season (Ghimire 2010). Thus, agro-forestry is highly profitable which can easily

Table 1. Agro-forestry species used for land degradation management in Nepal

Local Name	Scientific Name	Uses
Fodder		
Badahar	<i>Artocarpus lakoocha</i>	Fodder, fuel, fruit
Bhatmase	<i>Flemingia congesta</i>	Fodder, fuel, soil conservation
Dabdabe	<i>Garuga pinnata</i>	Fodder, fuel, soil conservation
IpilIpil	<i>Leucaena spp.</i>	Fodder, fuel, soil conservation
Kabro	<i>Ficus lacor</i>	Fodder, fuel, soil conservation, pickle
Khanyu	<i>Ficus semicordata</i>	Fodder, fuel, fruit
Khasreto	<i>Ficus hispida</i>	Fodder, fuel
Kimbu	<i>Morus alba</i>	Fodder, fuel, sericulture
Koiralo	<i>Bauhinia variegata</i>	Fodder, fuel, pickle
Rahar	<i>Cajanus cajan</i>	Fodder, fuel, food
Kutmero	<i>Litsea monopetala</i>	Fodder, fuel
Tanki	<i>Bauhinia purpurea</i>	Fodder, fuel
Fuelwood/Timber trees		
Bakaino	<i>Melia azedarach</i>	Timber, fuel, fodder, medicinal
Sal	<i>Shorea robusta</i>	Timber, fuel, fodder
Sissoo	<i>Dalbergia sissoo</i>	Timber, Fuel
Australian wattle	<i>Acacia auriculiformis</i>	Nitrogen fixture
Khair	<i>Acacia catechu</i>	Soil conservation
Babul	<i>Acacia nilotica</i>	Soil conservation
Siris	<i>Albizia labbeck</i>	Shade tree, wind break
Uttis	<i>Alnus nepalensis</i>	Nitrogen fixture
Neem	<i>Azadiracta indica</i>	Shade tree
Fruit trees		
Amba	<i>Psidium guajava</i>	Fruit, fuel
Amp	<i>Mangifera indica</i>	Fruit, fuel
Anar	<i>Punica granatum</i>	Fruit, fuel
Aru	<i>Prunus persica</i>	Fruit, fuel
Bhui-katahar	<i>Ananus sativus</i>	Fruit, Soil conservation
Kagati	<i>Citrus aurantifolia</i>	Fruit, fuel
Kera	<i>Musa sapientum</i>	Fruit
Lichi	<i>Litchi chinensis</i>	Fruit, fuel
Mewa	<i>Carica papaya</i>	Fruit
Naspati	<i>Prunus communis</i>	Fruit, fuel
Nibuwa	<i>Citrus lemon</i>	Fruit, fuel
Rukh-katahar	<i>Artocarpus integrifolia</i>	Fruit, fuel, fodder
Bael	<i>Aegel emarmelos</i>	Wind breaker

Source: Adopted from Acharya and Kafle (2009)

compensate the crop yield losses and helps to mitigating climate change effect by sequestration of atmospheric carbon. Farmers can earn money by carbon trading in future if they plant trees in their private land.

Agro-forestry for bio-remediation and bio-fuel

Agro-forestry not only addresses the problem of land degradation but also assures bio-remediation of the polluted sites with production of timber, firewood, fodder and oils for meeting the demand of rural people. Castor plant is grown well in dumping site of roads and river belt areas, which can exhaust heavy metal and harmful product of decomposing materials. Sajeewan (*Jatropha curcas*) also offers large potential as a bio-fuel in agro-forestry system. It can be grown in most of the soil and climates. Agro-forestry land use also smoother the weed population underneath and around the tree periphery

(Sharma et. al. 2001). Neem tree has medicinal properties with deep root system and does not compete with field crops.

Agro-forestry technologies can produce a wide range of production from same piece of land i.e. food, fuel, fodder, fruits and fiber. This system has to be transferred to the farmers' fields as agri-silviculture (crops+trees), agri-horticulture (crops+fruit trees), alley cropping, boundary plantation, silvi-culture, horti-pasture, energy plantation, shelter-belts, block plantation, biological fencing, forage-forestry and homestead plantation. Use of multi-purpose tree species especially the nitrogen fixing preferably with greater fodder value is better. The fruit plants should be included in the system for nutritional security. Agro-forestry is highly efficient due to persistence of one of the component species (i.e. tree) in the system which not only utilizes the resources continuously but also has better ability to protect resources from deterioration and efficient nutrient recycling add to the sustainability of the system. This system help better adaptation of crop under changing scenario of climate change and mitigate the climate change through carbon sequestration. So, Nepal Agricultural Research Council has to strengthen agro-forestry research for attracting the resources in climate change research for the immediate benefit of rural community and the country in long-run.

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Effect of Nitrogen on Grain Production of Hybrid Maize (RML-4/NML-2) in the Acid Soil of Rampur, Chitwan

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ABSTRACT

Hybrid maize (RML-4/NML-2) was evaluated for its grain production by the application of different levels of nitrogen (60, 120 and 180 kg N ha⁻¹) at varying plant densities (55555, 66666 and 83383 plants ha⁻¹) along with 60 kg P₂O₅ and 40 kg K₂O ha⁻¹ in the acidic soil (pH 5.3) of National Maize Research Program, Rampur, Chitwan during the years of 2008/09 and 2009/10. Factorial randomized complete block design (RCBD) with three replications was employed in the experiment. The crop was planted at the plot size of 18 m² (3.6 × 5 m). The crop was planted in the month of September and harvested in February. The results showed a sharp response of nitrogen application to this crop whereas the effect of density was observed to be insignificant. Two years mean yield results showed that highest grain yield (11.10 t ha⁻¹) was recorded when the crop was supplied with 180 kg nitrogen and with 83383 plants ha⁻¹ followed by the crop supplied with 120 kg N ha⁻¹ and 66,666 plant population (10.69 t ha⁻¹). It is inferred that application of high dose of N (180 kg N ha⁻¹) could help increase hybrid maize grain production in acidic soils.

INTRODUCTION

Maize (*Zea mays* L.) is one of the leading crops in Nepalese agriculture economy. It can be used as food and feed. The increasing demand of maize as food and feed has forced to produce higher yield from an unit area of land and traditional varieties cannot meet the demand so hybrid maize can only fulfill the demand if they are supplied with adequate amount of fertilizers, adequate irrigation and planted at proper densities because they have higher genetic potential of producing more grains compared to those of OPVs (composite) and local varieties. The crop varieties, mainly hybrids, optimum planting date and plant population, water management and combination of desirable practices could influence the response and efficiency of nitrogen given to maize crop. Modern crop hybrids have been bred for increased tolerance to high population and optimum yield can only be obtained near the optimum population (Swanson et al 1973). Singh (1983) suggested maize plant population of 60-65 thousands ha⁻¹ at harvest to attain maximum yield from OPVs. He further suggested that hybrids and composite varieties exhibit their full yield potential only when supplied with adequate quantities of plant nutrient at proper time. A crop of maize yielding about 14 tons of dry matter takes up approximately 161 kg N, 34 kg P and 110 K kg ha⁻¹. The need of fertilizer application mainly depends on the type of varieties and plant densities ha⁻¹ and soil fertility status of growing areas. Incoming solar radiation interception is influenced by the crop leaf area so as to achieve complete ground cover. This can be attained by manipulating plant density and its distribution over the land surface. Koirala et al (1977) reported that plant densities of maize could be increased up to 66000 plants/ha. Under solo-culture short duration variety (Arun-2) did better under high plant population (90,000 plants ha⁻¹) (Sen and Sthapit 1982). An experiment was conducted at NMRP, Rampur to evaluate the effect of N levels on maize planted at varying densities. The yield results showed that Hill Pool White variety (HPW) responded positively up to 120 kg N ha⁻¹ with higher productivity and there was to extra benefit to put extra N than this level in Rampur condition. Adhikary et al (2004) reported that highest grain yield of 5284 kg ha⁻¹ could be obtained when HPW

was supplied with 120 kg N at the density of 55,333 plants ha⁻¹. The hybrid Gaurav produced the highest grain yield of (8.63 t ha⁻¹) at this number of plant population when fertilized with 180 kg N ha⁻¹. Adhikary and Baral (2010) reported that highest grain yield (12.16 t ha⁻¹) was produced when this hybrid was supplied with 120:60:40 NPK kg ha⁻¹ and 10 ton of FYM with the crop planted at the population of 83383 plants ha⁻¹. There is a need to improve the productivity of maize in order to maintain food balance in the hills (Sharma et al 2004). Therefore, it is only the way to introduce or develop hybrids which can produce higher grain yield compared to those of OPVs, composite and local varieties when hybrids are supplied with adequate quantities of nutrients, adequate irrigation and with proper plant density maintenance. The objective of this study was to evaluate the effect of adequate dose of nitrogen and plant densities for increasing grain yield of hybrid maize (RML-4/NML-2) in acidic soil condition.

MATERIALS AND METHODS

Hybrid maize namely RML-4/NML-2 was planted at varying plant densities using different levels of nitrogen under the acidic soil conditions of NMRP farmland during the two consecutive years 2008/09 and 2009/10. A factorial randomized complete block design was employed in the experiments. Three levels of nitrogen (60 kg, 120 and 180 kg N ha⁻¹) were applied. Phosphorus and potassium fertilizers at 60 and 40 kg P₂O₅ and K₂O and 10 t ha⁻¹ of compost were applied basally in all the plots, respectively. The crop was planted in a plot size of 18 m² (3.6m × 5 m) at the spacing of 60 cm row to row distance, and 20, 25 and 30 cm plant to plant distance in a row. The crop was planted in the month of September in the year 2007/08 and 2008/09. Soil samples were analyzed before crop planting and after the crop harvest following Kjeldahl digestion method for N analysis, Bray II method for P and Spectrophotometer for potash analysis. All growth and yield parameters taken into study were analyzed statistically. The following treatments were used in the experiments.

Physio-chemical properties of soil of the experimental plots before crop planting (composite sample) and after crop harvest (treatment-wise) were analyzed. P and K was analyzed at Soil Science Division, NARC, Khumaltar and soil texture, OM and N content were analysed at NMRP soil laboratory, Rampur, Chitwan.

Table 1. Treatments combination

Treatment	Treatment combination	Remarks	Spacing
T1	D1 N1	55,555 plants ha ⁻¹ and 60 kg N ha ⁻¹	30 × 60 cm
T2	D1 N2	55,555 plants ha ⁻¹ and 120 kg N ha ⁻¹	
T3	D1 N3	55,555 plants ha ⁻¹ and 180 kg N ha ⁻¹	
T4	D2 N1	66,666 plants ha ⁻¹ and 60 kg N ha ⁻¹	
T5	D2 N2	66,666 plants ha ⁻¹ and 120 kg N ha ⁻¹	25 × 60 cm
T6	D2 N3	66,666 plants ha ⁻¹ and 180 kg N ha ⁻¹	
T7	D3 N1	83,383 plants ha ⁻¹ and 60 kg N ha ⁻¹	
T8	D3 N2	83,383 plants ha ⁻¹ and 120 kg N ha ⁻¹	20 × 60 cm
T9	D3 N3	83,383 plants ha ⁻¹ and 180 kg N ha ⁻¹	

RESULTS AND DISCUSSION

Growth results revealed that the effect of plant densities on straw yield, plant height and kernel numbers were found to be insignificant in the year 2008/09, where as its effect on ear height and ear length was observed to be significant. The highest straw yield of 8.84 ton ha⁻¹ was recorded when the crop was supplied with 120 kg N and with population of 83,383 plants ha⁻¹ (Table 2) which was observed to be insignificantly different to other plant densities. Similarly, the effect of nitrogen on growth of maize plant was observed to be insignificant during the year 2008/09 (Figure 1). On the other hand, the effect of plant densities on ear height, ear length, kernel rows and stover yield was

observed to be insignificant in the following year 2009/10 (Table 3). The tallest plant height of 177.6 cm was recorded when the crop was supplied with 180 kg N ha⁻¹ and with the plant density of 83,383 plants ha⁻¹ which was highly significantly different to other densities. The shortest plant height of 148.6 cm was recorded with the 60 kg N and with plant density of 55,555 plants ha⁻¹ (Figure 2). Similarly, other plant growth and yield parameters such as ear height, ear length, kernel rows and straw yield were found to be insignificant in the year 2009/10 (Figure 2). On the contrary, the effect of nitrogen on most of growth and yield parameters were observed to be highly significant. The highest stover yield of 9.1 t ha⁻¹ was recorded when this crop was supplied with 120 kg N and 66,666 plants ha⁻¹ (Table 3). The highest kernel number (33.06) was recorded when the crop was supplied with 180 kg N and 83,383 plants ha⁻¹ (T9, Table 3) which was observed to be highly significant.

Effect of nitrogen and plant density on the grain production of hybrid maize

The effect of density on 1000 grain weight during the years 2008 and 2009 found to be significant where as its effect on grain yield was observed to be insignificant for both the years (Table 4). On the other hand, the effect of nitrogen on 1000 grain weight and grain yield was found to be highly significant for both years. The interaction effect of nitrogen and plant density was observed to be non significant. It was noticed that the highest grain yield (10.16 t ha⁻¹) was recorded when the crop was supplied with 180 kg N and at plant population of 83,383 plants ha⁻¹ in the year 2008/09 followed by the crop supplied with 180 kg N and 66,666 plants ha⁻¹ (Figure 3). In the following year (2009/10), the highest grain yield of 12.16 t ha⁻¹ was recorded when the crop was supplied with 120 kg N and 83,383 plants ha⁻¹ followed by 120 kg N and 66,666 plants ha⁻¹ (T5, Figure 3). Two years mean yield indicated a sharp response to N application to the hybrid maize where as the effect of density found to be insignificant (Table 4). The two years mean showed that the grain yield of 11.1 t ha⁻¹ was obtained when the crop was fertilized with 180 kg N ha⁻¹ at the plant population of 83,383 plants ha⁻¹ followed by the crop (10.69 t ha⁻¹) supplied with 120 kg N and with 66,666 plants ha⁻¹ (Figure 4). Lowest grain yield of 8.14 t ha⁻¹ was recorded when the crop was supplied only with 60 kg N and at the plant population of 55,555 plants ha⁻¹. Highest yield increase of 36.36% was observed over D1N1 when the crop was supplied with highest level of N and highest population of maize plant (D3N3, Table 4). It was noticed that highest density mean of 10.08 t ha⁻¹ and highest N mean of 10.53 t ha⁻¹ was observed as shown in two way table means (Figure 4, Table 5).

Table 2. Growth and yield parameters of hybrid maize (RML-4/NML-2) as affected by nitrogen levels and plant densities during the year 2008/09

Treatment nos.	Treatment combination	Ear length (cm)	Kernel row ear ⁻¹ (number)	Kernels row ⁻¹ (number)	Straw yield (t ha ⁻¹)
T1	D1N1	13.86	15.06	27.73	7.94
T2	D1N2	13.80	15.33	29.66	7.84
T3	D1N3	13.46	14.93	28.53	8.70
T4	D2N1	13.20	14.80	27.93	7.87
T5	D2N2	12.86	14.80	27.73	8.58
T6	D2N3	13.46	15.86	29.13	8.17
T7	D3N1	12.26	15.46	27.60	8.68
T8	D3N2	12.60	15.46	26.60	8.84
T9	D3N3	12.46	15.60	26.60	8.75
Grand mean		13.11	15.25	27.94	8.37
F-test	D	*	ns	ns	ns
	N	ns	ns	ns	ns
	D × N	ns	ns	ns	ns
LSD	D	0.925	-	-	-
	N	-	-	-	-
	D × N	-	-	-	-
CV, %		7.07	3.68		12.75

**, highly significant; *, significant; ns, not significant

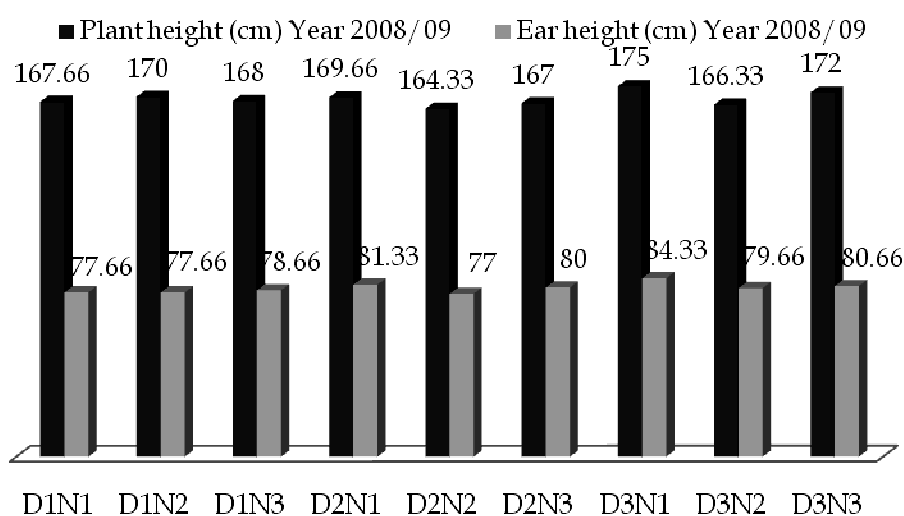


Figure 1. Plant height and ear height influenced by varying treatment combination of plant densities and nitrogen rates in 2008/09

Table 3. Effect of nitrogen rates on the growth and yield characters of hybrid maize planted at varying densities (N × D) during 2009/10 at NMRF farmland, Rampur

Treatment nos.	Treatment combination	Ear length, cm	Kernel rows ear ⁻¹ nos.	Kernel row ⁻¹ , nos.	Stover wt, t ha ⁻¹
T1	D1N1	12.26	13.33	27.53	6.06
T2	D1N2	14.80	16.13	32.53	8.76
T3	D1N3	14.06	15.86	32.80	8.70
T4	D2N1	13.33	15.00	30.13	6.83
T5	D2N2	13.53	16.13	32.20	9.10
T6	D2N3	14.33	16.53	32.60	8.90
T7	D3N1	12.80	15.60	29.06	6.90
T8	D3N2	13.53	16.00	30.60	8.80
T9	D3N3	14.06	16.40	33.06	8.66
Grand mean		13.63	15.66	31.17	8.08
CV, %		2.51	3.89	5.86	5.42
F-test	Density, a	ns	*	ns	ns
	Nitrogen, b	**	**	**	**
	a × b	*	*	ns	-
LSD, 0.05	a	-	0.678	-	-
	b	0.355	0.626	1.875	0.448
	a × b	0.512	1.085	-	-

** , highly significant; * , significant; ns, not significant

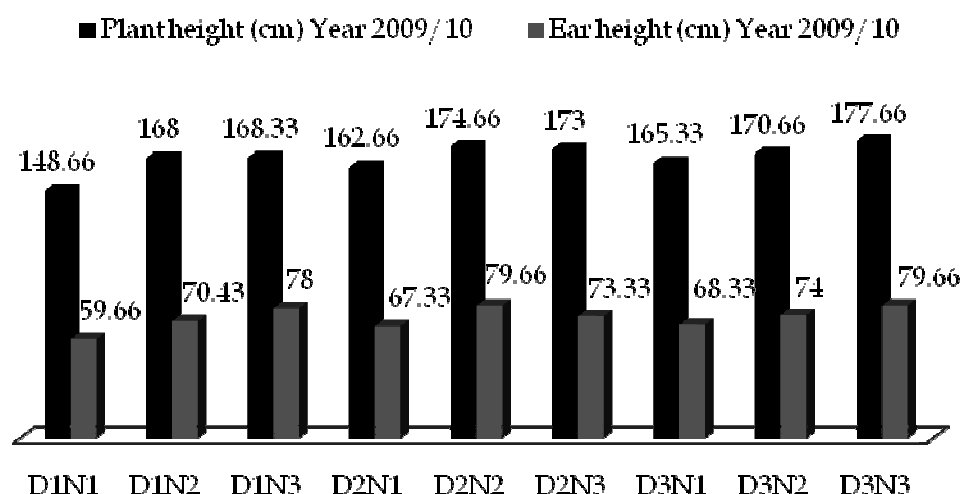


Figure 2. Plant height and ear height influenced by varying treatment combination of plant densities and nitrogen rates in 2009/10

Table 4. Responses to N application for the grain production of hybrid variety during the years 2008/09 and 2009/10

Treatment	Treatment combination	Hybrid maize (2008/09) 1000 grain wt (g)	Hybrid maize (2009/10) 1000 grain wt (g)	Two-years mean grain yield (t ha ⁻¹)	% increase over D1N1 (control)
T1	D1N1	407.78	410.66	8.14	00.00
T2	D1N2	438.12	445.33	9.90	21.62
T3	D1N3	472.37	456.33	10.02	23.09
T4	D2N1	440.77	425.33	8.98	10.31
T5	D2N2	473.41	456.66	10.69	31.32
T6	D2N3	482.16	477.00	10.48	28.74
T7	D3N1	424.10	410.66	8.52	04.66
T8	D3N2	463.88	448.33	10.63	30.58
T9	D3N3	474.73	456.33	11.10	36.36
Grand mean		453.03	442.96	09.828	
F-test	D	*	**	ns	
	N	**	**	**	
	D × N	ns	ns	ns	
LSD	D	19.27	10.06	-	
	N	19.27	10.06	0.809	
	D × N	-	-	-	
CV, %		4.26	2.44	8.745	

**Highly significant, *Significant, ns = not significant

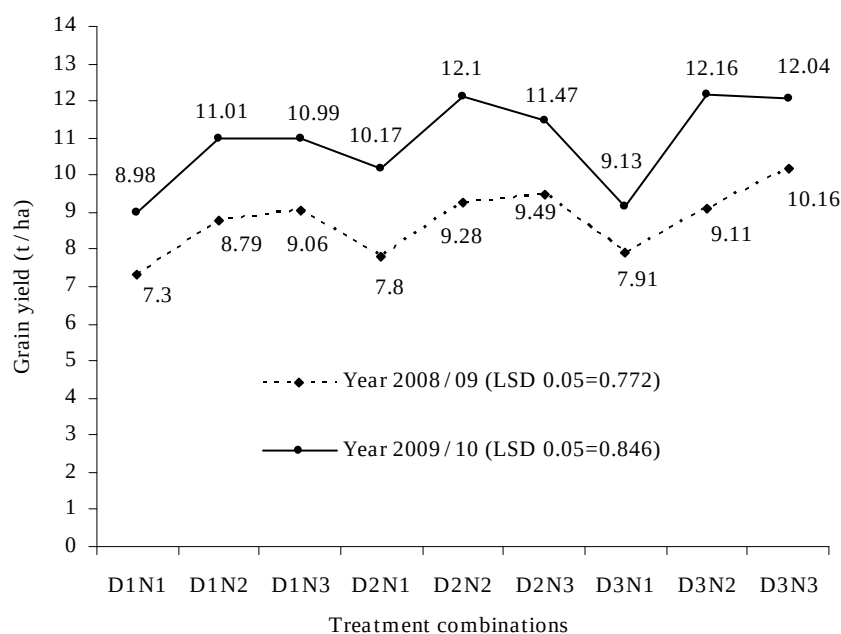


Figure 3. Grain yield of maize influenced by nitrogen and plant

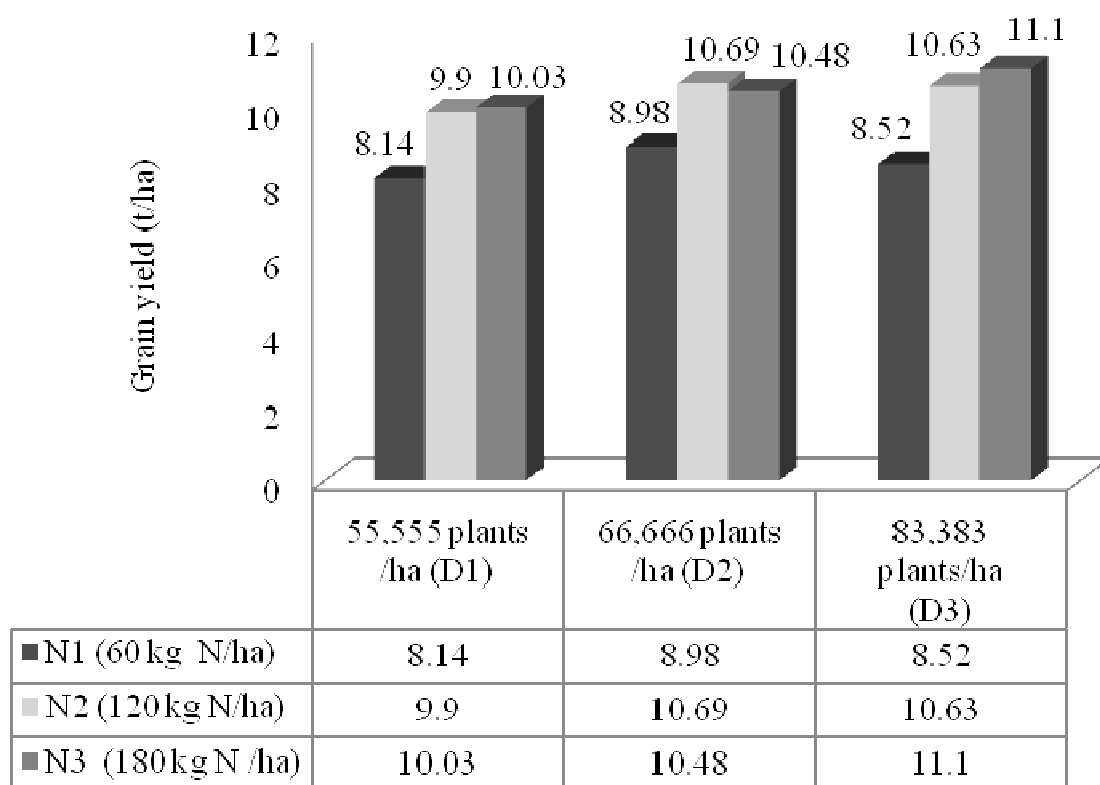


Figure 4. Graphical presentation of grain yield (two years mean) influenced by plant population and nitrogen rates

Table 5. Treatment means from two way table of grain yield as affected by nitrogen and plant densities

Treatment means	Grain yield (t ha ⁻¹)
Nitrogen rates	
N1 (60 kg N ha ⁻¹)	8.54
N2 (120 kg N ha ⁻¹)	10.04
N3 (180 kg N ha ⁻¹)	10.53
Plant densities	
D1 (55,555 plants ha ⁻¹)	9.35
D2 (66,666 plants ha ⁻¹)	10.05
D3 (83383 plants ha ⁻¹)	10.08

Soil test results showed that pH of the experimental plot was found slightly decreased compared to that of composite sample taken before crop planting (5.3). On the contrary the organic matter (OM) content of soil after crop harvest was observed to be increased than the OM level before crop planting (2.0%). Nitrogen, phosphorus and potassium content of soil at crop planting and after the crop harvest has been shown in Table 6.

Table 6. Physico-chemical properties of soil at the experimental plots before crop planting (composite sample) and after crop harvest (treatment-wise) during the year 2008/09 and 2009/10 (two years mean)

Treatments	Soil texture	PH Scale, 1-14 units	Organic matter, %	N, %	P ₂ O ₅ , kg ha ⁻¹	K ₂ O, kg ha ⁻¹
T1	Silt loam	4.70	2.40	0.117	357.52	163
T2		4.99	2.50	0.122	377.18	160
T3		4.98	2.50	0.121	342.12	191
T4		4.94	2.30	0.115	371.93	206
T5		4.80	2.30	0.115	383.84	131
T6		4.93	1.99	0.099	387.39	128
T7		5.03	2.50	0.118	399.21	148
T8		5.00	2.35	0.104	399.12	143
T9		4.90	2.05	0.102	365.24	137
Composite sample	Silt loam	5.30	2.00	0.100	359.42	161

The effect of plant densities on the plant growth parameters were observed to be insignificant for the both years (2008/09 and 2009/10) but the effect of N on plant growth was observed to be highly significant in the second year but not in the first year. The highest 1000 grain wt (482.16 g) was recorded in the first year when the crop was supplied with 180 kg N and the plant population of 66,666 plants ha⁻¹. Similarly, this level of N and density produced the highest 1000 grain wt (477.0 g) in the second year (2009/10). Two years grain yield mean revealed that highest grain yield of 11.10 t ha⁻¹ was recorded when the crop was supplied with 180 kg N and 83,383 plants ha⁻¹ which was 36.36% higher than those produced by 60 kg N at 55,555 plants ha⁻¹ (8.14 t ha⁻¹). It is suggested that high dose of N (180 kg N ha⁻¹) and high plant density (83,383 plants ha⁻¹) could help to increase hybrid maize grain yields.

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Use of Participatory Variety Selection Approach for the Identification of Farmers' Preferred Quality Protein Maize Varieties

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ABSTRACT

Participatory variety selection (PVS) was practiced using mother-baby trial scheme at three locations of each Gorkha, Arghakhanchi and Dang districts. Five QPM varieties performed well in previous years namely Poshilo Makai 1, S99TLYQ-B, S01SIWQ-2, S01SIWQ-3, Corralejo S99SIWQ and farmers' local were experimented. Results from mother trials when combined over locations of all districts showed highly significant differences for flowering among the tested varieties. Similar results were observed for genotype by environment interactions. Corralejo S99SIWQ flowered earliest followed by Poshilo Makai 1 and S99TLYQ-B. Highly significant results were recorded for plant and ear height among the entries. Genotype by environment interactions were absent for this trait. Tallest plant and ear height was recorded in farmers' local variety. Grain yield differences were highly significant among the entries when combined over locations. S01SIWQ-3 produced the highest grain yield (5922 kg/ha) followed by Poshilo Makai 1 (5918 kg/ha) and S99TLYQ-B (4882 kg/ha). The lowest grain yield of 4140 kg/ha was obtained from farmers' variety. Combined feed back over locations from baby trials showed better germination in S99TLYQ-B and reported by 77.8% of the respondents followed by Poshilo Makai 1 (74.7%) and S01SIWQ-3 (68.9%). Reduced plant height, stover yield and lodging problem as compared to their local were reported by majority of the farmers. Grain yield increment was reported by large number of farmers (75.6%) in S01SIWQ-3 followed by Poshilo Makai 1 (71.9%), S99TLYQ-B (69.2%), S01SIWQ-2 (63%) and Corralejo S99SIWQ (62.2%). Among the collaborating farmers 75.6, 86.7, 71.4, 79.4 and 82.6% express their desire to plant Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively in the next year. Based on overall performance, farmers of all the districts ranked Poshilo Makai 1 the first and S01SIWQ-3 the second and S99TLYQ-B the third. Organoleptic test was also carried out to find the QPM varieties suitable for different culinary purposes. QPM varieties are easy for grinding as compared to farmers' variety. *Bhat* from QPM varieties namely Poshilo Makai 1 and S01SIWQ-3 is very soft and preferred by elderly population and children. Majority of the respondents reported better taste of QPM varieties than their local.

INTRODUCTION

Adoption of new crop varieties in Nepal is relatively poor. It might be because many varieties do not meet farmers' consumption and management preferences. A crop variety performing excellent under optimum conditions is recommended to a larger geographical area. These tested varieties upon exposure to the real farmers' field situation not always perform well and farmers have been reluctant to adopt them (Joshi 2002). There is no guarantee that the released variety will meet farmers' requirements. In addition to that, farmers are rarely involved in the research process at the initial stage. Till date, farmers have to depend on other organizations for choosing the new variety seeds for their use. To overcome these problems, participatory variety selection (PVS) has evolved as one of the innovative approaches to complement the conventional variety development and dissemination process. PVS is the selection of farmers' preferred varieties of different crops by themselves in their own fields under their own management and practices. The main objective of PVS is to overcome the

bottleneck of the diffusion of farmers' preferred varieties and to provide varietal selection options to fit in the niche environment. Once the variety is identified, farmer-to-farmer dissemination of PVS variety is the most common process of varietal diffusion. Participatory research can be used to empower farmers and promote development in farmers' communities. It can also be used to increase the efficiency of formal breeding programs in producing and popularizing varieties appropriate for resource-poor farmers. PVS approach helps to identify farmers' preferred varieties in their own field under their own management within a possible shortest period of time and provides varietal selection options (Sthapit et al 1996, Witcombe et al 1998, Joshi and Witcombe 2001, Weltzien Eva et al 2002). Collaborative participation allows farmers to decide overall which varieties they prefer as a simpler and more effective solution. PVS also increases varietal biodiversity as more varieties are adopted by farmers, when given choices.

Farmers are not aware of low cost and low risk intervention technology (QPM) that makes their maize farming effective and efficient as twice as normal maize in terms of protein production from the same unit of land. Considering these facts, farmers' preferred quality protein maize (QPM) varieties were identified using Mother-baby (MB) trial design. The QPM varieties till date are popular among researchers and are beyond the farmers' reach. Only a single variety Poshilo Makai 1 (S99TLWQ-HG-AB) has been released in 2009 for commercial cultivation. Western and Mid-western hill farmers have not exploited yield potential of improved varieties, especially QPM. The normal way to measure a crop's yield is in kilograms per hectare, but with QPM there is an additional level of yield, the amount of nutrients produced per hectare. Therefore, QPM's productivity can actually be expressed in terms of the efficiency of feeding people. Thus, the nutritional benefits of QPM have broad implications for economic development. For instance, each gram of QPM gives the same amount of usable protein as at least two grams of normal maize. By extension, therefore makes maize farming at least twice as efficient in terms of protein production, or said another way, half of the land area can fulfill an individual's protein requirements. It is just like a low-volume and high-value in real sense.

MATERIALS AND METHODS

Mother-baby trials were conducted at three locations of each Arghakhanchi, Dang and Gorkha district. Five QPM varieties performed well in previous years in different experiments at various locations of hills namely, Poshilo Makai 1, S99TLYQ-B, S01SIWQ-2, S01SIWQ-3, Corralejo S99SIWQ and farmers' local were experimented. Half to one kg seed of each variety was given to five farmers. As there were 5 varieties, 25 farmers got these varieties. When a single variety (1/2-1 kg) is given to the farmer to compare it with his/her local variety using his/her own management is called Baby trial (BT). These 25 farmers evaluated 5 varieties in their own field under their own management at each site. The improved variety and their local were planted in the same field in adjacent plots. They compared the performance of each improved variety with their local from planting to post-harvest management. Individual farmer reported his/her own perceptions through a household level questionnaire (HLQ) through matrix ranking. Data in HLQ was recorded as scores where the new variety was compared to their local counterpart as better, same or worse. The following points were considered in HLQ: germination, plant height, lodging problem, disease and insect pests problem in the field, drought tolerance/resistance, shade tolerance, prolificacy, stay green after physiological maturity, thickness of maize stover, stover liked by animals, days to maturity, ear size, grain color, grain size, grain yield, stover yield, taste of different items after cooking, heavy after eating (*Adilo*), disease problem (rot) in storage, insect pests problem in storage and overall ranking (only for focus group discussion - FGD). In addition to these above mentioned points, the following information was also collected from each household - Do they plan to plant this variety next year? Why? How much amount of seed of this variety do they want to plant next year? And is there any seed demand of this variety by anyone? If yes, how much?

All the varieties tested in the BTs including local check were grown together in a centrally located area of that site are referred to Mother trial (MT). Two sets of MTs (single farmer as a replicate) at a site managed by researchers using improved package of practices were planted in the centre of the site. In the MT- plot size was: 6 rows of 3 m long/variety, seed rate @ 20 kg/ha, spacing: 75 cm x 25 cm, fertilizers @ 80:40:30 NPK kg/ha. Observations were taken from four central rows. Observations were recorded for days to flowering, plant and ear height, insect and disease problem; grain yield and plant stand at harvest from MTs. Data was recorded from 18 MTs planted in three districts and feedback from farmers was duly considered. Randomized complete block design was used for experimentation.

Evaluation of MTs was done by matrix ranking by farmers during focus group discussion (FGD) after monitoring all babies and mother trials first at pre-harvest and second at about 2-3 months after harvest. Male and female groups were formed separately to avoid dominance of male farmers. As there were 27 farmers at a site, 5 groups were formed. The points included in HLQ were the same for FGD. Layout plan of a mother-baby trail of five varieties (improved) and one local in five farms (households) each has been presented below (Example for one site):

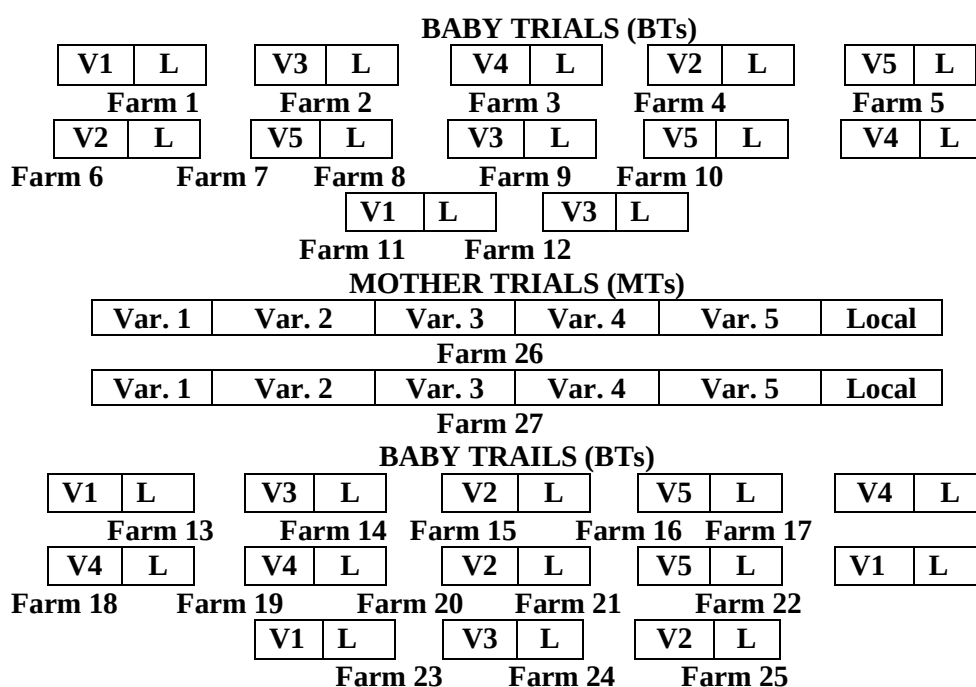


Figure 1. Layout plan of a mother-baby trail of five varieties (improved) and one local in five farms (households), V1-V5 = New QPM varieties, L = Local variety compared with V1-V5

Most of the pre-harvest traits preferred by consumers were identified by household level questionnaire, focus group discussions, feedback from minikits and interactions with farmers and other stakeholders. This activity was conducted for identifying farmers' reactions on different post-harvest traits like culinary characters, ease on grinding, grit recovery and storability. A program called "Maize Day" was organized where organoleptic test of all new five varieties including local was carried out. In this program, all six varieties including farmers' local varieties were popped, boiled; *Bhat* (food from grits) and bread were prepared and tested. Most of the stakeholders reported that they were not used to eat *Dhindo* (pudding) from maize; therefore, it is not necessary to taste that particular item. Farmers, researchers, development workers (representatives from DADOs and NGOs),

representatives from agrovets participated the program. For the convenience of the farmers, name of the variety was placed in each item prepared. Varieties were ranked on 1 to 6 scale, where 1 stands for better and 6 the worse. The person taking part in testing the items filled in a format. All the formats were collected and preferences towards particular variety for certain item were finalized. It helped to identify and rank the varieties based on participants preferences towards particular item.

RESULTS AND DISCUSSION

Mother trials

Gorkha: In Gorkha district, experiments were carried out at Phinam-5, Baguwa-3 and Masel-9. Results combined over locations in Gorkha showed insignificant differences for flowering among the tested genotypes (Table 1). However, significant differences were observed for genotype by environment interactions. Plant height differed highly significantly only at Baguwa-3 and did not differ at other locations. Genotypes by environment interactions were not evident for plant and ear height. Tallest plant and ear height was recorded in farmers' local at all the sites. Regarding grain yield, statistically similar performance was found for all the tested varieties at all the locations (Table 2).

Table 1. Mean days to flowering, plant height (cm) and ear height (cm) of the tested genotypes combined over locations, 2007

Variety	Gorkha			Arghakhanchi			Dang			Combined		
	Fl	Ph	Eh	Fl	Ph	Eh	Fl	Ph	Eh	Fl	Ph	Eh
Poshilo Makai 1	65	240	114	62	233	123	67	249	114	64	240	117
S99TLYQ-B	65	211	107	61	223	121	66	228	113	64	221	114
S01SIWQ-2	65	229	118	62	229	106	67	232	117	65	230	114
S01SIWQ-3	65	240	119	65	246	131	69	240	125	66	242	125
Corralejo S99SIWQ	64	224	108	57	222	124	63	223	112	61	223	115
Farmers' Local	65	271	143	64	296	173	67	290	155	65	286	157
G. Mean	65	236	118	62	242	129	66	244	123	64	123	123
F-test (variety)	ns	**	**	**	**	**	**	*	**	**	**	**
F-test (G x E)	*	ns	ns	**	ns	ns	**	ns	ns	**	ns	ns
LSD (0.05)		23.03	18.56	0.59	14.56	15.94	1.25	40.88	20.98	1.09		
CV, %	1.09	7.94	12.81	0.78	4.9	10	1.53	13.64	13.92	2.56	9.22	12.63

Fl, flowering; Ph, plant height; Eh, ear height; *, significant; **, highly significant; ns, not significant

Table 2. Grain yield (kg/ha) of the tested genotypes at different locations in Gorkha, 2007

Variety	Phinam-5	Baguwa-3	Masel-9	Gorkha
Poshilo Makai 1	4363	5635	6505	5501
S99TLYQ-B	3641	6390	5563	5198
S01SIWQ-2	3962	5316	5429	4902
S01SIWQ-3	4693	5356	7151	5733
Corralejo S99SIWQ	2630	5897	3231	3919
Farmers' Local	2630	4051	5798	4159
G. Mean	3653	5440	5612	4902
F-test (variety)	ns	ns	ns	ns
F-test (G x E)				ns

ns, not significant

Arghakhanchi: In Arghakhanchi, experiments were carried out at Dibharna-4, Sandhikharka-6 and Kimdanda-1. Highly significant differences were recorded for days to flowering at all the sites (Table 1). Corralejo S99SIWQ was found earliest for flowering at all the sites and ranged from 56-58 days. Grain yield and ear height differences among the tested varieties differed significantly at Dibharna-4 and Sandhikharka-6 whereas insignificant at Kimdanda-1. Grain yield of the tested genotypes ranged

from 3550 kg/ha (farmers' local) to 5790 kg/ha (Poshilo Makai 1) at Dibharna-4, 3908 kg/ha (farmers' local) to 7745 (S01SIWQ-3) at Sandhikharka-6 and 4343 kg/ha (Corralejo S99SIWQ) to 6747 kg/ha (Poshilo Makai 1) at Kimdanda-1 (Table 3). Plant height of the tested varieties was recorded insignificant at Sandhikharka-6 whereas highly significant at Dibharna-6 and Kimdanda-1. Among the tested varieties, farmers' local was found tallest which makes it prone to lodging. Plant height of the local variety ranged from 281 cm (Sandhikharka-6) to 310 cm (Kimdanda-1).

Table 3. Grain yield (kg/ha) of the tested genotypes at different locations in Arghakhanchi, 2007

Variety	Dibharna-4	Sandhikharka-6	Kimdanda-1	Arghakhanchi
Poshilo Makai 1	5790	6995	6747	6511
S99TLYQ-B	4922	4577	5566	5021
S01SIWQ-2	3875	4558	6080	4838
S01SIWQ-3	5742	7745	5475	6320
Corralejo S99SIWQ	3742	5112	4343	4399
Farmers' Local	3550	3908	5205	4221
Grand Mean	4603	5482	5569	5218
F-test (variety)	**	**	ns	**
F-test (G x E)				**
LSD (0.05)	789	1109		655.7
CV, %	6.67	7.87	13.57	10.21

**, highly significant; ns, not significant

Dang: In Dang district, experiments were carried out at Rampur-5, Loharpani-7 and Syuja-9. Results combined over locations were highly significant for days to flowering (Table 1). However, it was insignificant Rampur-5 (data not shown). Results combined over locations at Dang showed that Corralejo S99SIWQ flowered earliest (63 days) and followed by S99TLYQ-B (66 days). Highly significant differences were observed both for varieties and genotype by environment interactions. Combined results over locations differed significantly for plant height (Table 1) though it did not differ at Rampur-5 and Syuja-7 (data not shown). Genotypes by environment interactions were not evident for plant and ear height. Tallest plant and ear height was recorded in farmers' local at all the sites. Regarding grain yield (Table 4), statistically similar performance was found for all the tested varieties at Rampur-5 and Syuja-9. Grain yield differences were recorded at Loharpani-7. Highest grain yield was produced by Poshilo Makai 1 (6977 kg/ha) followed by Corralejo S99SIWQ (6810 kg/ha) and S01SIWQ-3 (6764 kg/ha). Genotypes by environment interactions were insignificant for grain yield in Dang district.

Table 4. Grain yield (kg/ha) of the tested genotypes at different locations in Dang, 2007

Variety	Rampur-5	Loharpani-7	Syuja-9	Dang
Poshilo Makai 1	5381	6977	4868	5742
S99TLYQ-B	4391	5381	3511	4428
S01SIWQ-2	4317	5291	4566	4725
S01SIWQ-3	4674	6764	5699	5712
Corralejo S99SIWQ	3705	6810	3021	4512
Farmers' Local	3253	6124	2747	4041
G. Mean	4286	6224	4068	4860
F-test (variety)	ns	**	ns	*
F-test (G x E)				ns
LSD (0.05)		418		1073
CV, %	27.2	2.61	23.26	17.94

*, significant; **, highly significant; ns, not significant

Grain yield differences were highly significant among the entries when combined over locations (Table 5). S01SIWQ-3 produced the highest grain yield (5922 kg/ha) followed by Poshilo Makai 1

(5918 kg/ha) and S99TLYQ-B (4882 kg/ha). The lowest grain yield of 4140 kg/ha was obtained from farmers' local variety.

Table 5. Grain yield (kg/ha) of the tested genotypes combined over locations, 2007

Variety	Gorkha	Arghakhanchi	Dang	Combined
Poshilo Makai 1	5501	6511	5742	5918
S99TLYQ-B	5198	5021	4428	4882
S01SIWQ-2	4902	4838	4725	4821
S01SIWQ-3	5733	6320	5712	5922
Corralejo S99SIWQ	3919	4399	4512	4277
Farmers' Local	4159	4221	4041	4140
G. Mean	4902	5218	4860	4993
F-test (variety)	ns	**	*	**
F-test (G x E)	ns	**	ns	ns
LSD (0.05)		655.7	1073	707.7
CV, %	29.99	10.21	17.94	21.34

Baby trials

Gorkha: Farmers' preferences on different traits of different varieties in Gorkha are presented in table 6. Total of 86.7, 86.7, 100, 86.7 and 93.3% of the responds reported better germination of QPM varieties namely Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively compared to their local variety. Reduced plant height of the newly introduced QPM genotypes were reported by 93.3-100% farmers. Likewise, less insect pests' infestation was observed by 40, 60, 43.8, 53.3 and 33.3% respondents in Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively. Because of reduced plant height most of the varieties were resistant lodging and produced less stover yield as compared to their local. Majority of the respondents reported similar shade and drought tolerance capacity of QPM varieties with their local one. Stay green character of Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1 was reported by 73.3, 80.0, 93.8, 73.3 and 93.3% of the households Similarly, 80.0, 73.3, 87.5, 93.3 and 86.7% farmers reported increased grain yield of Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively. Increased grain size of the newly tested varieties was reported by majority of the farmers. Better taste of QPM varieties than local was observed by most of the respondents. About 93.3, 93.3, 87.5, 93.3 and 86.7% of the farmers reported their interest to plant Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1 in the next year, respectively.

Arghakhanchi: Farmers' preferences on different traits of different varieties in Arghakhanchi are presented in table 7. Total of 53.3, 80, 80, 73.3 and 93.3% of the responds reported better germination of QPM varieties namely Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively compared to their local variety. Reduced plant height of the newly introduced QPM genotypes were reported by 86.7-100% farmers. Likewise, less insect pests' infestation was observed by 60, 80, 80, 66.7 and 80% respondents in Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively. More damage by insect pests only in Corralejo S99SIWQ than in farmers' local was recorded by 13.3% of the farmers. Because of reduced plant height most of the varieties were resistant lodging and less stover yield as compared to their local. Majority of the respondents reported similar shade and drought tolerance capacity of QPM varieties with their local one. Stay green character of Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1 was reported by 86.7, 93.3, 86.7, 86.7 and 100% of the households. Earlier maturity of QPM cultivars was reported by majority of the farmers. Similarly, 53.3, 86.7, 60, 60 and 66.7% farmers reported increased grain yield of Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively. Increased grain size of the newly tested varieties

was reported by majority of the farmers. Better taste of QPM varieties than local was observed by most of the respondents. About 60, 86.7, 66.7, 73.3 and 80% of the farmers reported their interest to plant Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1 in the next year, respectively.

Table 6. Farmers' preferences (percent respondents) on different QPM varieties compared to their local, Gorkha, 2007

Trait	Corralejo S99SIWQ			S01SIWQ-3			S99TLYQ-B			S01SIWQ-2			Poshilo Makai 1		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Germination	86.7	0.0	13.3	86.7	13.3	0.0	100.0	0.0	0.0	86.7	6.7	6.7	93.3	6.7	0.0
Plant height	100.0	0.0	0.0	93.3	6.7	0.0	100.0	0.0	0.0	93.3	0.0	6.7	100.0	0.0	0.0
Maize stover	80.0	13.3	6.7	86.7	6.7	6.7	81.3	12.5	6.3	100.0	0.0	0.0	93.3	6.7	0.0
Insect pest problem	40.0	60.0	0.0	60.0	33.3	6.7	43.8	43.8	12.4	53.3	40.0	6.7	33.3	66.7	0.0
Lodging problem	60.0	40.0	0.0	73.3	20.0	6.7	62.5	37.5	0.0	86.7	13.3	0.0	73.3	20.0	6.7
Shade tolerance	33.3	66.7	0.0	6.7	93.3	0.0	6.3	93.8	0.0	26.7	73.3	0.0	13.3	80.0	6.7
Drought tolerance	20.0	66.7	13.3	20.0	73.3	6.7	12.5	87.5	0.0	26.7	73.3	0.0	26.7	60.0	13.3
Stay green	73.3	13.3	13.3	80.0	13.3	6.7	93.8	6.3	0.0	73.3	13.3	13.3	93.3	6.7	0.0
Maturity period	73.3	26.7	0.0	46.7	40.0	13.3	68.8	31.3	0.0	80.0	20.0	0.0	80.0	20.0	0.0
Stover yield	93.3	6.7	0.0	66.7	26.7	6.7	87.5	0.0	12.5	93.3	0.0	6.7	80.0	0.0	20.0
Grain yield	80.0	6.7	13.3	73.3	26.7	0.0	87.5	6.3	6.3	93.3	6.7	0.0	86.7	13.3	0.0
Grain size	86.7	6.7	6.7	86.7	13.3	0.0	93.8	0.0	6.3	93.3	6.7	0.0	100.0	0.0	0.0
Taste after roasting	66.7	26.7	6.7	66.7	26.7	6.7	56.3	18.8	25.0	80.0	13.3	6.7	80.0	13.3	6.7
Grain color	80.0	20.0	0.0	100	0.0	0.0	62.5	12.5	25.0	86.7	13.3	0.0	66.7	26.7	6.7
Taste of grit	80.0	20.0	0.0	93.3	0.0	6.7	93.8	6.3	0.0	73.3	20.0	6.7	86.7	6.7	6.7
<i>Adilopana</i>	66.7	33.3	0.0	93.3	6.7	0.0	56.3	37.5	6.3	66.7	26.7	6.7	66.7	33.3	0.0
Rot in storage	33.3	66.7	0.0	26.7	60.0	13.3	31.3	68.8	0.0	33.3	60.0	6.7	20.0	60.0	20.0
Insect pests in storage	13.3	53.3	33.3	13.3	53.3	33.3	18.8	62.5	18.8	6.7	60.0	33.3	20.0	53.3	26.7
Next year planting	93.3	6.7	0.0	93.3	6.7	0.0	87.5	6.3	6.3	93.3	6.7	0.0	86.7	0.0	13.3
Have you saved seed?	80.0	6.7	13.3	93.3	0.0	6.7	87.5	6.3	6.3	80.0	6.7	13.3	86.7	6.7	6.7

1, better than local; 2, similar to local; 3, worse than local

Table 7. Farmers' preferences (percent respondents) on different QPM varieties compared to their local, Arghakhanchi, 2007

Trait	Corralejo S99SIWQ			S01SIWQ-3			S99TLYQ-B			S01SIWQ-2			Poshilo Makai 1		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Germination	53.3	46.7	0.0	80.0	13.3	6.7	80.0	20.0	0.0	73.3	20.0	6.7	93.3	6.7	0.0
Plant height	100	0.0	0.0	93.3	6.7	0.0	73.3	13.3	13.3	86.7	0.0	13.3	93.3	0.0	6.7
Maize stover	40.0	33.3	26.7	60.0	20.0	20.0	66.7	33.3	0.0	46.7	33.3	20.0	46.7	46.7	6.7
Insect/pests problem	60.0	26.7	13.3	80.0	20.0	0.0	80.0	20.0	0.0	66.7	33.3	0.0	80.0	20.0	0.0
Lodging problem	66.7	33.3	0.0	80.0	20.0	0.0	73.3	20.0	6.7	73.3	20.0	6.7	86.7	13.3	0.0
Shade tolerance	20.0	73.3	6.7	40.0	40.0	20.0	20.0	53.3	26.7	26.7	60.0	13.3	13.3	46.7	40.0
Drought tolerance	26.7	66.7	6.7	33.3	60.0	6.7	13.3	73.3	13.3	20.0	60.0	20.0	6.7	73.3	20.0
Stay green	86.7	13.3	0.0	93.3	0.0	6.7	86.7	13.3	0.0	86.7	6.7	6.7	100.0	0.0	0.0
Maturity period	40.0	46.7	13.3	66.7	26.7	6.7	66.7	20.0	13.3	66.7	26.7	6.7	66.7	13.3	20.0
Stover yield	26.7	26.7	46.7	26.7	66.7	6.7	33.3	40.0	26.7	46.7	26.7	26.7	26.7	46.7	26.7
Grain yield	53.3	20.0	26.7	86.7	6.7	6.7	60.0	26.7	13.3	60.0	20.0	20.0	66.7	33.3	0.0
Grain size	33.3	46.7	20.0	66.7	20.0	13.3	46.7	26.7	26.7	60.0	26.7	13.3	53.3	46.7	0.0
Taste after roasting	80.0	6.7	13.3	86.7	6.7	6.7	80.0	13.3	6.7	93.3	0.0	6.7	93.3	0.0	6.7
Grain color	100.0	0.0	0.0	86.7	13.3	0.0	80.0	0.0	20.0	100	0.0	0.0	93.3	6.7	0.0
Taste of grit	100.0	0.0	0.0	100	0.0	0.0	100	0.0	0.0	93.3	6.7	0.0	93.3	6.7	0.0
<i>Adilopana</i>	53.3	46.7	0.0	66.7	33.3	0.0	60.0	40.0	0.0	60.0	40.0	0.0	46.7	53.3	0.0
Rot in storage	46.7	33.3	20.0	46.7	33.3	20.0	33.3	13.3	53.3	46.7	20.0	33.3	20.0	46.7	33.3
Insect pests in storage	20.0	60.0	20.0	40.0	40.0	20.0	26.7	26.7	46.7	40.0	20.0	40.0	20.0	20.0	60.0
Next year planting	60.0	20.0	20.0	86.7	6.7	6.7	66.7	33.3	0.0	73.3	6.7	20.0	80.0	6.7	13.3
Have you saved seed?	53.3	46.7	0.0	73.3	26.7	0.0	46.7	53.3	0.0	60.0	40.0	0.0	80.0	20.0	0.0

1, better than local; 2, similar to local; 3, worse than local

Dang: Farmers' preferences on different traits of different varieties in Dang are presented in table 8. Total of 40, 40, 53.3, 42.9 and 37.5% of the respondents reported better germination of QPM varieties namely Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively compared to their local variety. Reduced plant height of the newly introduced QPM genotypes were reported by 78.6-100% farmers. Likewise, less insect pests' infestation was observed by 33.3, 66.7, 60.0, 50.0 and 62.5% respondents in Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively. Because of reduced plant height most of the varieties were resistant lodging and produced less stover yield as compared to their local. Majority of the respondents reported similar shade and drought tolerance capacity of QPM varieties with their local one. Stay green character of Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1 was reported by 80.0, 80.0, 73.3, 71.4 and 87.5% of the households. Similarly, 53.3, 66.7, 60.0, 35.7 and 62.5% farmers reported increased grain yield of Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and S99TLWQ-HG-AB, respectively. Increased grain size of the newly tested varieties was reported by majority of the farmers. Better taste of QPM varieties than local was observed by most of the respondents. About 73.3, 80.0, 60.0, 71.4 and 81.3% of the farmers reported their interest to plant Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1 in the next year, respectively.

Table 8. Farmers' preferences (percent respondents) on different QPM varieties compared to their local variety, Dang, 2007

Trait	Corralejo S99SIWQ			S01SIWQ-3			S99TLYQ-B			S01SIWQ-2			Poshilo Makai 1		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Germination	40.0	33.3	26.7	40.0	53.3	6.7	53.3	26.7	20.0	42.9	50.0	7.1	37.5	50.0	12.5
Plant height	86.7	13.3	0.0	80.0	20.0	0.0	100	0.0	0.0	78.6	21.4	0.0	100	0.0	0.0
Maize stover	46.7	33.3	20.0	86.7	0.0	13.3	66.7	13.3	20.0	78.6	21.4	0.0	68.8	18.8	12.5
Insect pest problem	33.3	53.3	13.3	66.7	13.3	20.0	60.0	33.3	6.7	50.0	42.9	7.1	31.3	62.5	6.3
Lodging problem	86.7	13.3	0.0	86.7	13.3	0.0	93.3	6.7	0.0	92.9	7.1	0.0	62.5	31.3	6.3
Shade tolerance	20.0	46.7	33.3	0.0	66.7	33.3	6.7	53.3	40.0	0.0	100	0.0	18.8	75.0	6.3
Drought tolerance	13.3	60.0	26.7	0.0	100	0.0	0.0	80.0	20.0	7.1	57.1	35.7	25.0	56.3	18.8
Stay green	80.0	0.0	20.0	80.0	13.3	6.7	73.3	20.0	6.7	71.4	14.3	14.3	87.5	6.3	6.3
Maturity period	40.0	46.7	13.3	40.0	6.7	53.3	26.7	46.7	26.7	42.9	21.4	35.7	43.8	31.3	25.0
Stover yield	13.3	26.7	60.0	20.0	20.0	60.0	26.7	20.0	53.3	7.1	28.6	64.3	37.5	12.5	50.0
Grain yield	53.3	20.0	26.7	66.7	13.3	20.0	60.0	13.3	26.7	35.7	35.7	28.6	62.5	25.0	12.5
Grain size	33.3	33.3	33.3	73.3	20.0	6.7	46.7	20.0	33.3	64.3	28.6	7.1	62.5	25.0	12.5
Taste after roasting	40.0	33.3	26.7	66.7	13.3	20.0	40.0	33.3	26.7	50.0	35.7	14.3	56.3	37.5	6.3
Grain color	86.7	6.7	6.7	86.7	13.3	0.0	60.0	6.7	33.3	78.6	14.3	7.1	81.3	6.3	12.5
Taste of grit	80.0	20.0	0.0	80.0	20.0	0.0	73.3	20.0	6.7	50.0	42.9	7.1	68.8	25.0	6.3
Adilopana	73.3	26.7	0.0	80.0	13.3	6.7	66.7	26.7	6.7	57.1	42.9	0.0	68.8	25.0	6.3
Rot in storage	73.3	20.0	6.7	86.7	6.7	6.7	66.7	6.7	26.7	64.3	21.4	14.3	81.3	6.3	12.5
Insect pests in storage	66.7	6.7	26.7	86.7	6.7	6.7	80.0	6.7	13.3	57.1	28.6	14.3	81.3	6.3	12.5
Next year planting	73.3	0.0	26.7	80.0	13.3	6.7	60.0	20.0	20.0	71.4	14.3	14.3	81.3	6.3	12.5
Have you saved seed?	53.3	0.0	46.7	80.0	0.0	20.0	66.7	0.0	33.3	50.0	7.1	42.9	37.5	31.3	31.3

1, better than local; 2, similar to local; 3, worse than local

When combined over locations (Table 9), better germination was reported in S99TLYQ-B by 77.8% of the respondents followed by Poshilo Makai 1 (74.7%) and S01SIWQ-3 (68.9%). Likewise, reduced plant height, stover yield and lodging problem as compared to their local were reported by majority of the farmers. Grain yield increment was reported by maximum farmers (75.6%) in S01SIWQ-3 followed by Poshilo Makai 1 (71.9%), S99TLYQ-B (69.2%), S01SIWQ-2 (63%) and Corralejo S99SIWQ (62.2%). Majority of the respondents reported better taste of QPM varieties than their local. About 75.6, 86.7, 71.4, 79.4 and 82.6% of the collaborating farmers express their desire to plant Corralejo S99SIWQ, S01SIWQ-3, S99TLYQ-B, S01SIWQ-2 and Poshilo Makai 1, respectively in the next year. Based on overall performance, farmers of all the districts ranked Poshilo Makai 1 the first and S01SIWQ-3 the second and S99TLYQ-B the third for next year planting.

Table 9. Farmers' preferences (percent respondents) on different QPM varieties compared to their local variety, combined over locations in all three districts, Gorkha, Arghakhanchi and Dang, 2007

Trait	Corralejo S99SIWQ			S01SIWQ-3			S99TLYQ-B			S01SIWQ-2			Poshilo Makai 1		
	1*	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Germination	60.0**	26.7	13.3	68.9	26.7	4.4	77.8	15.6	6.7	67.6	25.6	6.8	74.7	21.1	4.2
Plant height	95.6	4.4	0.0	88.9	11.1	0.0	91.1	4.4	4.4	86.2	7.1	6.7	97.8	0.0	2.2
Maize stover	55.6	26.7	17.8	77.8	8.9	13.3	71.5	19.7	8.8	75.1	18.3	6.7	69.6	24.0	6.4
Insect pest problem	44.4	46.7	8.9	68.9	22.2	8.9	61.3	32.4	6.4	56.7	38.7	4.6	48.2	49.7	2.1
Lodging problem	71.1	28.9	0.0	80.0	17.8	2.2	76.4	21.4	2.2	84.3	13.5	2.2	74.2	21.5	4.3
Shade tolerance	24.4	62.2	13.3	15.6	66.7	17.8	11.0	66.8	22.2	17.8	77.8	4.4	15.1	67.2	17.6
Drought tolerance	20.0	64.4	15.6	17.8	77.8	4.4	8.6	80.3	11.1	17.9	63.5	18.6	19.4	63.2	17.4
Stay green	80.0	8.9	11.1	84.4	8.9	6.7	84.6	13.2	2.2	77.1	11.4	11.4	93.6	4.3	2.1
Maturity period	51.1	40.0	8.9	51.1	24.4	24.4	54.0	32.6	13.3	63.2	22.7	14.1	63.5	21.5	15.0
Stover yield	44.4	20.0	35.6	37.8	37.8	24.4	49.2	20.0	30.8	49.0	18.4	32.5	48.1	19.7	32.2
Grain yield	62.2	15.6	22.2	75.6	15.6	8.9	69.2	15.4	15.4	63.0	20.8	16.2	71.9	23.9	4.2
Grain size	51.1	28.9	20.0	75.6	17.8	6.7	62.4	15.6	22.1	72.5	20.6	6.8	71.9	23.9	4.2
Taste after roasting	62.2	22.2	15.6	73.3	15.6	11.1	58.8	21.8	19.4	74.4	16.3	9.2	76.5	16.9	6.5
Grain color	88.9	8.9	2.2	91.1	8.9	0.0	67.5	6.4	26.1	88.4	9.2	2.4	80.4	13.2	6.4
Taste of grit	86.7	13.3	0.0	91.1	6.7	2.2	89.0	8.8	2.2	72.2	23.2	4.6	82.9	12.8	4.3
Adilopana	64.4	35.6	0.0	80.0	17.8	2.2	61.0	34.7	4.3	61.3	36.5	2.2	60.7	37.2	2.1
Rot in storage	51.1	40.0	8.9	53.3	33.3	13.3	43.8	29.6	26.7	48.1	33.8	18.1	40.4	37.6	21.9
Insect pest in storage	33.3	40.0	26.7	46.7	33.3	20.0	41.8	31.9	26.3	34.6	36.2	29.2	40.4	26.5	33.1
Next year planting	75.6	8.9	15.6	86.7	8.9	4.4	71.4	19.9	8.8	79.4	9.2	11.4	82.6	4.3	13.1
Have you saved seed?	62.2	17.8	20.0	82.2	8.9	8.9	66.9	19.9	13.2	63.3	17.9	18.7	68.1	19.3	12.6

1, better than local; 2, similar to local; 3, worse than local

Preference ranking

Farmers' rank for different QPM varieties in different test locations of Gorkha, Arghakhanchi and Dang are presented in table 10 and 11.

Table 10. Farmers' overall rank (average of 3-5 groups) for different QPM varieties (QPM), Gorkha, Arghakhanchi and Dang, 2007

Variety	Gorkha			Arghakhanchi			Dang		
	Phinam 5	Baguw 3	Masel 9	Sangikharka 6	Dibharna 4	Kimdanda 1	Rampur 5	Syuja 9	Loharpani 7
Poshilo Makai 1	1	1	1	1	1	1	1	1	1
S99TLYQ-B	3	5	3	3	4	5	3	4	3
S01SIWQ-2	4	3	5	4	5	4	4	3	4
S01SIWQ-3	2	2	2	2	2	2	2	2	2
Corralejo S99SIWQ	5	4	4	5	3	6	5	6	5
Farmers' Local	6	6	6	6	6	3	6	5	6

Most of the farmers reported that these QPM varieties are easy for grinding. They added that Bhat (prepared from grits) from QPM varieties namely Poshilo Makai 1 and S01SIWQ-3 is very soft and preferred by elderly population and children. They also added that different items prepared from QPM are tastier than from normal maize. A one-kg maize was grind in local milling equipment called *Janto* and grit recovery percentage was calculated based on weight of grit and flour. Highest grit recovery of 71.8% was recorded in QPM variety S99TLYQ-B followed by Poshilo Makai 1 (69.7%). Farmers' local had grit recovery of 68.2%. Remaining QPM varieties had grit recovery percentage less than that of farmers' local.

Based on organoleptic test, for roasting purpose, S01SIWQ-3 was found best followed by S99TLYQ-B and Poshilo Makai 1. For boiling purpose, Poshilo Makai 1 was found superior followed by S01SIWQ-2 and S99TLYQ-B. For preparing *Bhat* from grits, S99TLYQ-B was most liked followed by S01SIWQ-3, Poshilo Makai 1 and S01SIWQ-2. For making breads, Poshilo Makai 1 was most preferred followed by S99TLYQ-B, S01SIWQ-3 and Corralejo S99SIWQ. Thus, for most of prevailing items that farmers prepare, QPM varieties seem to be better than local ones.

Table 11. Grit recovery and ranking of QPM varieties by stakeholders based on organoleptic test, combined over locations (Gorkha, Arghakhanchi and Dang district), 2008

Variety	Grit recovery (%)	Flour (%)	Average rank of the varieties (1-6)*			
			Roasted	Boiled	Bhat	Bread
S99TLYQ-B	71.8 (I)	28.2 (VI)	2.99 (II)	3.25 (III)	2.27 (I)	2.55 (II)
Poshilo Makai 1	69.7 (II)	30.3 (V)	3.17 (III)	2.44 (I)	3.15 (III)	2.26 (I)
Farmers' local	68.2 (III)	31.8 (IV)	3.28 (IV)	4.63 (V)	4.18 (V)	4.44 (VI)
S01SIWQ-3	65.8 (IV)	34.2 (III)	2.69 (I)	3.50 (IV)	2.95 (II)	3.37 (III)
S01SIWQ-2	63.2 (V)	36.8 (II)	4.61 (VI)	2.81 (II)	4.11 (IV)	4.34 (V)
Corralejo S99SIWQ	63.0 (VI)	37 (I)	4.26 (V)	4.63 (V)	4.25 (VI)	4.04 (IV)

*1, best; 6, worst

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Efficacy of Organic Fertilizers on Maize (*Zea mays* L.) Productivity in the Acidic Soils of Rampur, Chitwan

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ABSTRACT

Plant nutrients play vital role on maize productivity. Nutrients not only from chemical fertilizers increases crop yield but also with organic fertilizers. To evaluate the efficacy of organic fertilizers, received from NICO ORGO MANURES Company India, an experiment was conducted at NMRP farmland at Hariyali-Tandi on the acidic soil during the year 2011 winter season. Different agro-organic fertilizers along with other chemical fertilizers and manures were used in the experiment. The experiment was designed with randomized complete block and replicated three times. Manakamana-3 was the variety used in the experiment in the month of September at a spacing of 75 cm × 25 cm at the plot size of 22.5 sq. m. and was harvested in second week of February, 2012. Maize growth and yield parameters were taken into the study. The results showed significant effect of organic fertilizers in plant height, stover and grain yield production. The highest grain weight (2.94 t ha⁻¹) was recorded when the crop was supplied with 120: 60: 40 kg N, P₂O₅ and K₂O ha⁻¹ followed by Orgo Blend fertilizers at 617.5 kg ha⁻¹ which was 121% higher than those produced by non-treated crops. It seems that the highest net return of Rs 29,233.0 could be obtained when the crop is supplied only with NPK fertilizers (120: 60: 40 kg ha⁻¹) followed by the crop supplied with Orgo Neem at 150 kg ha⁻¹ which gave the net return of Rs 27555.0 ha⁻¹. This paper discuss and highlights the results of organic fertilizer application on maize productivity in detail.

INTRODUCTION

Fertilizers, both organic and inorganic (chemical) can help to produce double or even triple crop yields. By applying the correct amount of plant nutrients crop growth and grain yields are increased. Organic fertilizers (manures) are very important to increase nutrient status and organic matter (OM) content of soil but are little bit slow to function because they need to be mineralized to release the plant nutrients to the crops. Compost or farm yard manure (FYM), different sources of cakes, poultry manures, bi-products of animals, green manures, sewage and sludges, effluent of bio-gas plant etc. are the good sources of organic manures and are rich in OM and nutrient content (Chaudhary 1993). Currently, NICO ORGO MANURES Company, Gujarat, India has developed several organic fertilizers and are available to some extent in the Nepal. The main organic fertilizers the Company has produced are Orgo Neem, Orgo Blended Organic fertilizer, Jaivik, Samrat and Orgo Turf. Orgo is made by blending of natural organic substances in such a way that it provides the nutrients necessary for crop growth as well as soil health and fertility. The nutrients such as N, P, K, Ca, Mg as well as Fe, Zn, Cu etc. are contained in ORGO which has an organic content of 65% (minimum) and performs the important function of preserving the organic, chemical and physical characteristics of the soil. Fertility of the soil increases and it becomes soft and porous, the humidity is also protected. ORGO-fertilizer can be used by itself or can be blended with conventional fertilizers to augment the results and improve the soil fertility. ORGO has a 3 tier effect on soil: 1) supplies plant food (nutrients), 2) protects soil health, and 3) conditions soil. ORGO remains in the root zone for a longer time, therefore, plants can make more efficient and effective use of available nutrients. Its use has consistently improved crop yields from 5-25% or more (NICO ORGO, 2008). Similarly, Jaivik,

Samrat and Neem Seed Fertilizer also have positive effect in yield increase and soil health. These orgo-fertilizer seemed to be eco-friendly. Maize yields are increased not only by the application of chemical fertilizers but also by the application of compost and FYM (manures). Manures and fertilizers both play important role to increase maize (*Zea mays* L.) productivity. Hybrids and composite varieties exhibit their full yield potential only when supplied with adequate quantities of nutrients at proper time. The exact quantity of fertilizer that has to be applied to the soil depends not only on the plant requirements of the individual nutrient but also on how much of them the soil can supply, soil types, acidity and the maize genotypes (local, composite or hybrids). Field experiments were conducted at NMRP farmland to evaluate the effects of manures and fertilizers and results revealed that highest yield (4.82 t ha^{-1}) was reported in Uphar variety when the crop was supplied with 10 t ha^{-1} of compost applied along with $120:40:30 \text{ kg N, P}_2\text{O}_5 \text{ and K}_2\text{O ha}^{-1}$. This variety produced only 2.16 t ha^{-1} of grains when fertilized only with 10 t of compost (Adhikary et al 2010). Maize being a high nutrient mining crop it needs higher amount of NPK for its economic production. Farmers applying $20\text{-}25 \text{ t ha}^{-1}$ of compost or FYM (manures) are not sufficient to replenish the harvested nutrients and hence need sufficient amount of mineral fertilizers in addition with heavy manure application (Joshy 1997). Different researchers have reported highest grain yield by applying different dose of manures and fertilizers (Adhikary et al 2001; Adhikary and Ranabhat 2004). Due to a number of socio-economic factors, the primary input for maintaining and improving soil fertility is manure or compost but its quality is extremely variable. In accessible areas, chemical fertilizers are used to supplement manure and compost. To evaluate the effect of organic fertilizers supplied by NICO ORGO, India on maize production, this experiment was conducted at NMRP farmland, Chitwan, Nepal.

MATERIALS AND METHODS

Four organic fertilizers (Orgo Neem, Orgo Blended Organic Fertilizer, Jaivik Enriched Organic Fertilizer and Samrat Enriched Organic Fertilizer) received from NICO ORGO MANURES Company were taken into study and were compared with recommended dose of NPK fertilizers and compost. A total of 11 treatments were used. The experiment was conducted in a randomized complete block design and replicated 3 times. Manakamana-3 variety was planted in the acidic soil (in the plot size of 22.5 sq.m ($4.5 \text{ m} \times 5 \text{ m}$) in rows (6 rows of 5 m long). The crop was sown at Hariyali-tandi, NMRP farmland in a spacing of 25 cm and 75 cm in August 30, 2011 (Bhadra 13, 2068) and harvested in 14th Magh, 2068 (January 28, 2012). Four rows out of 6 were harvested and different growth and yield parameters were studied. Urea was purchased at Rs 35 per kg, DAP at Rs. 50, MOP at Rs 30 and compost at Rs. 2.8 per kg. Similarly, the market price of Orgo Blended was Rs 24, Neem Seed Rs. 35, Samrat Rs 25 and Jaivik cost Rs 25 per kg fertilizer, respectively. Grain cost was calculated @ Rs.15 per kg grains. On the basis of input cost and grain cost gross income and net income were calculated and reported accordingly. Organic fertilizer samples, composite soil samples (before crop planting) and other soil samples from each respective treatment plots after crop harvesting were collected and sent to Soil Science Division, NARC, Khumaltar for the analysis of nutrient content. Nitrogen was determined by Kjeldahl distillation method, phosphorus (P) by Olsen's method. The details of treatment combination are given below.

Treatments

1. Control plot (no organic manures and fertilizers)
2. Recommended dose of fertilizers ($120:60:40 \text{ kg N, P}_2\text{O}_5 \text{ and K}_2\text{O ha}^{-1}$)
3. Jaivik Enriched Organic Fertilizer @ 494 kg ha^{-1} (200 kg acre^{-1} recommended)
4. Jaivik Enriched Organic Fertilizer @ 247 kg ha^{-1} (half dose of recommendation)
5. Samrat Enriched Organic Fertilizer @ 494 kg ha^{-1} (200 kg acre^{-1} recommended)
6. Samrat Enriched Organic Fertilizer @ 247 kg ha^{-1} (half dose of recommendation)

7. Orgo Neem (Neem Seed Fertilizer) @ 300 kg ha⁻¹
8. Orgo Neem (Neem Seed Fertilizer) @ 150 kg ha⁻¹
9. Compost @ 20 t ha⁻¹
10. Orgo Blended Organic Fertilizer @ 617.5 kg ha⁻¹ (250 kg acre⁻¹ recommended)
11. Orgo Blended Organic Fertilizer @ 308.75 kg ha⁻¹ (half dose of recommendation)

RESULTS AND DISCUSSION

Effect of organic fertilizers on maize growth

Results of organic fertilizer application showed insignificant responses on the growth of maize and yield components. Plant and straw weight were significantly affected while the number of kernels per ear, number of kernel rows production, ear height and ear length in the rows were observed to be insignificant. The tallest plant height (141.33 cm) was recorded when the crop was supplied with 247 kg ha⁻¹ of Samrat Enriched Organic-fertilizer followed by the same fertilizer (Samrat) at 494 kg ha⁻¹ (140.66 cm). Lowest plant height (104 cm) was recorded in the untreated control plot (T1, Table 1).

Table 1. Response of different organic fertilizers on maize growth and Yield Parameters during the year 2011

Treatment nos.	Plant height, cm	Ear height, cm	Ear length, cm	Kernel rows ear ⁻¹ , nos	Kernel nos. row ⁻¹	Stover weight, t ha ⁻¹
T1	104.00	49.66	10.46	13.20	22.93	2.12
T2	140.00	70.00	12.20	12.80	27.93	4.34
T3	118.00	63.33	11.60	13.33	24.53	2.68
T4	128.66	67.33	11.26	13.06	24.50	2.70
T5	140.66	69.00	11.26	13.86	25.00	2.21
T6	141.33	71.33	11.46	13.20	24.93	2.41
T7	133.66	62.66	11.86	14.00	25.13	2.25
T8	137.66	63.66	11.46	13.73	25.06	3.05
T9	139.66	60.33	11.46	14.00	24.73	2.10
T10	129.66	65.66	12.20	12.80	25.60	3.58
T11	132.00	62.66	11.33	13.46	25.13	2.74
Grand mean	131.39	64.15	11.50	13.40	25.04	2.74
CV (%)	8.09	10.90	5.86	5.26	8.72	24.65
F-test	**	ns	ns	ns	ns	*
LSD(0.05)	18.108	11.913	1.149	1.201	3.718	1.153

**, highly significant; *, significant; ns, not significant

Effect of recommended dose of fertilizers (120:60:40 kg N, P₂O₅ and K₂O ha⁻¹), compost at 20 t ha⁻¹, Samrat Organo-fertilizer and Orgo Blended Organic-fertilizer were at par in plant height production. Similarly, the trend and effect of these organic-fertilizers to ear height production was observed to be almost similar to the plant height production but was not significant. The tallest ear height (71.33 cm) was recorded with Samrat organic fertilizer at 247 kg ha⁻¹ followed by NPK fertilizers at 120:60:40 kg ha⁻¹ (70 cm). The effect of Jaivik Enriched organic fertilizer, Samrat, Orgo Blended organic fertilizer and recommended dose of chemical fertilizer (120:60:40 kg N, P₂O₅ and K₂O ha⁻¹) were observed to be insignificantly similar to ear height production. The longest ear (12.2 cm) was recorded when the crop was fertilized by 120:60:40 kg N, P₂O₅ and K₂O ha⁻¹ or with Orgo Blended Organic-fertilizer. Shortest ear length (10.46 cm) was produced with the non-treated crop (Table 1). Increased kernel rows (14.2 rows ear⁻¹) was recorded when the crop was supplied by Orgo Neem (Neem Seed Fertilizer) at 300 kg ha⁻¹ and with compost at 20 t ha⁻¹ and both fertilizers were found at par in kernel row production. Other treatments produced insignificant effect on ear length production (Table 1). On the contrary, highest number of kernels (27.93 kernels row⁻¹) were recorded when the crop was fertilized only by NPK fertilizers at 120:60:40 kg ha⁻¹ and lowest by non-treated crop (22.93 kernels

row⁻¹). The kernel production with the use of Jaivik, Samrat, Neem Seed and Orgo Blend fertilizers were at par and was found to be insignificant among them. Similarly, highest stover yield (4.34 t ha⁻¹) was recorded with 120:60:40 kg N, P₂O₅ and K₂O ha⁻¹ followed by Orgo Blended Organic-fertilizer (3.58 t ha⁻¹). The lowest stover yield (2.12 t ha⁻¹) was recorded with non-treated crop (Table 1).

Table 2. Response of different organic fertilizers on maize grain production during the year 2011

Treatment nos.	Thousand grain wt, g	Grain yield, t ha ⁻¹	Increment over control, t ha ⁻¹	Increment over control, %	Cost of fertilizers, Rs.	Net profit, Rs.
T1(control)	402.00	1.33	0.00	0.00	0.00	19950.0
T2	456.00	2.94	1.61	121.05	14912.0	29233.0
T3	417.00	1.77	0.44	33.00	12350.0	14245.0
T4	463.00	1.82	0.49	36.84	6175.0	21125.0
T5	415.33	1.79	0.46	34.58	12350.0	14500.0
T6	446.66	1.72	0.39	29.32	6175.0	19625.0
T7	463.33	1.51	0.18	13.53	10500.0	12255.0
T8	454.00	2.18	0.85	63.90	5250.0	27555.0
T9	438.00	1.67	0.34	25.56	56000.0	(-)30950.0
T10	451.33	2.55	1.22	91.72	14820.0	23430.0
T11	422.66	2.05	0.72	54.13	7410.0	23385.0
Grand mean	439.03	1.94				
CV (%)	6.61	24.67				
F-test	ns	*				
LSD(0.05)	49.455	0.816				

**, highly significant; *, significant; ns, not significant

Effect of company organic-fertilizers on maize grain production

Highest thousand grains weight (463.33 g) was recorded when the crop was supplied with Orgo Neem (Neem Seed Organic-fertilizer) at 300 kg ha⁻¹ (T7) and was found similar to Jaivik Enriched Organic-fertilizer at 494 kg ha⁻¹ (463.33 g). The lowest test weight (402 g) was recorded by untreated control plot followed by Samrat Enriched Organic-fertilizer at 494 kg ha⁻¹. The effect of treatments on test weight was observed to be insignificant (Table 2). On the contrary, the organic fertilizer effect was observed to be significant on the grain yield of maize. Highest grain yield (2.94 t ha⁻¹) was recorded in crop supplied only with 120: 60: 40 kg N, P₂O₅ and K₂O ha⁻¹ followed by Orgo Blend organic fertilizer (2.55 t ha⁻¹). Lowest grain yield (1.33 t ha⁻¹) was recorded with untreated crop (Table 2). Application of compost @ 20 t ha⁻¹ increased maize yield only by 340 kg ha⁻¹ over to that of untreated crop and was observed to be uneconomical. Highest yield increment of 121.05% was observed when the crop was supplied only with recommended dose NPK fertilizers followed by Orgo Blend Organic fertilizer (91%) (Table 2). Highest net return of Rs. 29,233.00 was obtained when NPK at 120:60:40 kg ha⁻¹ was applied. The stover production and grain yield relationship was positively correlated (R²=0.927) as shown in the Figure 1, below.

Effect of company organic-fertilizers on soil nutrient content

Soil analysis report showed that there was no sharp response of organic fertilizer in soil pH increase. The pH of composite soil sample (taken before crop planting) was recorded as 4.2 and there was only a slight increase in the control plot (4.4) and in the plot treated with Jaivik organic fertilizer (4.4) (Table 3). However, a sharp response of treatments was observed in soil organic matter (OM) content. Highest OM content (5.215%) was recorded in the plot treated by Orgo Neem (Neem Seed Fertilizer) @ 150 kg ha⁻¹ (T8) where as the OM content of composite sample was only 3.993%. Similarly, the nitrogen (N) content was also found slightly increased (0.173- 0.190%) compared to that of composite sample ((0.169% N) except with Orgo Blended Organic Fertilizer @ 308.75 kg ha⁻¹. On the contrary, the phosphorus (P) content of soil was observed to be decreased. The composite sample contained a

total of 288 kg ha⁻¹ of P₂O₅ where as in other plots its content was found to be ranged from 166 to 275 kg ha⁻¹. The potash (K) content of composite sample was analyzed only to be 299 kg ha⁻¹ where as the highest K₂O content was recorded in the control plot (470 kg ha⁻¹) followed by the crop with recommended dose of fertilizers (120:60:40 kg N, P₂O₅ and K₂O ha⁻¹) (466 kg K₂O) and Orgo Neem (Neem Seed Fertilizer) @ 150 kg ha⁻¹ (434 kg).

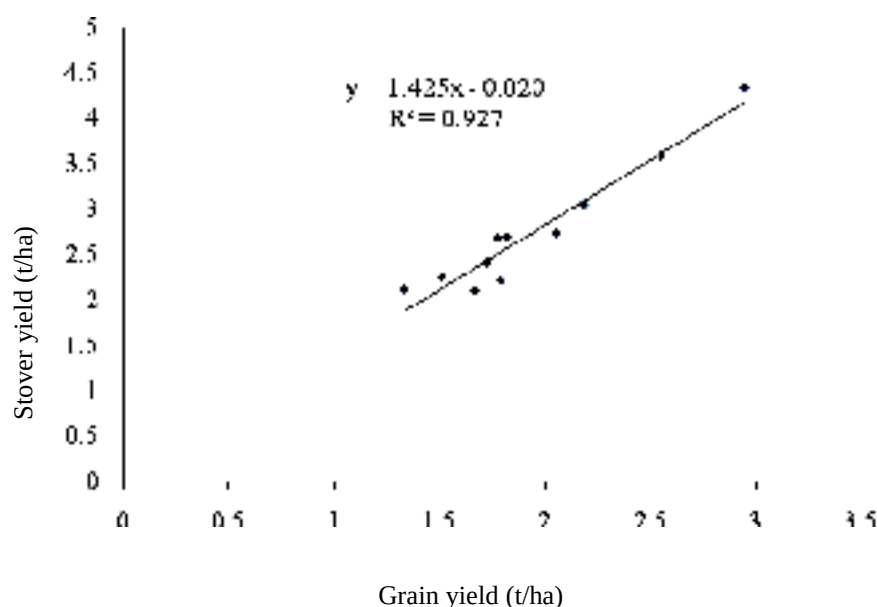


Figure 1. Relationship between stover and grain yield

Table 3. Physico-chemical properties of soils at experimental site and Company Organic-fertilizers (2011)¹

Samples	Soil type	pH	OM %	N %	P ₂ O ₅ kg ha ⁻¹	K ₂ O kg ha ⁻¹
Composite sample (before crop planting)						
	Light textured	4.2	3.993	0.169	288	299
Samples after crop harvesting						
T1	Light	4.4	5.05	0.173	212	470
T2	textured	4.2	4.91	0.181	224	466
T3		4.3	5.09	0.186	200	295
T4		4.4	4.45	0.177	195	300
T5		4.1	4.82	0.178	205	224
T6		4.3	5.12	0.190	224	434
T7		4.1	4.95	0.182	166	264
T8		4.3	5.21	0.190	225	434
T9		4.2	4.65	0.173	200	425
T10		4.0	4.91	0.181	210	277
T11		4.3	4.35	0.165	275	259
Orgo Blended Organic Fertilizer			65-85	4.130	0.585	2.75
Orgo Neem (Neem seed fertilizer)			70-80	7.175	0.600	2.50
Jaivik Enriched Organic fertilizer			-	0.875	0.500	1.38
Samrat Enriched Organic fertilizer			-	0.945	0.575	1.75

¹Soil and organic- fertilizer samples were analyzed and reported by Soil Science Division, NARC, Khumaltar, Lalitpur, Nepal.

The effect of organic fertilizers as well as chemical fertilizers was found positive only in few of the growth parameters of maize. Tallest plant height (141.33 cm) was recorded when the crop was supplied with 247 kg ha⁻¹ of Samrat Enriched Organic Fertilizer followed by the same organic fertilizer when applied at 494 kg ha⁻¹ (140.66 cm). Increased kernel rows (14.2 rows ear⁻¹) was recorded when the crop was fertilized by Orgo Neem at 300 kg ha⁻¹. Equal number of rows were observed (14.2 rows ear⁻¹) when the crop was fertilized with 20 t ha⁻¹ of compost. Similarly, highest stover yield (4.34 t ha⁻¹) was produced by the crop when fertilized with 120:60:40 kg ha⁻¹ of N, P₂O₅ and K₂O followed by Orgo Blend Organic Fertilizer (3.58 t ha⁻¹). Significant effect of treatments was observed in stover production. Similarly, highest test weight (463.33 g) was recorded when the crop was supplied with Neem Seed Fertilizer at 300 kg ha⁻¹ followed by Jaivik Enriched Organic Fertilizer when applied at 494 kg ha⁻¹ (463.33 g). Highest grain yield (2.94 t ha⁻¹) was recorded when the crop was fertilized only by 120:60:40 kg N, P₂O₅ and K₂O followed by full dose of Orgo Blend Organic Fertilizer (2.55 t ha⁻¹). The highest yield increment of 121.05% was observed with NPK fertilization followed by Orgo Blend Organic Fertilizer (91% increment). Economically, the response of compost application to maize was observed to be negative (- Rs. 30,950.00) because of its higher price (Rs. 2.8/kg compost or Rs. 56,000.00 per 20 t of compost). It is noted that Orgo Blend Organic Fertilizer might be better than those with other organic fertilizers in maize production. It seems that the highest net return of Rs 29,233.00 could be obtained when the crop is supplied only with NPK fertilizers (120:60:40 kg ha⁻¹) followed by the crop supplied with Orgo Neem at 150 kg ha⁻¹ which gave the net return of Rs 27555.00 ha⁻¹. However, application of NPK alone could help increase maize productivity under Rampur, Chitwan soil conditions. It is suggested to conduct such experiments for next two years to vary and confirm the results of this investigation.

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Screening of Resistance for Stored Grains of Promising Maize Genotypes against Maize Weevil (*Sitophilus zeamais* Motsch)

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ABSTRACT

Maize weevil (*Sitophilus zeamais* Motsch) is one of the serious insect pests of stored grains of maize in Nepal. Weevil resistant maize is the best option to minimize maize loss in storage. Maize grains of 14 maize genotypes were evaluated for their resistance against maize weevil under free choice test under room conditions. Maize resistance was evaluated based on grain damage index (GDI) value ranging from 0.00 to 1 calculated based on the number of weevils in F₁ progeny, rubbish weight from the damaged grains, and weight loss from the sample grains. Non-preference resistance was also tested for the test entries. Among the 14 maize genotypes, seven genotypes were found less damaged (GDI: 0.34-0.49), five were found moderately damaged (GDI: 0.50-0.65), and two were found highly damaged (GDI: 0.66-0.82). The maize genotype 'Rampur SO3FO4' was the least damaged one (GDI: 0.34) whereas the genotype 'RML4 x NML2' was the most damaged one (GDI: 0.82). The non-preference resistance test showed that some of the less damaged and highly damaged genotypes have possessed less and more number of weevils, respectively. This study has explored the level of resistance for the tested maize genotypes and has identified some weevil resistant maize that can be recommended to Nepalese farmers.

INTRODUCTION

Maize weevil (*Sitophilus zeamais* Motsch) is one of the serious insect pests of stored maize in Nepal. Field maize is infested by this pest from the stocks of stored grains which is again carried in maize stores along with the infested maize ears/grains where it multiplies in many generations and causes heavy loss to stored maize. As reported previously the post harvest loss of maize in Nepal is mainly due to the infestation of various weevils (*Sitophilus zeamais*, *Sitophilus oryzae* and *Sitophilus granarius*) and angoumois grain moth (*Sitotroga cerealella*) (Boxall et al 1982, Yubak 2001). Heavy yield loss, generally 6-24%, of stored maize is reported to cause solely by insect damage (Shivakoti 1984, Manandhar et al 2004, Yubak 2001). In some cases, up to 32% of maize yield loss is caused only due to the infestation of maize weevil in maize storage (Panthee et al 1993).

Chemical insecticide is usually unsafe and impractical to most of the Nepalese farmers to use it in maize storage. Use of weevil resistant maize is one of the promising alternatives to Nepalese farmers to protect maize in maize storage. Several works have been done on resistance screening against this pest outside the country (McCain et al 1964, VanDerSchaaf et al 1969, Dobie 1974, Widstrom et al 1978). Resistance screening against this pest has been initiated in Nepal since the past few years (Sharma et al 2010, 2012). National Maize Research Program (NMRP) including some other research stations under NARC have regular programs to breed and develop improved maize lines/varieties every year. Before releasing of improved/promising maize lines, NARC has to evaluate them for their resistance/susceptibility response against the major insect pests of maize. In this context, it is here reported the resistance/susceptibility response of some promising maize genotypes against the maize weevil.

MATERIALS AND METHODS

Maize grains of 14 maize genotypes were evaluated for their resistance against maize weevil (*Sitophilus zeamais*) under free choice test in a circular metal bin under room conditions following the methodology as adopted by Sharma et al (2010, 2012) previously. Maize grains were oven dried at 52°C for 5 days so as to kill the different stages of insect and dry out the moisture from the maize grains. The maize grains were kept in a small plastic pot (height 5 cm, diameter 3.5 cm) at the rate of 10 g per genotype and was replicated thrice. The plastic pots containing the maize grains were left in a room for long enough time so as to raise the moisture level to 14% in the grains. The maize grains kept in the plastic pots were then transferred in a circular metal bin (115 cm x 35 cm) arranging them in a circular fashion around the corner of the bin. Newly emerged weevils were released at the rate of one insect per gram in the center of the bin so that the weevils could freely move in and out to every sample in the bin. Mouth of the bin was closed with muslin cloth after releasing the insect.

Experiment was conducted under room conditions of maximum and minimum temperature with 26 and 22°C, respectively and maximum and minimum relative humidity with 86 and 65%, respectively. Data for rubbish weight from the damaged grains, number of F₁ weevils and reduced weight of the test grains were observed at three months of the insect release. Reduced weight of the sample grains were taken only after the oven drying of the samples as done in the beginning. Data for number of weevils in non-preference test was taken at 5th day of the insect release. Maize resistance was evaluated based on the grain damage index (GDI) value ranging from 0.00 to 1. For less damaged (LD), GDI = 0.34-0.49; for moderately damaged (MD), GDI = 0.50-0.65; and for highly damaged (HD), GDI = 0.66-0.82. The data were analyzed with GENSTAT-5 for completely randomized design.

RESULTS AND DISCUSSION

Maize resistance was evaluated based on GDI value under free choice condition (Table 1). Among the 14 maize genotypes, the seven genotypes - Terai Pool Yellow, S99TLYQB, Gulmi-2, Rampur SO3FO8, Rampur SO3FO6, Rampur SO3FO4 and Rampur SO3FO1 were the less damaged ones which possessed the GDI value ranging from 0.34 to 0.49 and can be recommended as weevil resistant maize to farmers. The five genotypes- Across 9942 X Ac.9944, HG-B, Resunga composite, P501SRCO/P502SRCO and HG-A possessed GDI value within 0.50 to 0.65 and were categorized to be the moderately damaged ones. The remaining two genotypes- HG-AB and RML4 X NML2 were the highly damaged ones which possessed the GDI value ranging from 0.66 to 0.82. The genotype 'Rampur SO3FO4' was the least damaged one and the genotype 'RML4 X NML2' was the most damaged one which possessed the least GDI value 0.34 and the highest GDI value 0.82, respectively.

Also the non-preference test was performed for the grains of 14 maize genotypes. The 14 maize genotypes differed significantly for their resistance/susceptibility response to maize weevil (Figure 1). The non-preference test has shown that most of the less and moderately damaged genotypes have generally possessed lesser number of weevils and hence indicating the possessing of non-preference resistance in them. Number of weevils was found significantly lesser in the maize genotypes - Across 9942 X Ac 9944, Terai Pool Yellow, Resunga composite, P501SRCO/P502SRCO, S99TLYQ-B, Gulmi-2, Rampur SO3FO8, Rampur SO3FO4, Rampur SO3FO6, and Rampur SO3FO1 as compared to the genotypes - HG-B, HG-AB, HG-A, and RML4 x NML2. Among the tested maize genotypes, Rampur SO3FO1 possessed least number (3) of weevils and thus showed highest non-preference resistance whereas RML4 X NML2 possessed highest number (25.6) of weevils and hence showed highest susceptibility response to the maize weevil.

Table 1. Levels of maize grain damage for 14 maize genotypes based on weevil number, rubbish weight and weight loss in the test grains

Maize genotype	Number of weevils in F1 progeny	Rubbish wt from the damaged grains (mg)	Weight loss of the test grains (g)	Grain damage index (GDI) (0.00-1)	Level of maize grain damage
Across 9942 X Ac. 9944	20.7	78.3	1.92	0.61	MD
HG-B	16.7	99.3	2.26	0.64	MD
HG-AB	19	109	2.43	0.70	HD
Terai pool yellow	14	33.3	1.43	0.38	LD
Resunga composite	17.3	68	1.8	0.52	MD
P501SRCO/P502SRCO	20.3	26.3	1.9	0.50	MD
HG-A	18.7	42.3	1.88	0.50	MD
S99TLYQ-B	10	27	1.73	0.36	LD
Gulmi-2	11	55.7	1.58	0.41	LD
RML 4 X NML 2	21	143	2.89	0.82	HD
Rampur SO3FO8	13	41	1.46	0.39	LD
Rampur SO3FO4	12.7	27.3	1.34	0.34	LD
Rampur SO3FO6	18	35	1.63	0.47	LD
Rampur SO3FO1	53.3	45.3	1.61	0.46	LD
F-test	ns	*	**	**	
CV%	35.4	63.6	20.5	27.1	
LSD (0.05)	9.62	63.42	0.63	0.23	

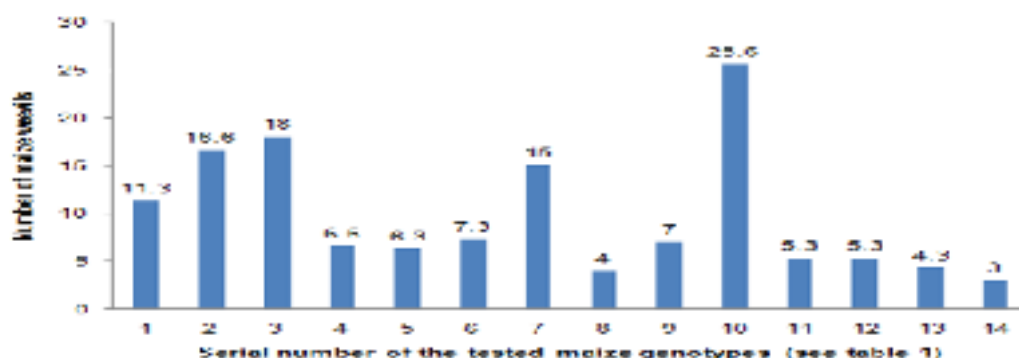


Figure 1. Number of weevils in non-preference test for 14 promising maize genotypes [(GM: 9.7, F-test: *, CV%: 74.2, LSD (0.05): 12.10]

The seven maize genotypes - Terai Pool Yellow, S99TLYQB, Gulmi-2, Rampur SO3FO8, Rampur SO3FO6, Rampur SO3FO4 and Rampur SO3FO1 were the less damaged ones and can be recommended as weevil resistant maize to farmers. The five maize genotypes - Across 9942 X Ac.9944, HG-B, Resunga composite, P501SRCO/P502SRCO and HG-A were moderately damaged ones. The genotype 'Rampur SO3FO4' was the least damaged one and the genotype 'RML4 X NML2' was the most damaged one. Rampur SO3FO1 showed the highest non-preference resistance whereas RML4 X NML2 showed the highest susceptibility response to maize weevil.

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Performance Stability of Promising Wheat Genotypes under Timely Sown Irrigated Conditions for Terai, Tar and Lower Valley of Nepal

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ABSTRACT

Wheat (*Triticum aestivum* L.) is the third most important cereal crop after rice and maize in Nepal. Out of total wheat growing area (731,131 ha) and production (1,556,539 metric tons) of the country 58% area and 71% production is occupied by terai region. In terai, 75% wheat is grown under fully or partially irrigated conditions. This is the major wheat growing domain in which cultivation of wheat is done under well managed conditions. In order to develop stable wheat varieties with high yield potential and resistance to major diseases multi-location replicated testing of promising wheat genotypes under coordinated varietal trials was performed during 2008/09 and 2009/10, respectively. Field experiments were managed according to recommended practices for wheat in alpha lattice design and Cropstat 7.2 and Excel were used for data analysis. In coordinated varietal trial (2008/09), genotypes BL3348 (3084 kg/ha), BL3401 (3050 kg/ha), BL3128 (2984 kg/ha), BL3555 (2951 kg/ha), BL3623 (2948 kg/ha) and in (2009/10) genotypes BL3623 (3399 kg/ha), BL3555 (3187 kg/ha) were observed superior than the Bhrikuti, Gautam and RR21 Checks. Genotype BL3623 was promoted to coordinated farmers' field trial and participatory variety selection. Genotype BL3623 observed most promising for this environment. Stability analysis for grain yield was performed according to regression coefficient (bi). Results revealed that the genotype BL3623 performed very well and remained stable across terai region. Present finding will help to increase wheat production, productivity and ultimately improves food security of the nation.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the third most important cereal crop after rice and maize in the country. It has 731,131 ha area, 1,556,539 tons production and 2.129 tons/ha average productivity (Krishi Diary 2068). Terai represents about 424,056 hectares of major wheat area (58%) with the production of 1,105,143 tons of wheat and contributes about 71% of total wheat production in the country. In terai, 75% wheat is grown under fully or partially irrigated conditions. This is the major wheat growing domain in which cultivation of wheat is done in well managed conditions. Wheat varieties currently available for terai and river basin areas are Nepal 297 (released in 1985), BL1022 (1991), Bhrikuti (1994), BL1473 (1999), Gautam (2004), Aditya (2009) and NL971 (2009). Among these, Nepal 297 is still popular variety in the country and has become susceptible to new biotypes of leaf rust. Bhrikuti possesses durable resistant to leaf rust and moderately susceptible to foliar blight (Bhatta 1997 and 1999, Pokhrel and Bhatta 2000). It is popular especially in western terai, Bara and Parsa districts. It has sterility problem in eastern terai and in Chitwan valley. BL1473 is widely adapted throughout terai and mid hills. It has also become susceptible to yellow rust in the hills (personal observations in Kathmandu, Pyuthan and Dailekh, 2007). However, it is still resistant to leaf rust and safe to grow in terai areas. BL1473 is suitable for eastern terai, where sterility is a problem. Gautam has resistance to both leaf rust, yellow rust and foliar blight diseases.

Therefore, new varieties with high yield potential and resistant to major diseases are needed to replace old varieties to increase the production and maintain the present productivity level. The major objective of this project is to develop wheat varieties with high yield potential, resistant to major diseases, bold and amber grains, high protein content and suitable under rice-wheat system.

The per capita wheat consumption has increased from 17.4 kg in 1972 (when the National Wheat Research Program was established) to 60 kg in 2009. Wheat is consumed in the form of chapatti, bread, noodles, biscuits, cookies and other products (Annual Report 2009-10). BL3623 has been identified as a most promising genotype for this environment.

MATERIALS AND METHODS

Evaluation and selection of local and exotic germplasms from various nurseries and their use in hybridization/crossing between selected parents is a routine work of National Wheat Research Program (NWRP) breeding program. Selected genotypes are tested in various nurseries, initial evaluation trial (IYT), coordinated varietal trial (CVT) and farmer's field trial (FFT) for variety development. On-station experiments on CVT were conducted across terai namely: Bhairahawa, Hardinath, Parwanipur, Surkhet, Tarahara and Nepalganj in Alpha-Lattice Design during 2008/09 and 2009/10 winter season (November to March). This experiment consisted of twenty genotypes each year including three checks: Gautam, Bhrikuti and RR21. However, in two consecutive years five genotypes (2 promising and 3 checks) were common, hence stability adaptation analysis was performed of those 5 genotypes. Each experimental plot of 10.0 m² (4 m x 2.5 m) was seeded at the standard seed rate of 120 kg/ha and net area harvested was 8.0 m² (4.0 m x 2.0 m). The space between rows was 25 cm and continuous seeding on line, respectively. Fertilizers were applied at the rate of 100: 50:25 kg NPK/ha. Half dose of N, full dose of P and K was applied basally, remaining half N was applied as top dressing at the time of crown root initiation stage after irrigation. The plots were kept free of weeds either manually or by using herbicides. Traits of each plot were recorded for: days to 50% heading and maturity, plant height in cm (mean of 5 plants in each plot), number of spikes/m², number of grains /spike, 1000 kernel weight (TKW) in gram and grain yield gram/plot later converted to kg/ha at 15% moisture content.

Stability and adaptability of grain yield was determined using the observed means in a two- way genotype-environment table (Petersen 1989). The statistics used to assess the stability and adaptability of genotypic characters were genotypic co-efficient of variation (CV) (Francis and Kennenberg 1987), regression coefficient (bi) (Eberhart and Russell 1966), deviation from regression mean square (SEm) and coefficient of determination (Ri²). The genotype is considered stable if bi value is equal or close to 1.00 (Eberhart and Russell 1966). Wheat genotypes possessing bi value >1.00 show adaptability in high yielding environments and genotypes having bi values <1.00 exhibit adaptability in low yielding environments (Finlay and Wilkinson 1963). The genotype is considered more stable that has bi value equal or very close to 1.00 and minimizes rest of the statistics except Ri² which ranges from zero to 1.00 and its high value determines the stability of a genotype (Petersen 1989). Analysis for grain yield and other variables were carried out using CROPSTAT 7.2 and Excel program.

RESULTS AND DISCUSSION

During 2008/09 the genotype BL3399 was the earliest (107 days after seeding, DAS) for maturity followed by BL3623, BL3063, and BL3625 (108 DAS). The genotype BL3063 produced highest 1000 grain weight (51 g) followed by BL3623, BL3218 and BL3539 (49 g). The genotype BL3348

produced the highest (3048 kg/ha) grain yield followed by BL3401 (3050 kg/ha) and BL 3128 (2984 kg/ha), respectively (Table 1).

Table 1. Summary of means of variables across 5 locations (Bhairahawa, Hardinath, Parwanipur, Nepalganj and Tarahara) during 2008/2009

Genotypes	DH	DM	PH	SM	GS	TGW	GY
BL 3063	66	108	92	262	33	51	2896
BL 3064	68	110	94	260	35	48	2831
BL 3128	80	116	99	233	40	45	2984
BL 3218	74	111	100	219	37	49	2907
BL 3278	71	110	92	251	42	43	2926
BL 3399	68	107	92	248	39	42	2797
BL 3348	72	109	88	235	39	46	3084
BL 3401	71	109	88	249	40	44	3050
BL 3404	75	112	80	250	40	39	2880
BL 3539	77	113	95	232	40	49	2723
BL 3555	69	109	86	259	38	48	2951
BL 3623	68	108	83	214	39	49	2946
BL 3625	67	108	81	194	40	49	2478
BL 3943	77	114	80	267	41	42	2825
BL 1012	79	114	82	256	40	41	2808
NL 1013	68	109	87	236	38	43	2491
NL 1042	73	112	89	240	43	40	2902
Gautam	70	111	86	200	43	46	2685
Bhrikuti	70	110	80	252	39	41	2783
RR 21	67	110	90	252	35	45	2289
Mean	72	110	88	240	39	45	2812
Genotypes (G)	**	**	**	**	**	**	**
Environments (E)	**	**	ns	*	ns	**	**
G x E	**	**	**	**	**	**	**
CV%	2	2	8	21	10	3.7	14
LSD	2	2	9	65	10	3	790

1000 grain weight is the mean of 3 locations only: Bhairahawa, Nepalganj and Parwanipur; DH, days to 50% heading; DM, days to 50% maturity; PH, plant height (cm); SM = spikes/m² (number); GS, grains/spike (number); TGW, thousand grain weight (TGW, gm); GY, grain yield (kg^{-ha}); *, significant; **, highly significant; ns, not significant

During 2009/10 the genotype BL3623 was the earliest (114 DAS) for maturity followed by NL1042, NL1050 and RR21 (115 DAS), respectively. BL3623 produced the highest 1000 grain weight (47 g) followed by BL 3555 (46 g), respectively (Table 2).

Genotypes (G), Environments (E) and G x E interactions for grain yield were highly significant for both two years (Table 1 and 2). Genotype x environment interaction as such do not provide the individual genotypic behavior, thus regression analysis using Eberhart and Russell's (1966) model was needed to be accomplished so as to ascertain stability and adaptability of varieties (Shah et al 2009). The bi values (Table 3) indicated a range of stability among wheat genotypes for grain yield.

In the present studies BL3623 showed highest mean grain yield (3197 kg/ha) and lowest SE m (328 kg/ha) among the tested genotypes. It has highest positive phenotypic index (Pi) value 212 followed by BL3555. BL3623 also has lowest CV% after BL3555. BL3623 and Gautam have highest coefficient of determination (R²) 92% among the tested genotypes (Table 3). Genotypes BL3623 and BL3555 showed bi nearly 1 and genotypic mean is > grand mean exhibit "average stability" i.e., well adapted to all environments. Gautam, a popular check variety, has bi >1, it is specifically adapted to high yielding environments. (Fig. 1 and Table 3).

Table 2. Summary of means of variables across 5 locations (Bhairahawa, Hardinath, Parwanipur, Surkhet and Tarahara) during 2009/2010

Genotypes	DH	DM	PH	SM	GS	TGW	GY
BL 3404	85	118	81	242	48	40	2743
BL 3555	82	117	85	234	44	46	3187
BL 3623	80	114	87	228	50	47	3399
NL 1013	83	117	91	211	39	41	2617
NL 1042	80	115	92	223	53	39	2876
BL 3819	86	119	93	221	44	44	2976
NL 1023	80	117	84	227	46	40	2866
NL 1026	79	116	89	204	48	40	2582
NL 1041	83	117	86	236	49	38	2503
NL 1044	86	119	86	223	48	37	2113
NL 1046	87	119	91	225	50	39	2641
NL 1049	86	119	85	221	47	39	2606
NL 1050	80	115	85	217	47	38	2556
NL 1053	83	118	90	229	46	36	2695
NL 1054	84	118	86	225	47	36	2789
NL 1067	84	119	90	233	47	42	2744
NL 1073	79	116	83	234	48	39	2753
Gautam	81	119	94	222	48	41	3079
Brikuti	84	118	85	227	50	39	3111
RR 21	79	115	92	218	42	39	2269
Mean	82	117	88	225	47	40	2755
Genotypes (G)	**	**	**	**	**	**	**
Environments (E)	**	**	ns	ns	**	ns	**
G x E	**	**	**	ns	**	**	**
CV%	1.8	0.8	4.8	13.1	10.3	5.3	13.7
LSD	3	2	8	59	10	4	755

1000 grain weight is the mean of 3 locations only: Bhairahawa, Nepalganj and Parwanipur; DH, days to 50% heading; DM, days to 50% maturity; PH, plant height (cm); SM = spikes/m² (number); GS, grains/spike (number); TGW, thousand grain weight (TGW, gm); GY, grain yield (kg^{-ha}); **, highly significant; ns, not significant

Table 3. Mean grain yield and estimate of stability parameters in wheat genotypes

Genotypes	Mean ± SE m	Phenotypic index	CV %	R ²	bi
BL 3623	3197 ± 328	212	33.8	0.92	1.02
BL 3555	3090 ± 461	105	32.9	0.83	0.98
Bhrikuti	2967 ± 468	-18	34.7	0.84	1.03
Gautam	2909 ± 356	-76	40.0	0.92	1.13
BL 3404	2763 ± 549	-222	35.8	0.71	0.82

From this study we can conclude that the genotype BL3623 is the most promising and adapted to all environments (rich and poor) for timely-sown irrigated conditions of terai Tar and lower valley of Nepal.

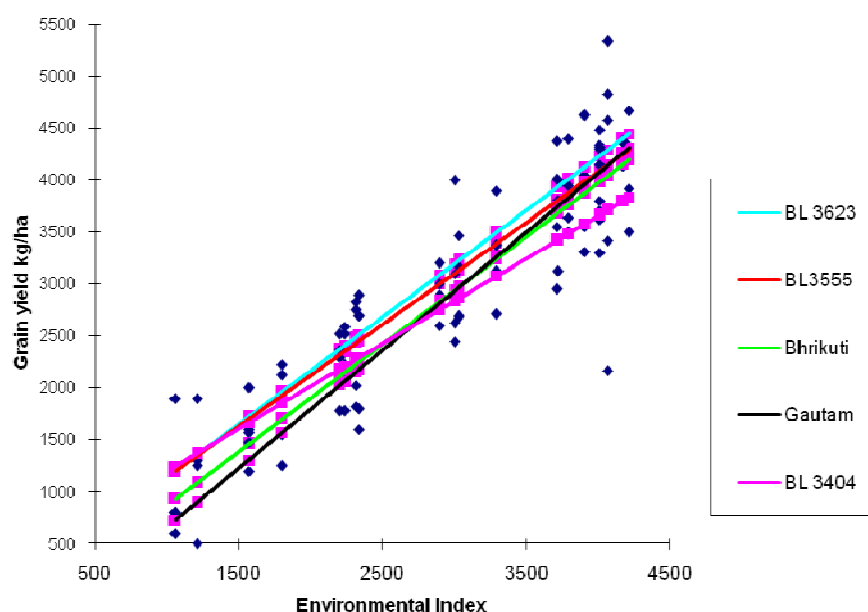


Fig. 1: Patterns of grain yield stability of wheat genotypes in CVT TS/I across 10 environments of Nepal.

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Varietal Performance of Phaseolous bean in Jumla

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ABSTRACT

Bean is an indigenous crop of Jumla. In order to identify and generate high yielding varieties, Agriculture Research Station, Vijayanagar, Jumla had carried out varietal trials on bean during the years 2067/068 and 2068/2069. The study revealed that parameters like 75% maturity days, plant height, pods/plant, 100 grain weight were found significantly different at $p < 0.01$, while days to 50% flowering and yield parameters were found insignificant in 067/068. In 068/069, the parameters such as 75% maturity, plant height, pods number, grain weight were found significantly different at $p < 0.01$ while yield parameters were insignificant. The difference in yield due to genotypes was found insignificant in both the years. Despite insignificant performance in yield, the genotype PB-0001 found superior in 067/068 producing 2500 kg/ha grain yield followed by KBL-1 (2171.00 kg/ha) and KBL-3 (2064.20 kg/ha), respectively. Similarly, during 068/069, the genotype KBL-3 recorded highest mean grain yield (2466.20 kg/ha) followed by PB-0001 (1832.80 kg/ha) and PB-0048 (1780.80 kg/ha), respectively. The two years mean yield was highest from KBL-3 which recorded 2265.20 kg/ha followed by PB-0001 and KBL-1 which obtained 2166.30 and 1922.60 kg/ha, respectively.

INTRODUCTION

Jumla is a high hill and leading district of Karnali zone of Nepal. It is also a food deficit district. The major crops grown here are rice, maize, finger millet, barley, wheat and bean. Buckwheat, prosomillet, foxtail millet, naked barley, amaranths are also grown as minor crops. Bean in Jumla is mostly consumed as a thick soup (*Dal*). Guests are also served with this thick soup. It is also mixed and boiled with leg pieces of male goats, and the soup is eaten as nutritive diet. It is also consumed in the form of boiled beans, mixed and boiled with maize (locally known as *Kol*). Jumli bean is also taken as gift of Jumla. The dried and broken stem after threshing is called *Kunauro* which is used as fodder for sheep and goat.

Bean (*Phaseolous vulgaris*) is an indigenous pulse crop of Jumla and Karnali zone as a whole. It is a highly diversified crop of high hill area like Jumla and can tolerate drought conditions, too. The major part of bean area is mostly under upland conditions near forest. The area of bean has not been included in statistical data of the country; however, District Development Committee (DDC) of Jumla (2066) has reported its area as 467.01 ha in the district. But the area has been assumed to be more than reported by the DDC. District Agriculture Development Office (DADO), Jumla (067/068) has reported the average yield of bean under irrigated conditions as 1100.00 kg/ha. It has been growing as cash crop now a day as its nutritional value has been well understood by the farmers. Farmers have started to cultivate some improved genotypes which are producing more than local genotypes. The low land area is also being used for bean cultivation due to its commercial scope. It is grown in rainy season in Jumla while in terai area it is a winter season crop. It is grown after wheat. It is also grown with maize and potato.

It fetches good price (up to Rs. 150/kg) and thus increase farm income of all categories of farmers in the region. This income can be utilized to buy rice and other necessary items thus upgrading living standard of the farmers.

Agriculture Research Station (ARS), Vijayanagar, Jumla, situated at 2290 masl, has been carrying out varietal trials on bean to identify high yielding, disease and insect resistant genotypes suitable for high hill region like Jumla.

MATERIALS AND METHODS

During the summer season of the fiscal year 2067/068 and 068/069, ARS, Vijayanagar had conducted on-station varietal trials on bean. Six genotypes, PB-0001, PB-0002, PB-0048, KBL (Karnali Bean Line) -1, KBL-2 and KBL-3 were included in the trials. The experiments were laid out in randomized complete block design (RCBD) in five replications. Plot area allocated for each entry was 12m² and fertilizers were applied at the rate of 100:60:40 kg N: P₂O₅:K₂O/ha. The full dose of phosphorous and potash with half dose of nitrogen was applied as basal dose and remaining half dose of nitrogen was top-dressed. Seeding was done during 2nd and 3rd week of Ashad. Irrigation and intercultural operation was carried out as per need and recommendation for the bean cultivation.

Parameters: 50% flowering days, 75% maturity days, plant height (cm), number of pods/plant, number of seeds/pod, 100 grain weight (gm) and yield (kg/ha) were observed for both the years. The observed data were analyzed using MSTAT C package of statistics.

RESULTS AND DISCUSSION

Crop production was normal during 067/068 while it was affected by heavy rain fall during 068/069. All the parameters recorded in the 2067/068 trial were significantly different at p<0.01 level, except 50 per cent flowering days and yield of the crop (Table 1).

Table 1. Yield performance of bean in Jumla Selection Varietal Trial, 067/068

Genotypes	50% flowering days	75% maturity days	Plant height (cm)	Pods/plant	Seeds/pod	100 grain weight (gm)	Yield (kg/ha)	Remarks
PB-0001	51.20	94.40 ^B	61.00 ^B	20.80 ^{AB}	4.20 ^{BC}	42.64 ^A	2499.80	I
PB-0002	55.40	95.60 ^B	96.80 ^A	17.20 ^B	5.40 ^{AB}	33.64 ^B	1722.00	
PB-0048	52.40	96.20 ^B	90.40 ^A	14.60 ^B	4.00 ^C	44.52 ^A	1966.80	
KBL-1	55.00	96.20 ^B	100.60 ^A	21.00 ^{AB}	5.40 ^{AB}	25.88 ^C	2171.00	II
KBL-2	54.40	92.40 ^B	94.60 ^A	19.40 ^{AB}	6.20 ^A	22.58 ^C	1950.60	
KBL-3	55.20	102.40 ^A	107.20 ^A	24.80 ^A	4.60 ^{BC}	25.76 ^C	2064.20	III
F test	Ns	**	**	**	**	**	ns	
CV %	4.48	2.49	9.51	16.70	13.05	9.50	29.19	
LSD (0.01)	-	4.308	15.70	5.90	1.166	5.558	-	

**, highly significant; ns, not significant; Means followed by the same letter in the column are not significantly different.

The genotype PB-0001 was most early (51 days) for 50 per cent flowering, and the genotype PB-0002 was most late (55 days) as compared to other genotypes tested. Similarly, the genotype KBL-2 was found most early for 75% maturity (92 days), and the genotype KBL-3 was the most late (102 days). Similarly, KBL-3 had the highest plant height (107.20 cm) and the PB-0001 had the shortest (61.00 cm) among the genotypes. KBL-3 produced highest number of pods/plant (24.80) and PB-0048 produced the lowest number (15). KBL-2 produced highest number of seeds/pod (6.20), while PB-

0048 produced the lowest number (4.00). However, PB-0048 produced the highest 100 grain weight (44.52 gm) while KBL-2 had the lowest weight (22.58 gm) (Table 1). Despite the insignificant difference in yield, the genotype PB-0001 gave higher grain yield (2499.80 kg/ha) followed by KBL-1 (2171.00 kg/ha) and KBL-3 (2064.20 kg/ha), respectively (Figure 1). The genotype PB-0002 was lowest grain yielder (1722.00 kg/ha).

During the year 068/069, parameters: 50% flowering days, 75% maturity days, plant height, pods/plant, seeds/pod and 100 grain weight were found significantly different at $p < 0.01$ level, while the difference in yield due to genotypes was found insignificant (Table 2). The genotype KBL-3 was most late in 50% flowering (55 days), 75% maturity (105 days), attained highest plant height (197.20 cm) and produced highest number of pods/plant (26.60) among the entries. In contrast, the genotype PB-0001 was earliest in 50% flowering (48 days), attained shortest plant height (42.40 cm), and produced lowest number of pods/plant (14.60) and lowest number of seeds per pod (4.20).

Table 2. Yield performance of bean in Jumla Selection Varietal Trial, 068/069

Genotypes	50% flowering days	75% maturity days	Plant height (gm)	Pods/plant	Seeds/pod	100 grain weight (gm)	Yield (kg/ha)	Remarks
PB-0001	48.00 ^C	99.20 ^B	42.40 ^C	14.60 ^B	4.20 ^C	41.00 ^B	1832.80	II
PB-0002	53.20 ^{AB}	100.60 ^B	180.00 ^A	22.20 ^{AB}	5.60 ^B	34.20 ^C	1758.80	
PB-0048	47.20 ^C	99.00 ^B	130.00 ^B	18.80 ^{AB}	4.40 ^C	48.40 ^A	1780.80	III
KBL-1	54.00 ^{AB}	100.60 ^B	195.60 ^A	24.00 ^{AB}	6.20 ^B	21.20 ^E	1674.20	
KBL-2	52.40 ^B	102.20 ^{AB}	151.60 ^B	26.40 ^A	7.40 ^A	22.40 ^E	1726.80	
KBL-3	54.80 ^A	105.00 ^A	197.20 ^A	26.60 ^A	5.40 ^B	27.60 ^D	2466.20	I
F test	**	**	**	**	**	**	Ns	
CV %	2.39	2.10	10.11	23.69	9.27	4.64	26.14	
LSD (0.01)	2.219	3.82	27.18	9.42	0.9229	2.711	-	

**, highly significant; Means followed by the same letter in the column are not significantly different.

Despite insignificant difference in yield, the genotype KBL-3 gave higher yield (2466.20 kg/ha) followed by PB-0001 (1832.80 kg/ha) and PB-0048 (1780.80 kg/ha), respectively (Figure 2).

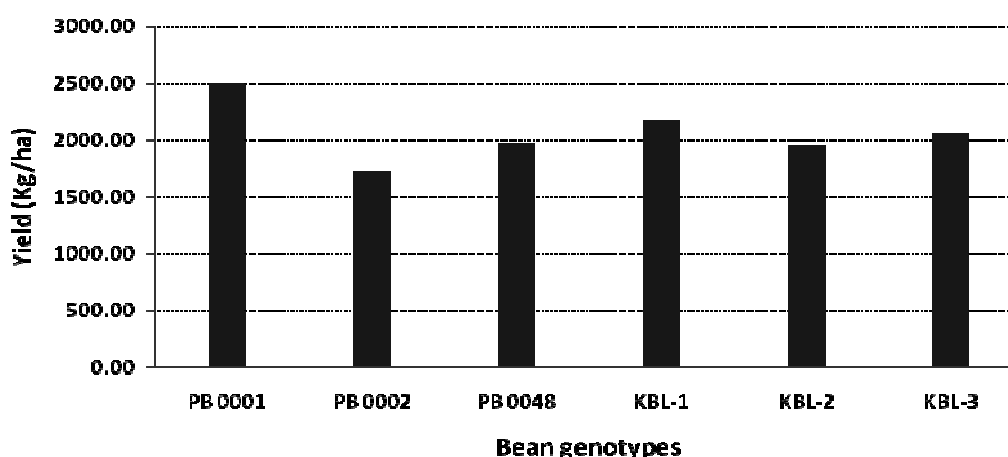


Figure 1. Average yield of bean genotypes during 066/067

Two years' pooled data analysis indicated that genotype KBL-3 was found superior genotype producing highest average grain yield of two years (2265.20 kg/ha) followed by PB-0001 (2166.30 kg/ha) and KBL-1 (1922.60 kg/ha), respectively (Figure 3). Effect of years for parameters: 50% flowering days, 75% maturity days, plant height and seeds/pod was found significantly different while

parameters; pods/plant, 100 grain weight and yield were insignificant (Table 3). These insignificant parameters indicate the stability of the crop.

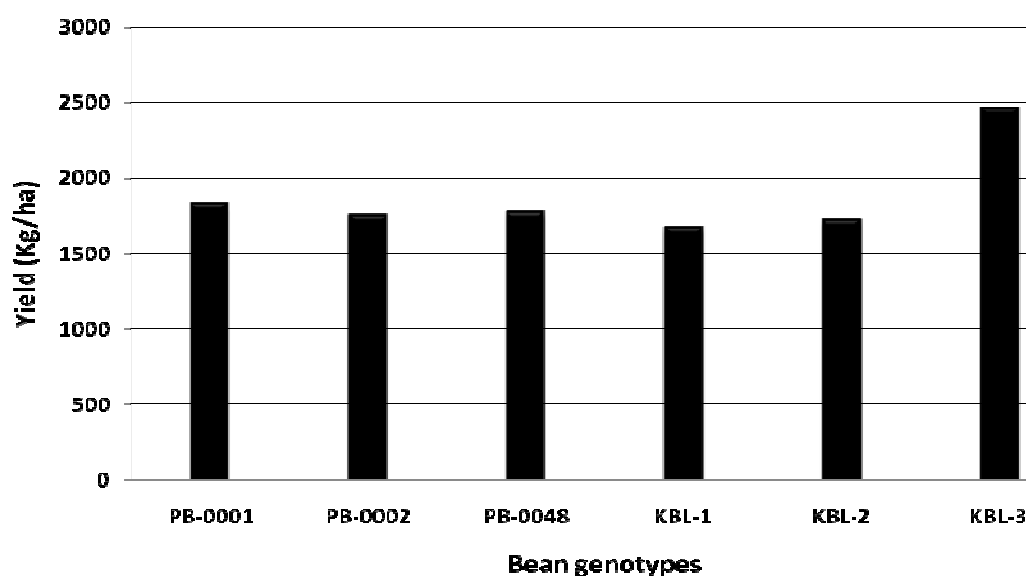


Figure 2. Average yield of bean genotypes during 068/069

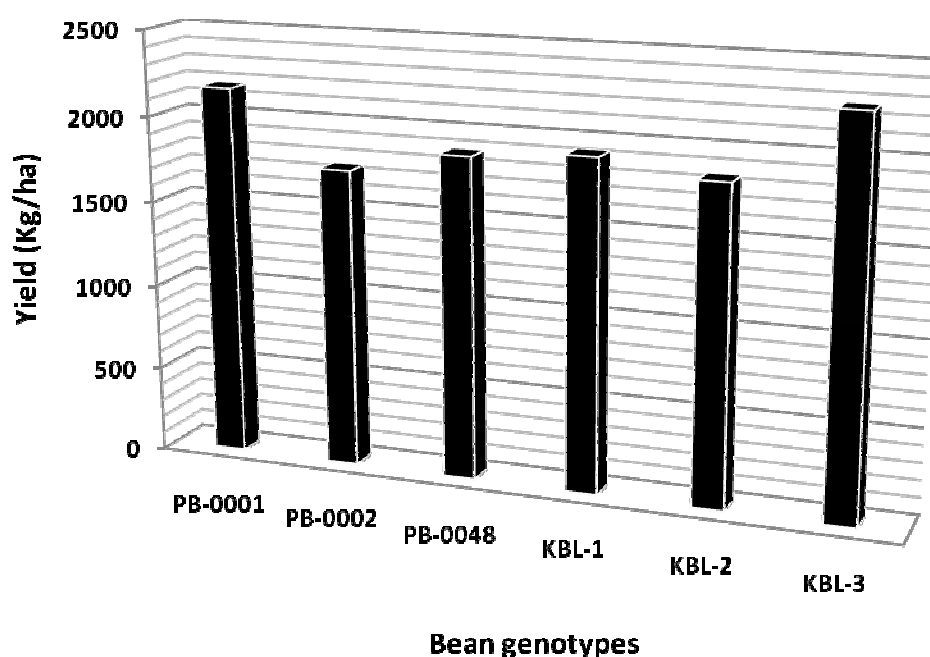


Figure 3. Average yield of bean genotypes of two years 067/068-068/069 (Pooled)

KBL-3, despite high yielding genotype, is a trailing type and can yield more if thatching is provided. All KBLs (Karnali Bean Lines) are trailing type. Genotype PB-0001 is suitable for both lowland and upland conditions. PB 0001 is non-trailing, suitable for intercrop with maize, apple orchard and also as sole crop. It is easy to thresh and can tolerate high rainfall as well. Farmers prefer PB-0001 and are

fetching good prices from bean (up to Rs. 150/kg). Bean can substantially contribute to increase farm income through selling in and out of the district because of its conversion from traditional crop to nutritive cash crop. NARC/WUPAP (Western Upland Poverty Alleviation Project) in joint funding has provided bean mill for value addition of bean in Talium VDC (Outreach Research Site of ARS). It is under installation. After its operation, it will further encourage farmers to grow more beans, process for pulse (*Dal*) and sell in the market and ultimately increase farm income. The experiments need to be continued and find out more KBLs.

Table 3. Yield performance of bean in Jumla Selection Varietal Trial, 067/068-068/069 (Pooled)

Genotypes	50% flowering days	75% maturity days	Plant height (cm)	Pods/plant	Seeds/pod	100 grain weight (gm)	Yield (kg/ha)	Remarks
PB-0001	49.60	96.80	51.70	17.70	4.20	41.82	2166.30	II
PB-0002	54.30	98.10	138.40	19.70	5.50	33.92	1740.40	
PB-0048	49.80	97.60	110.20	17.70	4.20	46.46	1873.80	
KBL-1	54.50	98.40	148.10	22.50	5.80	23.54	1922.60	III
KBL-2	53.40	97.30	123.10	22.90	6.80	22.49	1838.70	
KBL-3	55.00	103.70	152.20	25.70	5.00	26.68	2265.20	I
F test:								
Year (Y)	**	**	**	ns	**	ns	ns	
Factors (A)	**	**	**	**	**	**	ns	
Y x A	Ns	**	**	*	ns	**	ns	
CV %	3.64	2.29	10.23	20.93	11.13	7.48	27.89	

**, highly significant; ns, not significant

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Jute Seed Production in Mixed Cropping

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ABSTRACT

Jute (*Corchorus* spp.) is mainly grown in eastern terai of Nepal. The area, production and productivity of jute are more or less stagnant for last several years. The sole cropping of jute now considered as almost non-profitable and non-competable enterprise with other crops and only done in small scale for household consumption. So a study was conducted at Jute Research Program, Itahari during 2009/10 in randomized complete block design with seven treatments in three replications to know the most economical cropping system. Jute, sesame, niger and sunhemp were planted @ 6 kg/ha for each in mono and mixed cropping in 1:1 ratio. Jute genotype used in the experiment was JRO 524. Among the mono cropping, niger produced the maximum yield of 1350 kg/ha followed by jute only that produced 550 kg/ha. The cost-benefit ratio of niger mono crop was 0.31. Among the mixed cropping, the most profitable combination was jute and niger with cost-benefit ratio of 0.64 followed by jute and sesame of 0.65. Sunhemp sole gave the poorest performance with cost-benefit ratio of 1:55 followed by mixed with jute giving the ratio of 0.71.

INTRODUCTION

Jute (*Corchorus* spp.) mainly grown in eastern terai of Nepal. The area, production and productivity of jute remain more or less stagnant for last several years. The sole cropping of jute now considered as almost non-profitable and non-compatible enterprise with other crops. Productivity is low in marginal land due to low management practices compared to other competitive crops in the season. Jute cultivation becomes non-profitable due to high cost of cultivation in weeding and sole cropping practice. Manipulation in cultivation practices i.e. mix cropping has to be evaluated to reduce the cost of cultivation and raise the net income per unit area.

MATERIALS AND METHODS

The experiment was conducted at Jute Research Program, Itahari during the summer season of 2009/10 in RCBD with seven treatments and each treatment replicated thrice in plot size of 12 m² (3m x 4m) having the spacing row to row 25 cm and plant to plant continuous. Thinning was done to maintain plant population. Jute, sesame, niger and sunhemp were planted at the rate of 6.0 kg/ha for each in mono-cropping while in accordance with ratio in mix-cropping. Chemical fertilizer was applied @ 40:20:40; N: P₂O₅: K₂O kg/ha in which nitrogenous fertilizer was used in a split dose i.e. 50% as a basal dose with full dose of phosphatic and potassium fertilizer whereas remaining dose of nitrogenous fertilizer utilized in top dressing. Jute genotype used in the experiment was JRO-524. All the agronomic practices were provided for better growth of the crop. Seed yield, expenses, benefit, net-benefit and cost benefit ratio were recorded.

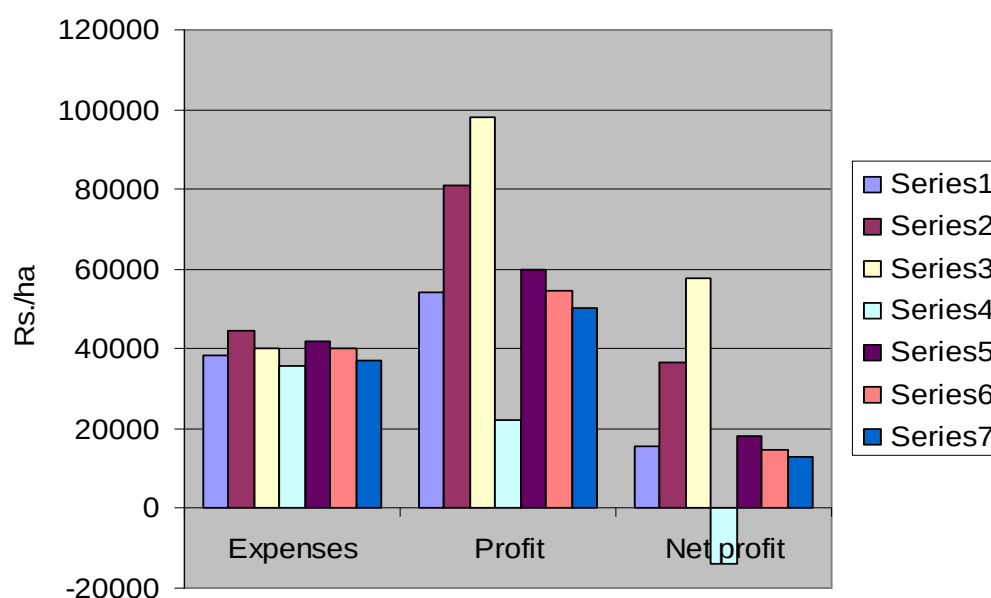
RESULTS AND DISCUSSION

Table 1 showed that niger produced the maximum yield (1350 kg/ha) in mono-planting followed by sesame (850 kg/ha) under the same conditions and also cost-benefit ratio 1.55 for sole cropping of sunhemp, which shows that mono-planting of sun hemp is not profitable.

Table 1. Seed yield of different crops either in combined or sole, JRP, Itahari, 2009/010

Treatment	Seed yield (kg/ha)			Cost-benefit Ratio
	Jute	Other crops	Mixed	
Jute sole	550	-	550	0.7
Sesame sole	-	850	850	0.5
Niger sole	-	1350	1350	0.31
Sunhemp sole	-	350	350	1.55
Jute + Sesame (1:1)	350	260	610	0.65
Jute + Niger (1:1)	450	230	680	0.64
Jute + Sunhemp (1:1)	350	300	650	0.71

The cost of cultivation was highest (Rs. 30520/ha) for sesame as mono crop. Production was converted in terms of money based on market price @ Rs. 90, 90, 70 and 60/kg for jute, sesame, niger and sunhemp, respectively to calculate the profit, net profit and cost-benefit ratio. Fig. 1 revealed that planting of niger under mono-conditions followed by sesame under same condition was most profitable. It also indicates that mix planting of jute with niger (1:1) ratio is better than solo cropping of jute in earning.

**Fig 1. Expenses, profit and net profit per hectare either of combined or sole crops conducted at JRP, Itahari during the F.Y. 2009/10**

In brief, planting of niger and sesame under mono-condition could be recommended to get more return. Jute cultivation for seed purpose can be recommended in mixing with niger in 1:1 ratio to earn more money.

Effect of Planting Time on Jute Seed Yield

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ABSTRACT

A study was conducted at Jute Research Program, Itahari during 2009/10 to find out the most suitable and profitable date of sowing of jute. Three jute varieties: Itahari 1, Itahari 2 and JRO 524 were planted on six dates: May 29, June 16, June 30, July 18, July 31, August 15 of 2010 in randomized complete block design in three replications. The study revealed that highest seed yield of 900 kg/ha, 700 kg/ha and 933 kg/ha were recorded on May 29 by the varieties: Itahari 1, Itahari 2 and JRO 524, respectively. The significant differences were observed among the agronomic traits like plant height, branch per plant and pod per plant for all the tested varieties in respect to date of sowing. Significant difference in the seed yield was also observed among the varieties. The interaction between date of planting and jute varieties was highly significant for branch per plant and pod per plant. Plant height of all the varieties in the experiment was drastically reduced on August 15 sowing.

INTRODUCTION

Jute is mainly grown in rainfed upland of eastern terai region of Nepal, especially in Jhapa, Morang, Sunsari, Siraha, Saptari and Udaypur districts. The crop well fits in existing cropping system without hampering main food grain crop, especially rice and wheat. It adds organic matter to soil and beneficial to succeeding crops. The time of sowing is the most important one, among the various constraints to higher and stable yields of the crop.

MATERIALS AND METHODS

The experiment was conducted at Jute Research Program, Itahari during the F.Y. 2009/10 in split-plot design with dates of planting as main plots whereas jute varieties as sub-plots. Jute varieties included in the trial were Itahari 1, Itahari 2 and JRO 524 and were planted on six dates (May 29, June 16, June 30, July 18, July 31 and August 15) and each variety was replicated thrice. The plot size was 12 m² with the row spacing of 30 cms and plant to plant continuous. Thinning was done to maintain the plant population. JRO 524 and Itahari 2 was planted with the seed rate of 4 kg/ha while Itahari 1 at the rate of 6 kg/ha. Chemical fertilizers were applied @ 40:40:40; N: P₂O₅: K₂O kg/ha in which whole dose of phosphatic and potassium fertilizer with 50% dose of nitrogenous fertilizer as a basal dose while remaining nitrogen fertilizer was applied as top-dress. All the agronomic practices were provided as per need for better growth of the plant. Various observations such as plant height, branch per plant, pod per plant and seed yield were recorded for the rating of each treatment.

RESULTS AND DISCUSSION

The results are presented in table 1. All the Jute varieties, Itahari 1, Itahari 2 and JRO 524 produced the highest seed yield of 900, 700 and 933 kg/ha separately as well as 844 kg/ha when combined with significant, non-significant, highly significant and highly significant difference among the treatments respectively planted in the first date i.e. May 29, 2009. It also revealed that there is highly

significant difference among the agronomic traits like plant height, branch per plant and pod per plant for all the varieties and combined analysis in respect to date of planting. Significant difference in the seed yield was also observed among the varieties. Highly significant difference among the treatments in the branch per plant and pod per plant were found in the interaction between date of planting and Jute varieties. Plant height of all used varieties in the experiment was reduced in the sixth date of planting (August 15).

Table 1. Mean performance of Jute varieties with respect to planting dates planted at Jute Research Program, Itahari, 2010

Date	Itahari-1				Itahari-2			
	Yield (kg/ha)	Plant ht. (cm)	Branch / plant	Pods/ plant	Yield kg/ha	Plant ht. (cm)	Branch / plant	Pods/ plant
May 29	900	225	4.6	75.0	700	160	2.2	14.0
June 16	470	190	5.2	33.0	560	150	2.0	11.0
June 30	670	120	2.3	21.0	440	120	1.8	8.5
July 18	610	115	3.2	12.0	480	120	2.1	14.0
July 31	705	130	2.5	19.0	550	135	2.1	10.0
August 15	495	85	2.4	8.0	450	52	1.7	7.0
F test								
Factor A	*	**	**	**	ns	**	**	**
Factor B								
A x B								
CV %	20.1	16.6	20.5	12.3	33.0	21.5	13.4	18.8
LSD 0.05	229.3	43.7	1.5	16.8	120.1	57.1	0.58	3.2

Table 1. contd.....

Date	JRO 524				Combined			
	Yield (kg/ha)	Plant ht. (cm)	Branch / plant	Pods/ plant	Yield (kg/ha)	Plant ht. (cm)	Branch / plant	Pods/ plant
May 29	933	260	2.4	9.4	844	228	3.0	30.5
June 16	650	170	2.4	7.6	560	173	3.0	14.6
June 30	690	125	2.0	7.7	550	120	2.0	11.0
July 18	550	125	2.1	9.1	535	118	2.4	10.3
July 31	600	135	2.0	6.9	655	117	2.5	11.6
August 15	400	50	1.7	4.7	405	60	2.0	5.9
F test								
Factor A	**	**	**	**	**	**	**	**
Factor B					*	ns	**	**
A x B					ns	ns	**	**
CV %	18.3	7.5	9.8	13.5	22.7	13.5	18.6	26.9
LSD 0.05	20.3	20.5	0.2	2.0				

*, significant; **, highly significant; ns, not significant

Planting of Jute variety Itahari 1 on May 29 and July 31; Itahari 2 on May 29 and JRO 524 on May 29, June 16, June 30 and July 31 date could be recommended for the purpose of seed production to obtain more yields.

Varietal Improvement of Jute (*Corchorus olitorius* and *Corchorus capsularis*)

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ABSTRACT

Jute (*Corchorus spp.*) is a major commercial crop grown in eastern terai of Nepal. Jute Research Program has released two varieties namely Itahari 1 (*C. capsularis*) and Itahari 2 (*C. olitorius*) in the year 1999. *C. olitorius* and *C. capsularis* are the two important commercial species grown in this region. The existing varieties have narrow genetic bases with low yield potentiality, low adaptability to changing macro agro-ecological conditions of the marginal lands and unsuited to current cropping patterns. There is utmost need of high yield varieties those can suit in different cropping patterns under different agro-ecological niches. Different varietal improvement works as germplasm collection and maintenance, hybridization, photo insensitivity screening nursery, initial evaluation trial, advance varietal trial and evaluation of genotypes for fast growth rate and fiber content were carried out in 2009/10 and 2010/11. Hundred and seven germplasms of *C. olitorius* and 80 germplasms of *C. capsularis* were collected and maintained.

INTRODUCTION

Jute (*Corchorus olitorius* and *Corchorus capsularis*) is a major commercial crop in eastern terai of Nepal. Tossa jute (*C. olitorius*) and Sada jute (*C. capsularis*) are the two important species grown in Nepal. A total of five varieties comprising of *C. olitorius* (JRO 632, JRO 524 and JRO 7835) and *C. capsularis* (JRC 212 and JRC 321) have been recommended for large scale cultivation. Jute Research Program (JRP) has released two varieties namely Itahari 1 (Sada jute) and Itahari 2 (Tossa jute) in the year 1999 these varieties are gaining popularity among the farmers. The yield potential of existing varieties is still low and JRP is working for more fiber yielding varieties for different environments. Varietal improvement work is a regular process to find out high yielding, good fiber quality and disease resistant/tolerant genotypes suitable for different production environment of the jute growing areas. Therefore, it is quite essential to develop high yielding, disease resistant, fast growing and photo-insensitive varieties that will be appropriate in prevailing cropping systems.

MATERIALS AND METHODS

Germplasm collection and maintenance

Local germplasm of jute were collected from different jute growing districts and they were regenerated in two-rows plots and characterized for further breeding program at JRP, Itahari during 2010/11. The existing germplasm (107 accessions of *C. olitorius* and 80 accessions of *C. capsularis*) were planted. All other cultural practices and plant protection measures were followed as per recommendation. The flowering date was recorded to match for crossing purpose.

Segregating population evaluation

The F₂ population obtained from the reciprocal crosses between JRO 524 and Itahari 2 were included in the experiment. Twenty lines including 30 plants per line at 3 meter width of each cross were planted and replicated three times. The six rows of the both parent lines were planted at every

replication as check plants to evaluate the performance of the segregating materials. Both qualitative and quantitative data were observed to evaluate the performance of the segregating population over parent materials.

Screening against photo insensitivity or other traits

A total of 58 entries were included in the experiment. Each genotype was planted in two rows of 2 m long with 25 cm row to row and 5 cm plant to plant spacing. The entries were planted in four different dates at 15 days interval. The first seeding was done on May 16, 2010 and the fourth seeding on April 29, 2010 in both the years. The parameters: days to first flowering and 50% flowering were recorded.

Initial evaluation trial (IET)

Initial evaluation trial was laid out in a randomized complete block design (RCBD) with three replications. The seeds of genotypes were sown on 28 Baisakh, 2067 and harvested on Bhadra 24, 2067. The size of each plot was 3.0 m². The spacing was maintained at 25 cm row to row and 5 cm plant to plant. The parameters: incidence of plant diseases, plant height, basal diameter, total green weight, green ribbon weight and dry fiber weight were recorded to evaluate the performance of the tested genotypes.

Advanced varietal trial (AVT)

Advanced varietal trial was laid out in RCBD with three replications. The size of each plot was 3.0 m². The spacing between the rows and plants were maintained by 25 cm and 5 cm, respectively. The seeds of genotypes were sown on 28 Baisakh 2067 and harvested on 22 Bhadra, 2067. The parameters: incidence of plant disease, plant height, basal diameter, total green weight, green ribbon weight and dry fiber weight were recorded to evaluate the performance of the tested entries.

Evaluation of genotypes for fast growth rate

The trial was conducted in RCBD replicated thrice with a plot size of 4 m². The crop was sown at spacing of 25 cm row to row with continuous plant to plant. Thinning was done to adjust the plant population. Plant height and basal diameter were recorded at 60 and 90 days after sowing and ratio of increase in percent calculated.

Seed setting or seed yield evaluation

An experiment was carried out to evaluate performance of ten genotypes in RCBD and replicated thrice. The size of each plot was 1 m². The plant spacing was 25 cm row to row and continuous sowing for plant to plant. Plant population was adjusted by thinning. All the agronomic practices provided for better growth of the crop. Parameters: first date of flowering, uniform flowering and seed setting after 60 days of first flowering were recorded.

RESULTS AND DISCUSSION

Segregating population evaluation

Although the observed characters were found intermediate between parents and off-spring, the diameter of the base, petiole length, thickness of the green ribbon and total mass of the 10 plants were found significantly different between the parents and off-springs.

Table 1. Performance of segregating population over parent lines

Parent/ Progeny	Plant height, cm		Diameter, cm			Petiole length (cm)	Leaf size, cm		GRT (cm)	GRW (kg)	TGW (kg)
	Total	Tech.	Basal	Middle	Top		Breadth	Length			
JRO524 (Parent)	335.9	314.0	1.91	1.251	0.503	5.019	4.357	14.861	0.253	0.698	2.235
Itahari-2 (Parent)	356.7	332.5	1.79	0.980	0.687	4.152	5.725	15.352	0.197	1.091	3.328
JRO524/ Itahari-2	353.3	326.7	1.52	1.101	0.627	5.480	4.786	14.134	0.162	0.789	2.783
Itahari-2/ JRO524	341.6	327.3	1.83	1.921	0.412	4.521	4.912	13.751	0.155	0.906	2.352
F test	ns	ns	ns	*	ns	*	ns	ns	*	ns	*
CV %	4.54	6.40	4.80	6.19	10.44	5.61	5.26	7.12	7.57	24.55	14.27
LSD 5%				0.133		0.544			0.026		0.746

GRT, thickness of green ribbon (cm); GRW, green ribbon weight (kg of 10 plants); TGW, total green weight (kg of 10 plants); *, significant; ns, not significant

Screening against photo insensitivity or other traits

Among 58 entries, following genotypes were selected from the experiment for further evaluation of other traits, and these lines could also be utilized in developing converter lines for the development of photo-insensitive varieties of jute:

1	O-4	5	DS-058	9	IJO-TAN-x-003
2	SM-007	6	BL-106 G	10	KEN-DS-033
3	SM-024G	7	BJRI-1965G	11	JRO-40
4	SM-010	8	F-6 oli	12	BRO-SRB-076

Initial evaluation trial (IET)

The highest plant population was recorded in genotypes YA 041 (129 cm) followed by the genotypes Itahari 2 (123 cm). Similarly, the highest plant height in the genotypes YA 041 (347 cm) followed by JRO-3690 (347cm) and the highest basal diameter in IJO-CHN-FJ-050 (1.5 cm) followed by Itahari-2 (1.4 cm). These parameters play important role in production of fiber yield in jute. The genotypes JRO-3690 produced the highest dry fiber yield (3563 kg/ha) followed by IJO-CHN-FJ-050 (3540 kg/ha) and YA 041 (3451 kg/ha), respectively and were found statistically insignificant.

Table 2. Performance of elite genotypes of jute (*Corchorus olitorius*) in Initial Evaluation Trial during 2009/10

Entries	Plant population	Plant height (cm)	Basal diameter (cm)	Dry fiber yield (kg/ha)
SUR-SRB-027	116.6	344.6	1.36	2711
BRD-SRB-061	109.3	346.4	1.36	3140
BRD-SRB-076	112.6	283.1	1.26	3036
JRO-3690	117.3	346.7	1.26	3563
YA-041	128.6	347.2	1.31	3451
JRP Acc # 102	120.0	346.6	1.35	2800
YA – 023	93.6	315.4	1.16	3155
IJO-CHN-FJ-050	115.3	339.5	1.46	3540
Itahari-2	123.0	334.8	1.36	2913
JRO-524	106.0	342.9	1.33	3355
F test	ns	*	ns	ns
CV%	10.4	7.41	13.1	23.05
LSD		19.1		

*, significant; ns, not significant

Advanced varietal trial (AVT)

Table 3 reveals that there was insignificant difference in the fibre yield among the test genotypes. However, KEN-DS-066 produced the highest dry fiber yield (3854 kg/ha) followed by KEN-DS-058 (3762 kg/ha) and Itahari 2 (3321 kg/ha), respectively. The higher number of plant population was observed in KEN-DS-058 (134.6) followed by O-4 (132.6) and KEN-DS-066 (128.3), respectively. The higher number of plant height was recorded in the genotypes OM -1 (358 cm) followed by Itahari-2 (355 cm) and the higher basal diameter in the genotypes Itahari 2 (1.4 cm) followed by KEN-DS-058 (1.4 cm), respectively. But these performances were statistically insignificant.

Table 3. Performance of elite genotypes of jute (*Corchorus olitorius*) in advanced varietal trial during 2009/10

Entries	Plant population	Plant height (cm)	Basal diameter (cm)	Dry fiber yield (kg/ha)
KEN-DS-058	134.6	315	1.4	3762
KEN-DS-066	128.3	324	1.2	3854
F6 Oli	119.6	318	1.1	3167
BJRI-1965	119.6	342	1.1	3235
BJRI-1968	128.0	339	1.3	3053
O -4	132.6	308	1.3	2637
KEN-BL-130	122.0	312	1.2	2928
OM-1	117.0	358	1.3	2805
Itahari-2	121.0	355	1.5	3321
JRO-524	117.0	339	1.3	2909
F test	ns	ns	ns	ns
CV%	6.8	7.0	16.6	21.15
LSD				

ns, not significant

Evaluation of growth rate of genotypes

The fast growth rate (plant height and basal diameter) of the genotypes during the period of 60 to 90 days after seeding were considered to be the most important factors to contribute on fiber yield in Jute crop. In this experiment, these parameters were found insignificantly different. The genotype OM-1 had the highest plant height increase ratio (71.19%) followed by O-4 (69.57%) whereas the genotype BJRI-1968 (27.81% had highest basal diameter increase ratio followed by F6 Oli (26.22%).

Table 4. Growth rate of different genotypes during 2009/10

Entries	60 days after seeding		90 days after seeding		Percent increase	
	Plant height, cm	Basal diameter, cm	Plant height, cm	Basal diameter, cm	Plant height	Basal diameter
NPL-PACH-YPY-036	178.167	1.431	296.217	1.703	65.43	21.53
KEN-DS-066	182.987	1.360	295.467	1.603	61.70	24.22
F6 Oli	186.813	1.297	302.100	1.712	61.74	26.22
BJRI-1965	178.567	1.297	290.220	1.741	63.03	24.86
BJRI-1968	185.247	1.281	302.893	1.641	63.68	27.81
O-4	177.251	1.362	300.357	1.694	69.57	24.49
KEN-BL-130	178.833	1.380	264.633	1.553	48.74	21.89
OM-1	180.798	1.337	309.495	1.623	71.19	21.59
Itahari-2	182.867	1.541	307.033	1.653	66.62	21.34
JRO-524	176.347	1.532	293.567	1.623	65.83	18.52
F test	ns	ns	ns	ns		
CV%	3.85	5.99	8.09	7.36		

ns, not significant

Evaluation of seed setting or seed yield of genotypes

Table 5 reveals that first flowering and seed setting days of different genotypes. The genotype JRO-524 started flowering in 115 days followed by Itahari-2 in 117 days. These genotypes were early flowering genotypes. However, the flowering days were insignificant different among the genotypes. Seed setting was observed lowest in these genotypes after 60 days of first flowering. First flowering and seed setting after 60 days of first flowering ranged from 115 to 126 days and 126 to 133 days, respectively.

Table 5. Evaluation of genotypes for seed setting or seed yield during 2009/10

Genotype	First flowering days	Seed setting days
KEN-DS-058	126	133
KEN-DS-066	119	128
F6- Oli	121	132
BJRI-1965	119	129
BJRI-1968	121	130
O- 4	121	131
KEN-BL-130	122	128
OM- 1	119	131
Itahari- 2	117	126
JRO- 524	115	126
F - test	ns	ns
CV %	3.92	3.54

ns, not significant

Jute germplasm has narrow genetic base, and the yield difference among the genotypes was not significantly different. Introduction of high yielding and quality fiber producing varieties from Bangladesh and India is necessary to meet farmers' demand. Promising genotypes of Jute KEN-DS-066, KEN-DS-058 and JRO- 524 will be included in participatory variety selection (PVS) and distributed to farmers in front line demonstration for quick adoption.

Management of Stem Rot Disease of Jute in the Eastern Terai Region of Nepal

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ABSTRACT

Jute (*Corchorus* spp.) is a traditional commercial crop of eastern terai region of Nepal. The existing varieties have low adaptability to changing agro-ecological conditions of the marginal lands and more susceptible to several pest and diseases. The experiment was laid out in randomized complete block design and replicated three times during 2009/10 including nine treatments for seed yield and seven treatments for fiber purpose. The promising genotype JRO 524 was used. It is revealed from the experiment that the highest seed yield 731 kg/ha recorded in the treatment application of *Trichoderma viride* @10⁴/ml at 7, 14 and 21 days after seeding (DAS) followed by 7 DAS (666 kg/ha). The correlation between stem rot and seed yield, stem rot and pod per plant and pod per plant and seed yield was measured. Spraying of Bavistin @ 2 g/l water at 60, 70 and 80 DAS produced the highest fiber yield (3.19 mt/ha) and also controlled stem rot disease to some extent. It is also found that there was strong correlation (0.801**) between plant height and dry ribbon weight.

INTRODUCTION

Jute (*Corchorus* spp.) is a traditional commercial crop of eastern terai region of Nepal. Not only the area under jute is declining, the crop is also being pushed more and more to the marginal lands. The existing varieties have low adaptability to changing agro-ecological conditions of the marginal lands and more susceptible to several pest and disease problems. Thus, the yield per unit area has remained very low. Farmers are interested to have the varieties with free of pests and diseases and having good fiber quality. Stem rot caused by *Macrophomina phaseolina* is the major disease of jute.

MATERIALS AND METHODS

The experiment was conducted in the eastern terai region of Nepal at Jute Research Program during the fiscal year 2009/10. The experiment was laid out in randomized complete block design with nine treatments. Each treatment was replicated thrice with a plot size 12 m² with spacing of row to row 30 cm and plant to plant continuous. The promising genotype JRO 524 was used in the experiment. Chemical fertilizer was applied @ 40:20:40; N:P₂O₅:K₂O kg/ha. Half dose of nitrogen was top dressed after first weeding of the crop. The plant population was maintained by thinning during first weeding with plant to plant spacing of 5 cm. All the agronomic practices were provided for the excellent growth of the crop and disease development. Seeding was done during the last week of May and second week of July for seed and fiber yield, respectively.

The treatments included chemical fungicide Bavistin (carbendazim) and biological control agent *Trichoderma viride*. Treatment details can be seen in the result tables.

RESULTS AND DISCUSSION

The effect on seed yield was insignificant among the treatments (Table 1), though the treatment, *Trichoderma viride* at 7, 14 and 21 days after sowing gave the highest yield (731 kg/ha) followed by the treatment *T. viride* at 7 days after sowing (666 kg/ha). Plant population, plant height, branch per plant and pod per plant were observed comparatively higher in the treatment, *T. viride* at 7 DAS compared to *T. viride* at 7, 14 and 21 DAS. Disease score was also less in the treatments. Higher seed yield in the treatment, *T. viride* (7, 14 & 21 DAS) could be due to the boldness of the seed.

Table 2 showed that spraying of Bavistin @ 2 g/l water at 60, 70 and 80 DAS produced the highest fibre yield (3.19 mt/ha) and reduced the stem rot disease to some extent, however, there was no significant difference among the treatments. The severity of stem rot was observed low in fibre production plot in compared to seed production plot. That might be due to short crop period for fibre production and the vulnerable stage for the disease is pod formation.

Correlation between the stem rot disease and seed yield was significant (Table 3). Also, correlation was found between the disease and some of the fibre yield attributing parameters (Table 4). For some parameters highly significant difference was observed.

Table 1. Effect of bio-agent and fungicide on the incidence of stem rot disease and seed yield attributing parameters of jute crop, 2009/10

Treatments	Plant height (cm)	Plant population/ sq m	Branch / plant	Pod/ plant	Stem rot (0-9)	Seed yield (kg/ha)
<i>Trichoderma viride</i> at 7 days after sowing (DAS): Soil application	109	44	2.3	8.2	5.1	666
<i>Trichoderma viride</i> at 7 and 14 DAS: Soil application	101	40	2.0	8.0	6.5	602
<i>Trichoderma viride</i> at 7, 14 and 21 DAS: Soil application	106	38	2.2	8.3	6.2	731
Bavistin @ 2 g/l water at 60 DAS: Foliar spray	100	46	2.1	5.2	6.5	602
Bavistin @ 2 g/ water at 60 & 70 DAS: Foliar spray	98	34	2.0	8.3	7.6	565
Bavistin @ 2 g/ water at 60, 70 & 80 DAS: Foliar spray	97	40	2.1	7.2	5.1	566
Bavistin @ 2g/kg: Seed treatment	101	39	2.1	7.2	7.2	531
<i>Trichoderma viride</i> : Soil application before sowing	95	40	2.3	8.1	7.1	532
Control (water spray)	91	39	2.0	7.7	6.4	533
F- test	*	ns	ns	ns	ns	ns
CV %	6.0	18.1	15.3	24.1	25.9	14.2
LSD 0.05	10.6					

Means followed by same letters in the columns are not significantly different; *, significant; ns, not significant

Table 2. Effect of bio-agent and fungicide on stem rot disease and fiber yield and yield attributing characters of jute crop, 2009/10

Treatment	BD (cm)	PH (cm)	PP/ sq m	SR 0-9 scale	GP wt (mt/ha)	GR wt (mt/ha)	DF wt (mt/ha)	GS wt (mt/ha)	DS wt (mt/ha)
<i>Trichoderma viride</i> application: 26 days after sowing (DAS)	1.07	281	34	3.9	36.6	12.01	2.75	24.66	6.41
<i>Trichoderma viride</i> application: 26 and 33 DAS	1.12	291	41	3.2	38.3	13.05	2.76	25.30	5.42
<i>Trichoderma viride</i> application: 26, 33 and 40 DAS	0.98	256	37	3.1	37.0	14.98	2.46	22.03	5.57
Bavistin @ 2 g/l water: Foliar application at 60 DAS	0.96	240	39	4.9	34.5	13.58	2.41	21.00	5.28
Bavistin @ 2 g/l water: Foliar application at 60 & 70 DAS	1.05	249	41	2.1	34.1	12.63	2.55	21.51	5.41
Bavistin @ 2 g/ water : Foliar application at 60, 70 & 80 DAS	0.96	267	39	3.5	40.4	18.31	3.19	22.05	6.15
Control (water spray)	1.03	269	40	5.2	34.4	12.08	2.49	22.35	4.79
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV %	8.6	12.2	10.3	42.4	13.1	20.8	19.1	16.5	17.96

BD, basal diameter; PH, plant height; PP, plant population; SR, stem rot; GP wt, green plant weight; GR wt, green ribbon weight; DF wt, dry fiber weight; GS wt, green stick weight; DS wt, dry stick weight; ns, not significant

Table 3. Correlation between stem rot disease and seed yield of jute, and seed yield attributing parameters, JRP, Itahari, 2009/10

Correlation between	Correlation value
Stem rot vs. seed yield	-0.402*
Stem rot vs. pod/plant	-0.086ns
Pod/plant vs. seed yield	+0.253ns

*, significant; ns, not significant

Table 4. Correlation between stem rot disease and fibre yield, and fibre yield attributing parameters, JRP, Itahari, 2009/10

Correlation between	Correlation value
Stem rot vs. dry ribbon weight	-0.337ns
Stem rot vs. dry stick weight	-0.213ns
Stem rot vs. green ribbon weight	-0.147ns
Stem rot vs. green stick weight	-0.166ns
Dry stick weight vs. dry ribbon weight	+0.663**
Green ribbon weight vs. dry ribbon weight	+0.462*
Green plant weight vs. green ribbon weight	+0.568**
Green plant weight vs. dry ribbon weight	+0.616**
Plant height vs. dry ribbon weight	0.801**
Plant height vs. dry stick weight	+0.291ns
Basal Diameter vs. dry ribbon weight	+0.264ns
Basal Diameter vs. dry stick weight	+0.142ns

*, significant; **, highly significant; ns, not significant

Spraying of Bavistin @ 2 g/L water at 60, 70 and 80 days after sowing and application of *Trichoderma viride* @ 10⁴/ml at 7, 14 and 21 days after planting of jute could be recommended to protect the crop from stem rot disease and improve the quality of seed and fiber as well.

Current Scenarios and Future Strategies of Horticultural Research in Nepal

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ABSTRACT

Horticulture sector in Nepal is contributing to about 30% of agricultural gross domestic product (AGDP) and its contribution is increasing gradually. Horticultural commodities fall in the top priority when issues come for commercialization, value addition, export promotion, import substitution and employment generation. As of result of that technological demand on horticultural commodities is very high. Commercial entrepreneurs are adopting/adapting technologies from developed countries but even subsistence growers started seeking hybrid varieties. Since horticultural research in Nepal is undertaken by public sector institutions, primarily by Nepal Agricultural Research Council (NARC), clear strategies should be formulated to cater the technological need for the sector. Broadly, major strategies should be through public-private partnership (PPP) model for exportable commodities like tea, coffee, flowers; hybrid breeding to cover all types of growers; conservation and utilization of genetic diversity of horticultural crops; technologies to combat climate change effects; domestication of high value medicinal and underutilized crops; team approach for different sub-sectors like fruits, vegetables, flowers, plantation crops; mechanization for labor reduction and water use efficiency; and central level reference laboratory for all horticultural research support – clear research link with central and federal research system. To implement these strategies effectively and efficiently, NARC should act as national agriculture research system and horticulture institutes should be formulated within the system.

BACKGROUND

Nepal has wide variety of climate and soil on which a large range of horticultural crops such as fruits, vegetables, potato, plantation crops, spices, ornamentals, and medicinal and aromatic plants can be grown. Its contribution to AGDP, currently about 30%, and importance in employment and income generation is in increasing trend. Although horticultural crops are grown all over the country, its contribution is more significant in the hills and mountains. Some of the horticultural crops such as potato, sweet potato can directly contribute to food security whereas other high value fruits and vegetables give higher income per unit area which helps to afford basic requirements.

Despite having favorable conditions for horticultural crops in the hills and mountains, their potential for commercialization has not been exploited satisfactorily. About 25 percent of the vegetables supplied in Kathmandu market are imported from India. However, the fact is that the vegetables produced during summer and rainy season in the hills and mountain of Nepal are out of season for the plains of Nepal, India and Bangladesh and has clear window of opportunity for export. Besides fresh vegetables, Nepal's dependency on imports for hybrid and open-pollinated vegetable seeds is also increasing. Not only have the vegetables, national statistics depicts the more miserable scenario of fruit supplied situation in Nepalese markets. The grave concern is that our fruit market is also

primarily dominated by imports. Paradoxically, not all but most of the major imported commodities can easily be produced within the country in a commercially viable approach. Success stories in several production pockets of Nepal have demonstrated the contribution of horticultural commodities on gender equity, employment generation, livelihood support, nutritional security to women and children, and solving migration problem is very significant especially for small and marginal farmers. However, the taste of its benefit is not sufficiently enjoyed by the majority of the potential users.

The main factors behind it might be either the generated technologies on horticultural crops are insufficient or the available technologies are not disseminated at expected level. Most importantly, Nepal has to compete in the markets with its highly populated and technologically advanced giant neighbors, India and China. Market competition in present days is only possible through technological advancement in production, processing and market efficiency. In comparison to field crops, horticultural crops are more technology responsive owing to their versatile use, biological diversity, and sensitivity to the market, human health concerns, perishable in nature and competition in global market are few to mention. Considering the pertinent contemporary issues, this document proposes future strategies on horticultural research so as to harness full potential of the sector for the economic development of the country.

IMPORTANCE OF HORTICULTURE SECTOR

Scope in Nepal

Horticulture is a curious mixture of art, science and technology. It encompasses all the aspects of cultivation, processing and utilization of variety of crops such as fruits, vegetables, ornamentals, plantation crops, spices, medicinal and aromatic plants and mushrooms. In Nepal, more than 200 species of horticultural crops which encompass about 40 species of fruits and plantation crops, 50 species of vegetables, 100 species of ornamental plants and 25 species of spices are used in one way or another. Among them, more than 100 species are being grown commercially in Nepal. Not only in terms of use, the growth habit and life cycle also varies greatly among the horticultural crops. Except very few, most fruits and plantation crops are perennial trees or shrubs, vegetables are annual, and flowers are either annual or perennial. Horticultural commodities also differ greatly not only among groups but also among species in terms of climatic requirements, breeding and propagation techniques, production systems, post-harvest technologies and the ways they are used. Except ear, all other sense organs of the human body are very sensitive to horticultural products such as cosmetic for skin, spices for tongue, fruits, vegetables, medicinal plants and floriculture for brain and aromatic oil for nose. Thus, horticulture has vital role for food and nutritional security, prosperity and peace of individual and society, and importantly for nature. Horticulture as an economic enterprise is a dignified and respectable job and as a hobby is a source of pleasure, happiness and a great mental satisfaction, as well.

Commercialization

Horticulture is a high income generating enterprise. For example, potatoes and vegetables are 9 and 24 times more profitable, respectively than maize. Studies have shown that mango cultivation gives about 5 times, mandarin 24 times and banana 36 times higher income than cereals (Thapa 2009). Because of this, attraction of youth and educated people and business houses towards horticulture

enterprises is rapidly increasing. Majority of the commodities identified by One Village One Product (OVOP) programs are horticultural crops.

Value addition

Presently, our market is dominated by fresh products both for domestic and export market. We are exporting raw product in cheap price and importing processed products in much higher price. Government statistics shows that Nepal imported processed horticultural products worth of about NRs. 1 billion in 2009/2010 (MoAC 2010). Of the total import value of potato, chips was nearly Rs 233 million and more than 40 types of other processed fruit and vegetable products worth of Rs 700 million were also imported in Nepal during the same fiscal year. The processed/preserved horticultural products that have been imported in Nepal are in significant quantities, which include potato (chips, French fry, preserved, frozen), tomatoes, beans, jam, jellies, preserved fruit and juice. Such products can be produced easily in the country for domestic market through PPP approach. Moreover, market observation and news articles published in various print media indicate that import of processed horticultural products may be much higher than the government statistics. In the context of rapid urbanization demand of processed fruits is expected to increase in the future. Thus, there is ample opportunity to expand processing industries of horticultural crops, which will create additional employment and income through value addition and helps reducing the trade deficit of the nation. In addition to import substitution, processing and value addition will have special advantages for export in the context of high transportation cost.

Export promotion

Nepal is not benefitting from being a member of WTO as our export is very low. We have opportunity to export our products as niche commodities and branding. Export possibility with horticultural commodities is comparatively higher than in other crops. Lentil is the only non-horticultural commodity exported from Nepal in significant quantity. Large cardamom, ginger, tea, rainy season vegetables, cinnamon and herbs are major horticultural products exported to different countries. Organic coffee is also coming up as an exportable commodity since last decades. The number of commodities and their quantities being exported at present are far less than the potential. We can diversify commodities, increase quantity and quality for export and expand the export market destinations with special branding of our niche commodities. However, technological advancement and upgrading strategies at all level of commodity value chain is very critical to become competitive in global market and expand export.

Import substitution

Despite being an agricultural country having high potential for horticultural crops current gap between total demand and supply from domestic production is very high. According to the government statistics of 2009/10, Nepal imported horticulture commodities worth of Rs 17.38 billion and exported about half of this value (Rs 9.35 billion). We are importing many commodities such as potato, dried vegetables and beans, onion, garlic, fresh vegetables, vegetable seeds, chili, coriander, cumin, fenugreek, turmeric and most of the fruits that can be easily produced in the country. Table 2 gives a clear picture on how much imported horticultural products are being consumed by the elite citizens of Kathmandu valley including top level politicians, bureaucrats, business households, civil society and others. All these statistics gives clear confirmation that there is huge scope to expand production scale of horticultural commodities targeting to import substitution. But most importantly

the program should be technology driven rather than input driven like *Onion Mission* and *Citrus Mission*.

Employment generation

Statistics show that there is 11.4 m labor force available in Nepal, and is growing at the rate of 2.6 percent per annum (NPC 2007). It roughly adds about 300 thousands employment seekers to the labor market annually. The comparative statistics from various empirical studies revealed that there are high numbers of laborers used per unit area in horticultural crops as compared to traditional cereal crops. Horticulture creates employment not only in production but also in transportation, storage, whole selling, and retails and processing. These value chain processes simultaneously develop other allied industries like bottle factories, packaging materials and cold storage. People involved in horticulture enterprises feel proud on the profession not privation like in general agriculture. Thus, youth and educated people are attracted to invest on horticultural activities. It has special significance in the context of lesser interest of youth on agriculture.

Pro-poor enterprises

While big farmers can get benefit from these crops, vegetables are very suitable for small land holders too to get higher income per unit time and land. Even landless people can make money by vegetable cultivation in hired land. It gives economic as well as nutritional security to poor farmers. Therefore, vegetable production has become a common gate way of NGOs to rural community for livelihood improvement programs. Examples of such success stories are regularly covered by print and electronic media.

CURRENT RESEARCH SCENARIO

Research policy

Agriculture Perspective Plan (APP) is the main guiding policy document for agriculture development at present. APP has identified technologies (research) as one of the four priority inputs and few horticultural commodities (off-season vegetables, vegetable seeds, citrus, and apple) as priority outputs. Under broader umbrella of APP, government has also released/promulgated, National Agricultural Policy - 2004, Agribusiness Promotion Policy - 2006 and Agro-biodiversity Policy - 2007 (MOAC 2008). Agricultural researches, including horticulture being undertaken by public sector are mainly based on very broad guidelines envisaged by APP, National Agricultural Policy 2004 and periodic plans (Tenth Five Year Plan, and Three Years Interim Plans). Since government does not have clear national research strategy and policy, various institutions are operating in their own way. It has resulted in lesser concentrated efforts, potential duplication, scattered resources and technologies generation in piece meal.

Institutional evolution

Agricultural research in Nepal began from 1937 during the Rana regime when the Agriculture Council and several agriculture research stations were established. The Council was dissolved in 1951 and agriculture research was entrusted to the departments under MoAC. In 1987, a separate organization named the National Agriculture Research and Service Centre (NARSC) was created under the Ministry of Agriculture to undertake all agricultural research works, and all central

divisions located at Khumaltar, research centres, and government farms came under its management. In 1991, NARSC was dissolved and Nepal Agricultural Research Council (NARC) was formed as an autonomous organization to conduct all agricultural research needed for the country. However, not all of the research assets for horticultural crops such as, central laboratories, research farms, and human resources that were enjoyed by NARSC were handed over to NARC. Comparatively better equipped horticulture sector research facilities were kept under the Department of Agriculture whose mandate is extension. This is the most critical issue and set back of the research was started from the day. This might have fulfilled the desire of certain person or group but country has been suffering from it.

In 2001, a separate institution, National Agricultural Research and Development Fund (NARDF) was established under the Ministry of Agriculture and Cooperatives to implement a competitive grant system for agricultural research and development. This institution does not implement research projects, but provides grants to government and non-government organizations on a competitive basis. There is no formal coordination mechanism between NARC and NARDF. This has resulted to a continuing risk of duplication of work and investment in unconsolidated works.

Institute of Agriculture and Animal Sciences (IAAS) under the Tribhuvan University has also been conducting research on agriculture primarily to fulfill the academic requirement of post-graduate students. Many International and National non-government organizations (I/NGOs) are operating in the country and many NGOs are implementing agricultural programme getting external funds. Majority of the NGOs have rural livelihood improvement programs and also carryout action and/or adoptive horticultural research to solve farmers' problems with research grants from national and international donors. Involvement of private sector-especially seed and input traders and processing industries- can not be ruled out on technology fine tuning to promote their own business.

As mentioned above, diverse types of agriculture research service providers are emerging in Nepal. However, NARC is the only organization that has to response on government and public concerns related to agricultural technologies. Therefore, NARC the public sector agricultural research institution, it has been and remains the main stream of agricultural research of Nepal. But past history shows that the government institutions involved in agriculture research have been subject to frequent organizational changes leading to instability and uncertainty. This has contributed to Nepal's lagging agriculture sector especially horticulture compared to neighboring countries. Since the nature and reasons of the institutional changes in the past were driven less by demands of the system or its end users, the farmers, such changes have also contributed to a disjointed system that is not working optimally. Despite difficulties in the operating environment, NARC has been the apex body of Nepal's national agricultural research system (NARS) and made a significant contribution to agricultural research for development. However, it needs immediate reforms for moving to build an efficient NARS in the context of changed political and socio-economic environment of the country.

Research infrastructures

A number of research stations were developed by the government in the past for horticultural research. When NARC was created after the dissolution of NARSC very few of horticultural research stations were handed over to NARC and rest were kept with Department of Agriculture (DOA), the government organization for agriculture extension. At present, DOA owns 20 horticulture stations

while NARC (research organization) has only 11 horticulture research stations to cover the whole country and horticultural commodities. Moreover research stations under extension service are more specialized (at least in naming) like Tropical Horticulture Development Centre, Temperate Rootstock Development Centre, Coffee Development Centre, Cardamom development centre, Floriculture Development Centre etc. to name but not all). On the other hand the horticulture research stations under NARC are more common type and mixed with field crops and livestock. Such phenomenon contrasts with other countries' system. It has on the one hand resulted to lesser geographical area coverage by horticultural research failing to address the requirement of diverse agro-climatic conditions of the country and on the other hand underutilization of horticultural research stations holds by extension organization. Further, NARC has insufficient Commodity Research Programs on horticultural crops. For example there is no National Commodity Research Program on vegetables, fruits, flowers, tea, coffee and medicinal plants. Horticulture Research Division (HRD) still does not have research farm and laboratories of its own. Thus it will not be exaggerated to mention that horticulture is the weakest sector within NARC in terms of research infrastructure.

Human resources

Critical mass of competent researchers is the fundamental requirement to accomplish quality researches. In recent years, depleting number of scientific staff due to retirement and brain drain has been a serious problem in NARC. Process of new recruitment has been uninitiated to minimize the gap. However, horticulture sector in NARC has generic issues and constrains as listed below related to scientific human resources:

- At the time of NARC establishment the number of scientific positions for different disciplines and research stations were determined to adjust the integrated scientists from mainstream Agriculture Service. The positions of scientists were not created on the basis of need and scientific reasoning. NARC research as a whole and horticulture research in particular is still suffering from this generic problem. Since only few horticulture research stations were handed over to NARC and less number of horticulture scientists opted to transfer to NARC, inadequate number of positions were created in horticulture sector when NARC was created. Therefore, number of positions of scientists need to be evaluated and reallocation should be made on scientific basis.
- Horticulture by definition covers all aspects of fruits, vegetables, ornamental, plantation crops, herbs and aromatic plants from breeding to post-harvest and marketing system. Thus horticulture research can be accomplished only by of a multidisciplinary team of scientists. But in NARC system scientists are divided to various disciplines (horticulture, pathology, entomology, soil science, food technology etc.) and are generally doing disciplines based research in piece meal basis individually. Except those working in horticulture discipline scientists from other discipline are not permanently assigned as horticulture researcher. As a result there is no team of scientists for horticulture research. Within horticulture there is no commodity based specialization.
- There are extremely few (AVRDC and CIP) consultative group (CG) system to support horticultural crops research. In this case, national research system should be strong enough for genetic materials and technology development especially in fruits, plantation crops, ornamental and herbs. International market competition is comparatively tough in horticultural commodity

due to sensitivity on quality of produce. Hence, state has to invest more on human resource development in horticultural sector including international exposure.

Research investment

In 1992, total agricultural research budget for Nepal was 0.46 percent of AGDP (APP, 1995). The World Bank (1981) and FAO (1987) recommended two and one percent respectively of AGDP expenditure on public sector agricultural research. APP followed the FAO recommendation and suggested to double agriculture research expenditure to get tangible outcomes from research. While identifying technology as one of the priority inputs for agriculture commercialization, APP has recommended several areas to reform within NARC including increased investment. However, agriculture research was given second priority in Tenth Five Year Plan (2059/60-2063/64) and the Three Years Interim Plan (2064/65-2066/67) and budget was cut down substantially reaching lowest level of about 0.2 percent of AGDP. It was reverse of the APP recommendation. Because of international (global food crisis) and national (peace restoration and realization of importance of agricultural research in political level) scenarios investment on this sector has been increased significantly from FY 2068/69. However, it is still about 0.3 percent of the AGDP and far more needs to be invested to meet global average level (1% of AGDP).

Judicial distribution of agricultural research fund among different sector is another pertinent issue. Whole agriculture system is divided into four sectors – field crops, horticulture, livestock and fisheries - based on nature of commodities. System based research fund allocation among these sectors is not visible within NARC. Present level of investment on horticulture sector is not fair considering the contribution of horticulture sector on AGDP and its future potential. The current level (about 10%) of NARC's allocation in horticultural sector does not seem to be logical.

Research Programs

In NARC, there are no sector wise research programs on field crops, horticulture, livestock and fisheries. Only short term research projects are developed individually by the scientists without any program based strategies, goals, targets. Hence sector wise research programs need to be formulated based on agriculture research policy and program implementation responsibility should be given to the team of multidisciplinary researchers. Not only focused program, research targeting is another issue. Without much considering socio-economic differences of the users, technologies are being recommended to all farmers in blunt way.

Technological demand

The existing system of research problem analysis and prioritization is not robust. In one hand, national research system is not sufficient strong to dictate the research agenda in horticultural commodities. On the other hand, the technology users are not organized put forward common issues of their technological need or research problems. These situations have resulted development of inefficient/mediocre quality technologies leading to poor return from research investment. In practical sense, there are many instances that generated technologies become fantasy to researcher but of little value to the users.

Technological flow

Nepal is following vertical technology transfer system i.e. research to extension and finally to the users. Advantages and disadvantages always rest with all types of technology transfer models. But the current system of vertical flow does not seem to be effective in our context. Involvement of two to three organizations within the vertical steps and inefficient functioning of the system has resulted low return of high quality of research results. Handing over the first hand message from researchers to end users would have better impact, which also minimize the message distortion during communication. Technology flow without involving second party can be done using print and electronic means and it is possible at least in horticulture due to improved communication system in Nepal. This will create situation to adopt technology immediately by the needy ones and fresh technology will reach to the users with short span of time. Technological demand is not always a straight forward approach. Generally users share the felt need for technology but unfelt need might be more crucial in some cases. The duty of researchers is to foresee the potential opportunities and problems. In such cases researchers have to initiate research not waiting till the problem comes to a verse and opportunities tapped by outsiders. If researchers are well aware on it and develop the technology it will go to the users like any things. Examples of such technologies are hybrid vegetable seed, kiwi farming and plastic house technology.

Private sector involvement

Private sectors' involvement on technology generation of horticultural crops especially in tea, fruit processing, herbs and floriculture can not be ruled out. However, results of such research initiatives are not generally made public. Private sector entrepreneurs have started funding on testing exotic hybrid varieties and inputs for the purpose of getting import permit from government. In industry based commodities like tea, coffee, herbs, aromatic plants and large cardamom private sectors may join hands with public sector. Certain level of levy on these crops and investing it for technology generation on private sectors' demand would yield effective and efficient outputs.

FUTURE STRATEGY**Agriculture Research Policy****Need to promulgate agriculture research policy in general and horticulture in particular:**

Horticulture Master Plan was prepared during the late 80s with support from the Asian Development Bank. The draft document was circulated amongst the stakeholders during the period but it was never formally endorsed by the government. There is still a grave need of the master plan for horticulture research and development for the country which could lead to the same direction to all actors to mainstream the efforts carried out in piece meal. Despite having unique nature in production system and uses plans and policies of horticultural crops are often diluted with field crops.

Research investment based on economic contribution: Investment of at least 30 percent of the agricultural research budget on horticultural research is fair and economically justifiable. It will be a paradox to expect much contribution for livelihood improvements in days to come from horticulture sector with minimum investment.

Single door system of problem prioritization and technology recommendations: The present situation of problem identification is more generally in institutional level. Problems related with even a single commodity are differently reported in many cases. Likewise, technological recommendations have been made based on the discrete experiments without considering the holistic views. This has pressed to have clear single door problem identification and different organization could work on specific issues upon mutual understanding. This will lead to develop package within short span of time and minimize the duplication. Furthermore, there should be a pertinent need for the technology registration to make it more consistence, reliable and research based.

Import substitution or export promotion of high value crops: The current approach of growing everything would not be an approach, rather concentrate on few selected commodities having relative advantages with more specialized production like specialty coffee or orthodox tea. While talking about import substitution and export promotion, one should bear in mind that the net export value should exceed the net value of import. Focus should be made on the crops having niche advantages like large cardamom, herbs and unexploited crops having great future potential like gooseberry, kiwifruit, avocado etc. Research on medicinal and aromatic plants should be initiated under the umbrella of horticulture with appropriate institutional setup.

Institutional reform

Structural reform of NARC: NARC's current structure should be reformed splitting it into two distinctly separate bodies. NARC headquarters should work as national agriculture research system (NARS), which should only concentrate on policy issues, coordination and monitoring. Another bodies, preferably institutes should involve in nationwide direct research execution.

Interactive body within NARS with private sector, importers, exporters and business people: The self-centered working approach is common phenomenon of public sector institution of Nepal and NARC is not an exception. The proposed NARS should encompass a very strong and vigilant coordination wing which particularly works with private sector for priority setting or rectification, technologies validation and up-scaling and developing future strategies with could be more private sectors friendly. This approach has vital implication particularly in commercial horticultural commodities.

Horticulture research should be carried out through institute: Under institute model, the horticulture sector should be a separate institute to undertake the all researches related with horticultural crops. Taking consideration of the number of economically important horticultural commodities, a master plan should be formulated to cater the technological need to start with a minimum level of research facilities (physical, human, financial).

Complete set of multidisciplinary staffing in the institute: Taking care of all problems related with horticultural commodities by horticulturists themselves is no more relevant in the present context of specialized world. The proposed horticultural institute should have complete set of professionals of plant breeding, management, plant physiology, entomology, pathology, soil science, post-harvest, agricultural meteorologist and socio-economist.

Provision of research stations covering major agro-ecological conditions: Nepal is endowed with the climatic variations and microclimate within the same agro-ecological zones. The opportunity of diverse growing zones is also a challenge for researchers since horticultural crops are generally sensitive to climatic factors. This needs wider verification covering major growing climates. The current research facilities and its coverage is not at all representative and this could be easily expanded to an acceptable level by handing over a few selected farms of Department of Agriculture to NARC in general and horticulture institute in particular.

Testing and demonstration sites (perennials) in each minor agro-ecological site: Research methodology and technology up-scaling for perennial crops like fruits, plantation crops, herbs, ornamental trees are different than that of annual crops. It takes about a decade to get indicative results in case of fruits. In this situation, all new varieties should be established in minor-ecological sites which give opportunity to test the performance of new varieties and wider demonstration of the outstanding varieties.

Research on team approach: Researches in isolation by different institutions are observed in many cases. For example, club root problem of *Brassica* spp. was simultaneously dealt by three institutions. This has led to duplication of work and wastage of resources. For the benefit of the end users and the country, all researchers should work together in a team. The issue is not only intra-institution but poor team approach within an organization is one of the challenges within NARC. This problem is mitigated upon formulation of horticultural institute.

Public private partnership: This is a widely spoken phrase in this current decade in Nepal but has limited execution in practical sense. PPP in agriculture sector has greater importance and it could have implication on need based research and ownership in developed technologies. This could be done through:

Levy on exportable commodities: NARC priority is always given for the food and nutritional security commodities since technologies on those crops become helpful for majority of the farmers. Because of that less resource is available to exportable commodities. To make the research fund sufficient, levy should be put on the exportable commodity and the collected amount should be expended on the research and development of the same commodity. Same principle applies on import as well.

Research issues and matching-funds for technologies for industrial crops: Commodity specific processing or value addition industries are relying on few related commodities. They have their own technological need and industry orientated problems. These kinds of problems are jointly addressed by matching funds with specific research agendas. The conventional extension system (Research-Extension-Farmers) does not fit in such scenario because of high level technological demands for industries. In such cases the industries and researchers should have direct and strong linkage for technology development, dissemination and commercial use.

Responsive technologies

Client targeting: The technologies are currently recommended to farmers in general. But in reality, farmers are different in terms of technical understanding, resource availability, and market access and so forth. These factors make them really different to respond with the technologies. Hence, farmers should be categorized in terms of access (finance, technology, road, market) and resources and technology should be recommended accordingly.

Formulation and activation of national commodity growers' alliance: Strong need of farmers association on specific commodity is realized to get real problems and need of potential technologies. Farmers associations now in existence are primarily dominated by more politically motivated personnel rather than true farmers. True grower alliance will be helpful for the development of the sector.

Marketing, processing and value addition issues from business sector: Since majority of the researchers are from agricultural background, they have inadequate understanding of the processing and value addition issues. Ironically, business communities have practical realization on these issues. Hence, this type of issue should come from business sector and better to work jointly.

Technology supported by cross cutting issues like gender and climate change: Since majority of the research are carried out in isolation, incorporation of cross cutting issues is pivotal for its use. It is widely said that "technology should be technically feasible, economically viable and socially acceptable". While recommending new technology, rectification through cross-cutting lances should be made mandatory to make it highly acceptable.

Future market trend analysis: Despite huge number of subsistence farmers in the country, majority of the semi-commercial growers have been running horticultural enterprises and horticultural entrepreneurs are growing every year. The semi/commercial growers plan their commodity based on the current market situation. But for better return there should the market trend analysis (including international) to make the enterprise more profitable and dynamic.

Market vigilance for export promotion: Import substitution and import promotion is widely used jargon. Many horticultural products are being exported to many countries in raw and/or processed forms. Nepal is exporting the commodities without knowing the preferences of the end markets. There should be a system to update quality standards, market preferences, competition analysis, relative advantages and market trends of the end markets.

Technology delivery to users by researchers: The current system of technology delivery is not considered as efficient system in terms of adoption and pace of spreading. One of the factors of such situation is an involvement of second party (extension agents). This system adds up one ladder in delivery and also detaches the ownership from the technology generator. Hence, wider demonstration and verification should be carried out by technology generator themselves.

Table 1. Import and export situation of horticultural products in Nepal (2009/2010)

S.N.	Commodities	Import Values (Rs.)	Export Value (Rs)	Import-export ratio
1	Live trees & other plants: bulbs, roots and the like: cut flowers & ornamental foliage	9,230,758	20,874,606	0.44
2	Edible vegetables and roots and tubers **	3,706,098,200	3,781,868,489	0.98
2.1	Potatoes seed	15,362,211	357,817	42.93
2.2	Potatoes fresh , chilled and chips	1,257,818,916	0	
2.3	Tomatoes, fresh or chilled	10,782,730	0	
2.4	Onions, shallots & leeks	726,470,976	5,207,567	139.50
2.5	Garlic	232,962,426	0	
2.6	Various type of fresh vegetables	283,625,344	14,378,516	19.73
2.7	Fresh & Preserved mushrooms	7,642,779	6,058,408	1.26
2.8	Dried vegetables & beans	1,163,481,534	9,504,760	122.41
3	Edible fruits and nuts	4,714,767,570	486,355,192	9.69
3.1	Coconut	115,278,009	207,220	556.31
3.2	Other nuts	272,150,038	2,721,940	99.98
3.3	Citrus fruits	72,526,671	484,221	149.78
3.4	Apple	699,492,861	2,926,068	239.06
3.5	Betel nuts	3,352,626,205	479,108,280	7.00
3.6	Other fruits	202,693,786	508,700	398.45
4	Coffee, tea, mate and spices	1,071,969,360	2,895,882,553	0.37
4.1	Coffee	13,888,648	24,362,939	0.57
4.2	Tea	35,116,273	1,195,318,183	0.03
4.3	Pepper: fresh and grounded	351,380,584	551,513	637.12
4.4	Seeds of coriander	112,029,017	0	
4.5	Cumin seeds	292,472,958	3,051,053	95.86
4.6	Fenugreek (Methi)	35,995,130	10,769,431	3.34
4.7	Turmeric	15,097,763	9,173,146	1.65
4.8	Cinnamon	16,711,385	22,873,186	0.73
4.9	Ginger	45,763,877	456,013,528	0.10
4.10	Other spices	151,955,127	2,172,173	69.96
4.11	Large cardamom	0	1,171,597,401	0.00
5	Flower & Vegetable Seeds	141,263,365	2,731,419	51.72
6	Other plant products	171,817,483	440,474,666	0.39
7	Olive oil	23,787,774	0	
8	Processed products	698,263,543	1,086,934,702	0.64
	Total	17,379,371,914	9,353,458,456	1.85

** Out of total edible vegetable export share of lentil was Rs. 3,744,921,809

Source: Statistical information on Nepalese Agriculture, MoAC

Table 2. Arrival (kg) of horticultural commodities at Kalimati Wholesale Markey by Source in 2067

Commodity	Arrival from Import		Total Arrival (kg)	Import (kg)	Import %
	India	China			
Tomato Big	2453400		4029000	2453400	60.9
Potato Red	9638700	41000	29783800	9679700	32.5
Potato White	5051000		8409000	5051000	60.1
Onion Dry	15733000	1626000	17435150	17359000	99.6
Raddish Red	34000		111760	34000	30.4
Pointed Gourd	1813650		3855050	1813650	47.0
Apple	180000	921575	1102075	1101575	100.0
Banana	271870		282070	271870	96.4
Lime	1740100		1753100	1740100	99.3
Pomegranate	89920		92020	89920	97.7
Mango	943090		2024340	943090	46.6
Grapes	120674		120694	120674	100.0
Water Melon	3965390		3965390	3965390	100.0
Sweet Orange	242040		354990	242040	68.2
Pine Apple	115195		120485	115195	95.6
Pear	3710	42975	58475	46685	79.8
Guava	171050		184560	171050	92.7
Musk Melon	300		300	300	100.0
Kinnow	1400		1400	1400	100.0
Chilli Dry	82200		87200	82200	94.3
Chilli Green	2715000		4002650	2715000	67.8
Capsicum	349000		556000	349000	62.8
Garlic Dry Chinese		1790000	1791000	1790000	99.9
Clive Dry	3000		3100	3000	96.8
Fish Fresh	2588175	2600	2937640	2590775	88.2
Other	169300		521234	169300	32.5
Tamarine	87100		88100	87100	98.9

Source: www.kalimatimarket.com.np, Kalimati Fruits & Vegetables Market Development Boards

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Effect of Grafting Dates and Methods on Success and Growth of Mandarin (*Citrus reticulata* Blanco) Sapling

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ABSTRACT

A field experiment was conducted in Dhankuta to find the effect of grafting dates and methods on success and growth of mandarin sapling. Scions taken from 'Khoku Local' mandarin were grafted on one-year-old trifoliate orange seedling rootstock by shoot tip and veneer grafting methods in eight different dates starting from 29th October, 2009 to 12th February, 2010 at 15 days intervals. The grafts were planted inside the closed tunnel of jute and plastic sheet at 10×10 cm spacing in 50×60 cm experimental plots laid out in two factorial split-plot designs with three replications per treatment, containing 30 grafts per plot. The grafting methods were allotted on main-plots and the dates on sub-plots randomly. The success and growth of sapling was significantly affected by the dates while the methods had no effect. The highest success (96.11 %) was found on 13th January, followed by 28th January (91.11%) and the least (51.67%) on 29th October grafting. The mortality of sprouted grafts was lower in December and January, while observed higher in earlier and late season grafting. Observation taken at 180 days after grafting in successful graft revealed that 29th October had the highest number of primary branches (2.2) but the lowest sapling height (29.03 cm) and canopy volume (973.3 cm³); 14th November had the highest number of leaves (48.47), secondary branches (2.505) and canopy volume (1536.0 cm³); 29th December gave the maximum sapling height (32.86 cm); 13th January produced the lowest number of leaves (21.93) per sapling and 28th January produced the lowest number of primary (1.533) and secondary branches (1.172).

INTRODUCTION

Citrus is the most important fruit crop of mid-hill region of Nepal. Agriculture Perspective Plan (APP 1995) has envisaged citrus as the number one priority crop for mid-hill region. Citrus is commercially cultivated in 42 mid-hill districts (Regmi et al 2009). Mandarin is the most important and popular citrus fruits of Nepal. It is mainly cultivated throughout the mid-hill region of Nepal ranging the elevation from 750 m to 1,400 m above mean sea level which stretches from the east to the far-western region (Shah 1992). Total area, production and productivity of mandarin is 21,126 ha, 172,058 mt and 11.91 mt/ha, respectively (MOAC 2009).

Citrus decline due to diseases and poor nutrient management is a serious problem in Nepal (Baral 2008). *Phytophthora* root rot, huanglongbing (HLB), citrus tristeza virus (CTV), powdery mildew, citrus blight, gummosis etc. are the major diseases responsible for citrus decline in Nepal. Regmi et al (2009) reported seedling trees are highly susceptible to *Phytophthora* root rot disease which is one of the devastating diseases of citrus. Therefore, grafting onto trifoliate orange rootstock could be the solution of the citrus decline malady as it is tolerant to *Phytophthora* root rot, resistant to the citrus tristeza virus, less susceptible to blight and extremely suitable for the heavier soil conditions of the country.

The demand of citrus saplings is rising annually. Government of Nepal has put the target to increase citrus areas up to 35,000 ha by 2015. Thus, the area under citrus is to be increased with a rate of more

than 1,000 ha per year (Regmi and Shrestha 2001). The annual requirement of citrus saplings is estimated as 300,000 in Nepal. To meet the escalating demand of the saplings, nursery person should adopt the suitable method of grafting at appropriate time. Few studies conducted in citrus in western and mid-western regions of Nepal revealed that winter season is the best time for grafting. From the study in pummelo by Paudyal (1999) showed that November is suitable for grafting. Poon (1999) reported in mandarin that 83.75% success with tongue grafting, 85.80% with saddle grafting, 88.73% with shoot tip, 90.35% with cleft and 91.75% with veneer method. For the mandarin sapling production, Gautam et al (2001) suggested grafting from 16th to 31st January was the best time for Lumle conditions. He observed the maximum success (87.5%) on 31st January grafting whereas minimum success (37.5%) on 20th November grafting. Similarly, Adhikari (2006) reported the highest graft success (79.73%) in acid lime grafted onto trifoliate orange rootstock on 16th January by shoot tip method.

In mandarin, the research was lacking in eastern region of Nepal. Identifying the suitable time of grafting is a vital for the successful and profitable propagation. High graft success not only saves the time but also increases per unit production by minimizing the cost of production. Therefore, this study was undertaken to standardize the time of grafting, to standardize method of grafting and to assess the subsequent growth of mandarin sapling at nursery stage.

MATERIALS AND METHODS

The experiment was conducted at National Citrus Research Program, Paripatle, Dhankuta in winter season. Scions collected from the mother plant of 'Khoku Local' mandarin were grafted onto one-year-old trifoliate orange seedling rootstock by shoot tip and veneer methods in eight different dates from 29th October, 2009 to 12th February, 2010 at 15 days intervals. The grafts were planted inside the closed tunnel made from bamboo splits, jute and plastic sheet at 10×10 cm spacing in 50×60 cm experimental plots laid out in two factorial split-plot designs with three replications containing 30 grafts per plot. The methods of grafting were allotted on the main plots and the dates on sub-plots randomly. The beds were prepared by digging with spade three times. At final digging, vermi-compost (Nitrogen 1.25-2.5%, Phosphorus 0.75-1.6% and Potash 0.5-1.1%) was mixed with soil. Each 50×60 cm² sized experimental plot received 5 kg vermi-compost (4 kg per plot at final bed preparation and 1 kg per plot at top dressing, 4 months after grafting). Irrigation, de-suckering, weeding, hoeing and topdressing, plant protection, opening and closing of tunnel, removal of plastic laces were done as intercultural operations.

RESULTS AND DISCUSSION

Graft success

The graft success is the total number of successful grafts over the total number of grafts per plot at final observation. Successful grafts were those grafts which had sprouted scion. Unsprouted and dead scions were considered as the failure grafts. At initial observation, graft successes were recorded as percentage of sprouted grafts because in some grafts late sprouting was also observed and finally, sprouting percentage was considered as the graft success.

The effect of methods of grafting was observed insignificant from initial to final observation. But the effect of dates on success and growth of mandarin was found highly significant. At final observation, the highest graft success was recorded in sapling prepared on 13th January which was 96.11%. Grafting on 28th January (91.11%) and 13th January were statistically at par with 13th January grafting (Table 1).

Table 1. Effect of dates and methods of grafting on graft success of mandarin in Paripatle, Dhankuta, 2009/2010

Treatments	Sprouted scion (%)				
	15 DAG	30 DAG	45 DAG	60 DAG	12 th August
Methods of grafting					
Shoot tip	8.194	28.61	67.78	73.89	77.78
Veneer	9.583	32.36	70.97	78.19	82.08
F value	5.24 ^{ns}	2.07 ^{ns}	3.36 ^{ns}	10.53 ^{ns}	14.31 ^{ns}
CD (PG0.05)	2.610	11.20	7.487	5.706	4.896
SEm±	0.4290	1.840	1.230	0.9377	0.8047
Dates of grafting					
29 th October	21.11 ^a	42.22 ^a	51.11 ^c	51.67 ^d	51.67 ^f
14 th November	11.67 ^b	34.44 ^{bc}	67.78 ^b	71.11 ^c	72.22 ^e
29 th November	5.000 ^c	28.89 ^{cd}	66.11 ^b	72.22 ^c	73.33 ^e
14 th December	3.330 ^c	26.67 ^{de}	68.33 ^b	76.11 ^{bc}	81.67 ^d
29 th December	3.330 ^c	22.78 ^{de}	78.33 ^a	84.44 ^a	88.89 ^{bc}
13 th January	5.000 ^c	21.67 ^e	77.22 ^a	86.67 ^a	96.11 ^a
28 th January	6.670 ^c	26.67 ^{de}	75.00 ^{ab}	86.11 ^a	91.11 ^{ab}
12 th February	15.00 ^b	40.56 ^{ab}	71.11 ^{ab}	80.00 ^{ab}	84.44 ^{cd}
CV (%)	37.50	17.22	9.96	6.99	6.36
F value	22.48**	13.18**	9.41**	28.34**	46.19**
CD (PG0.05)	3.942	6.207	8.172	6.284	6.011
SEm±	1.361	2.143	2.821	2.169	2.075

SEm±, standard error of mean difference; CV, coefficient of variation; CD (PG0.05), critical difference at probability value 0.05; DAG, days after grafting; Treatment means followed by common letter(s) within a column are not significantly different at 5% by DMRT.

The maximum success of grafting (96.11%) was recorded on 13th January at 25.69°C temperature in Paripatle, Dhankuta and 90±5% relative humidity. The temperature and relative humidity inside the tunnel was observed about 2-times and 1.5-times higher, respectively as compared to air temperature and relative humidity which was achieved by closing all the edges of plastic sheet immediately after the irrigation of grafts and soaking of jute sheet. Due to the effect of temperature on callus activity, the percentage of success of grafting was observed minimum (51.67%) on 29th October at 36.76°C, then started rising up to the 13th January (96.11%) at 25.69°C and declining started from 28th January (91.11%) at 27.60°C and onwards (Figure 1).

Present finding was also supported by Poon (1999) who reported 88.73% success with shoot tip and 91.75% success with veneer method in mandarin. Gautam et al (2001) reported 31st January grafting gave the highest (87.5%) and 16th January produced 85.0% graft success in mandarin. Similarly, Adhikari (2006) reported highest graft success (79.73%) in acid lime grafted onto trifoliate orange rootstock on 16th January by shoot tip method.

Mortality of sprouted grafts

Mortality is the percentage of dead grafts after sprouting to the total number of sprouted grafts. Up to the final observation on 12th August, the number of plants died after sprouting was found to be relatively affected by the dates and methods of grafting. Higher percentage of mortality was found in shoot tip method as compared to veneer method of grafting. The highest graft mortality at final observation was recorded in the grafts prepared on 12th February, 4.5% in shoot tip and 2.9% in veneer method, respectively. The minimum mortality of sprouted grafts, 0.25% in shoot tip and 0.10% in veneer method was recorded on 29th December grafting. Different dates and methods of grafting gave different mortality rate at final observation on 12th August (Figure 2).

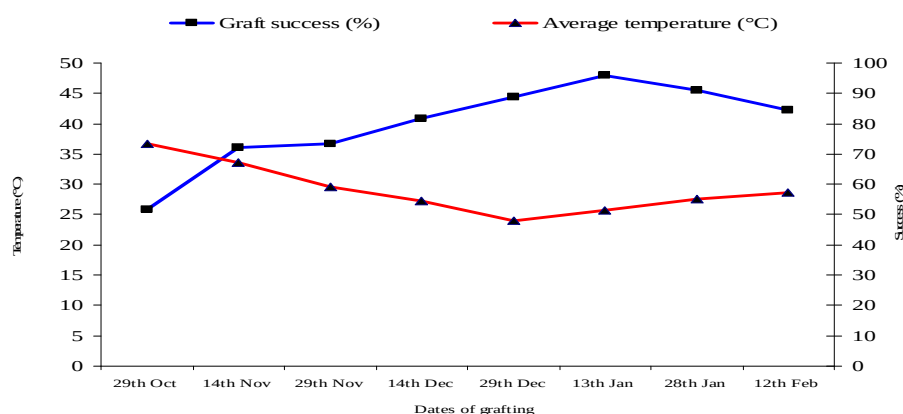


Fig 1. Relation of average tunnel temperature with graft success in different dates of grafting in Paripatle, Dhankuta, 2009/2010

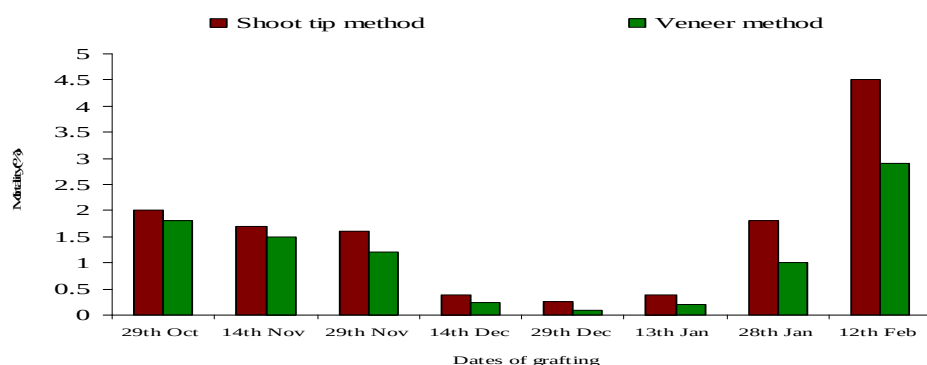


Fig 2. Mortality of sprouted grafts of mandarin in different dates and methods of grafting in Paripatle, Dhankuta, 2009/2010

The higher mortality of sprouted graft prepared on 12th February was thus due to the lack of moisture needed to meet transpiration loss from the newly expanded leaves because union formation competed only at the end of March when there was higher temperature.

Number of leaves per sapling

The effect of methods of grafting on number of leaves per sapling was found insignificant from 60 days to 180 days after grafting. But the effect of dates on number of leaves per sapling was found highly significant from 60 days to 180 days after grafting (Table 2).

Early season grafted saplings also have well developed root system to absorb the water and nutrient, the rate of photosynthesis was also higher because of easy availability of raw materials for photosynthesis. Greater the food availability, there would be more growth of whole plant. Therefore, this may be the reason that October and November grafted sapling produced higher number of leaves per sapling. Present finding was also supported by Dubey and Singh (2003). They observed 47 leaves per sapling in Darjeeling mandarin grafted onto rough lemon at 11 months after grafting. Similarly, in another study, Adhikari (2006) reported the highest number of leaves (47) per plant at 135 days after grafting in acid lime in Chitwan.

Table 2. Effect of dates and methods of grafting on growth different parameters of mandarin sapling at 180 days after grafting in Paripatle, Dhankuta, 2009/2010

Treatments	Sapling growth				
	Number of leaves/sapling	Sapling height (cm)	Number of primary branches /sapling	Number of secondary branches/sapling	Canopy volume (cm ³)
Methods of grafting					
Shoot tip	29.89	31.00	1.950	1.793	1162.0
Veneer	29.71	31.88	1.892	1.903	1263.0
F value	0.08 ^{ns}	2.05 ^{ns}	2.15 ^{ns}	12.2726 ^{ns}	1.55 ^{ns}
CD (PG0.05)	2.776	2.650	0.1712	0.1361	350.7
SEm±	0.4562	0.4355	0.02814	0.02236	57.64
Dates of grafting					
29 th October	34.38 ^b	29.03 ^b	2.200 ^a	2.338 ^{ab}	973.3
14 th November	48.47 ^a	31.91 ^a	2.150 ^{ab}	2.505 ^a	1536.0
29 th November	33.23 ^b	31.97 ^a	2.017 ^{ab}	2.153 ^{ab}	1446.0
14 th December	24.73 ^c	30.39 ^{ab}	1.883 ^{ab}	1.808 ^{bcd}	1094.0
29 th December	26.93 ^{bc}	32.86 ^a	1.800 ^{bc}	2.035 ^{abc}	1204.0
13 th January	21.93 ^c	30.43 ^{ab}	1.867 ^{abc}	1.333 ^{de}	1077.0
28 th January	24.19 ^c	32.74 ^a	1.533 ^c	1.172 ^e	1179.0
12 th February	24.53 ^c	32.17 ^a	1.917 ^{ab}	1.442 ^{cde}	1192.0
CV (%)	20.31	6.79	14.08	26.15	31.15
F value	12.55**	2.38*	3.61**	6.1969**	1.51 ^{ns}
CD (PG0.05)	7.158	2.526	0.3195	0.5721	446.8
SEm±	2.471	0.8720	0.1103	0.1975	154.2

SEm±, standard error of mean difference; CV, coefficient of variation; CD (PG0.05), critical difference at probability value 0.05, DAG, days after grafting; Treatment means followed by common letter(s) within a column are not significantly different at 5% by DMRT.

Sapling height

The effect of methods of grafting on sapling height was found insignificant from 60 days to 180 days after grafting. But the effect of dates on sapling height was found highly significant at 60 days to 150 days after grafting while significant at 180 days after grafting (Table 2).

Higher number of leaves per sapling produced more photosynthate and plant growth regulators, especially gibberellins, causing the faster elongation of internodes of main stem and branches as well. Similarly, accelerated growth of shoot also produced more new roots producing excess auxins, causing the dominance of main shoot over the side branches resulting into increased sapling height. The increased number of primary and secondary branches resulted number of leaves which ultimately caused the increased sapling height. Present finding was also supported by several researchers. Paudyal (1999) found somewhat similar height of pummel grafted onto the trifoliate orange rootstock in November. Gautam et al (2001) reported the highest sapling height grafted on 20th November and 7th December and lowest on 3rd March grafting. In another study, Dubey and Singh (2003) reported that at 11 months after grafting, Darjeeling mandarin grafted onto rough lemon rootstock produced 29.53 cm scion height. Similarly, the scion height of 21.23 cm was reported by Adhikari (2006) in acid lime grafted onto trifoliate orange rootstock at 4 months after grafting. In the present study, 6 months after grafting, mandarin onto trifoliate orange rootstock produced much lower scion height (17.86 cm) this was may be due to the use of dwarfing rootstock and difference in species taken under study and difference in climatic condition of the research sites.

Number of primary branches

The effect of methods of grafting on number of primary branches per sapling was found insignificant, whereas the effect of dates of grafting on number of primary branches per sapling varied at different dates of observation (Table 2).

Highly significant positive correlation was observed between the number of primary branches per sapling and the number of leaves (0.621), sapling height (0.566) and the number of secondary branches per sapling (0.609). The ultimate growth of sapling is dependent primarily on the number of leaves per sapling which was affected by the number of primary and secondary branches on the plant. Adhikari (2006) reported highest number of primary branches (3.11) per sapling in acid lime grafted on 16th January at 135 days after grafting in Chitwan, which was higher than the present result. This may be due to difference in species taken under the study and climatic conditions of the research sites.

Number of secondary branches

The effect of methods of grafting on number of secondary branches per sapling was found insignificant while dates of grafting were found highly significant at all the observation (Table 2).

Highly significant positive correlation was found between the number of secondary branches and the number of leaves (0.836), sapling height (0.794) and the number of primary branches (0.609). Higher number of leaves per sapling accumulated more photosynthate and phytohormone which contributed for higher growth of sapling. Greater sapling height, more number of primary branches gave the higher number of secondary branch per sapling in mandarin. The number of secondary branches per sapling in the present study was much lesser than reported by Adhikari (2006). He observed 5.20 secondary branches per sapling on 31st January grafted sapling of acid lime in Chitwan. This may be due to the difference in species taken under the study and climatic conditions of the research sites.

Canopy volume

The effect of methods of grafting on graft spread was found insignificant. But the effect of dates of grafting on graft spread was found highly significant at 60 and 90 days after grafting and insignificant at rest of the observations (Table 2).

Highly significant positive correlation was observed between the canopy volume and number of leaves per sapling (0.912) and height of sapling (0.933) of the mandarin sapling (Table 3). Adhikari (2006) reported the maximum volume of the canopy (5077.0 cm³) and the minimum (1799.0 cm³) in acid lime at 120 days after grafting which was very high as compared to the present finding. This might be due to the difference in species used under the study and variation in the climate. This finding is much higher than the findings of Poon (1999). He reported graft volume of 130 and 105 cm³ in veneer and shoot tip methods of grafting in mandarin grafted onto trifoliate orange rootstock.

Table 3. Correlation coefficient between different parameters of mandarin sapling in Paripatle, Dhankuta, 2009/2010

Parameters	lnos	sht	pbrnos	sbrnos	Canvol
lnos	1.000	0.859**	0.621**	0.836**	0.912**
sht		1.000	0.566**	0.794**	0.933**
pbrno			1.000	0.609**	0.547**
sbrnos				1.000	0.822**
canvol					1.000

**, correlation is highly significant at the 0.01 level (2-tailed); lnos, number of leaves; sht, sapling height; pbrnos, number of primary branches; lpbr, length of primary branches; sbrnos, number of secondary branches; lsbr, length of secondary branches; gspr, graft spread; canvol, canopy volume

Mandarin fruits can be propagated successfully through grafting. Either shoot tip or veneer method can best be used with higher rate of success, because shoot tip and veneer method did not differ significantly in their effect on success and growth of mandarin sapling. The effect of dates on success and growth of sapling was found highly significant. Grafting on 13th to 28th January was the most suitable time of grafting for achieving the highest success, because 13th January produced 96.11% and

28th January produced 91.11% success, statistically, they were at par. The growth of sapling showed no clear trend at 180 days after grafting. Sapling prepared on 29th October produced the highest number of primary branches (2.2); 14th November gave the highest number of leaves (48.47), secondary branches (2.505), maximum canopy volume (1536.0 cm³); 29th December gave the maximum sapling height (32.86 cm).

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Screening of True Potato Seed (TPS) Families for Tuber (F1C1) Production in Mid-Western Terai

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ABSTRACT

The experiment was carried out at Regional Agriculture Research Station, Khajura, Nepalgunj during the winter seasons of 2066/2067 and 2067/2068. Studies were performed taking seedling tubers of six TPS families, namely C96H-02.4xC99HT-2-32.43, C96H-02.4xC99HT-2-32.17, C96H-02.4xC99HT-1-58.1, C5HA-01.5xC99HT-2-32.17, C95HA-01xC99HT-2-32.43, C95HA-01.2xC959HT2-32.17 and Kufri Sinduri as a local check. The experiments were laid out in randomized complete block design (RCBD) with four replications. Plot size of 3.0 m x 2.4 m maintained and 48 seedling tubers were planted in four rows with spacing of 60 cm x 25 cm in each plot. Fertilizers were applied @100:100:60 kg/ha (NPK) and 20 t/ha compost. Observations were recorded as growth and yield attributing characters in order to identify the suitable true potato seed (TPS) families for tuber production in the mid-western terai. The highest tuber (F1C1) yield was produced by C96H-02.4xC99HT-2-32.17 (24.5t/ha) and followed by C96H-02.4xC99HT-2-32.43 (23.3t/ha). Lower late blight scoring was recorded in C95HA-01.2xC959HT2-32.17 (score 1.9) and C96H-02.4xC99HT-2-32.17 (score 2.1). All tested families of TPS bear white color. On the basis of results obtained it can safely be concluded that TPS family C96H-02.4xC99HT-2-32.17 (24.5t/ha) and C96H-02.4xC99HT-2-32.43 (23.3t/ha) were promising for tuber (F1C1) production in the mid-western terai. However, for recommendation, it requires further verification.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a major food crop of Nepal. It is utilized as a major vegetable in terai and mid hills; and as a vegetables and staple food in the high hills (Khairegoli 1997). Average productivity of potato in Nepal is very low, 13.58 t/ha (MoAC 2010) as compared to the neighboring countries and the world average. The major causes for this lower productivity are the high cost, poor quality seed and disease (NPRP 1990, NPRP 1997). There has been an increasing interest of the farmers in the production of potatoes from true potato seed. TPS offers alternative technology of crop production for the mid-western regions where resource poor farmers can have quality planting material of reasonable quality. There are several advantages of using TPS for potato production including the cost. It can almost reduce more than 50% cost of cultivation (Sadik 1983). Most of the pathogens are not transmitted to next generation through seed. It would make possible expansion of potato cultivation into areas previously unable to produce potato, due to the lack of good quality seed tubers (Acantino and Malagamba 1983, Sadik 1983). The production of seedling tubers from the TPS in the first season and planting them to raise the crop in the succeeding season appears promising for ware potato production. Hence, this investigation was undertaken to evaluate the TPS families for tuber (F1C1) production.

MATERIALS AND METHODS

The experiment was conducted during the winter season of 2066/2067 and 2067/2068 at the Regional Agriculture Research Station, Khajura (RARS), Nepalgunj. Studies were performed taking seedling tubers of six TPS families, namely C96H-02.4 x C99HT-2-32.43, C96H-02.4 x C99HT-2-32.17, C96H-02.4 x C99HT-1-58.1, C5HA-01.5 x C99HT-2-32.17, C95HA-01 x C99HT-2-32.43, C95HA-01.2 x C959HT2-32.17 and Kufri Sinduri as a local check. The experiments were laid out in randomized complete block design with four replications, plot size of 3.0 m x 2.4 m maintained and 48 seedling tubers were planted in four rows with spacing of 60 cm x 25 cm in each plot. Fertilizers were applied @ 100:100:60 kg/ha (NPK) and 20 t/ha compost. The other cultural practices were applied as per the recommendation. Observations were recorded as plant uniformity, ground cover percent, plant height (cm), stem number/plant, late blight scoring, tuber number and weight by size class, total number of tuber and yield (kg/plot), yield (t/ha), tuber shape and tuber color. Data were analyzed in MSTATC.

RESULTS AND DISCUSSION

Plant uniformity

The plant uniformity was recorded after 60 days of planting on 1-5 scale. The examination of data in the mean table regarding plant uniformity indicated that the effect of TPS family were insignificant in both the years. However, the two years mean data showed maximum level of plant uniformity 2.9 in C96H-02.4 x C99HT-2-32.17 and minimum 2.3 in C95HA-01 x C99HT-2-32.43.

Ground cover percent

A highly significant difference was observed on ground cover percent in the effect of TPS families. In the year 2066, C96H-02.4 x C99HT-2-32.43 bear significantly maximum ground cover percent (35%) followed by C95HA-01.2 x C959HT2-32.17 (34.5%) whereas minimum ground cover by C5HA-01.5 x C99HT-2-32.17(31.0%). In the year 2067, significantly maximum ground cover percent was recorded by C96H-02.4 x C99HT-2-32.43 (47.5%) whereas minimum by variety Kufri Sinduri (31%). The mean data showed the ground cover was maximum in family C96H-02.4 x C99HT-2-32.43 (41.3%) and minimum in Kufri Sinduri (31.2%).

Plant height

In the year 2066, C96H-02.4 x C99HT-2-32.43 gave maximum plant height (44.20 cm) followed by C95HA-01.2 x C959HT2-32.17 (44.10 cm) and minimum recorded in Kufri Sinduri (37.2 cm). In the year 2067, significantly maximum plant height was recorded in C96H-02.4 x C99HT-2-32.43 (64.3 cm) followed by C96H-02.4 x C99HT-2-32.17 (61.0 cm), and minimum in Kufri Sinduri (37.0 cm). The mean data showed that the maximum plant height was in C96H-02.4 x C99HT-2-32.43 (54.3 cm) and minimum in Kufri Sinduri (37.1 cm).

Stem number/plant

Maximum number of stems per plant was recorded in C95HA-01.2 x C959HT2-32.17 (2.4), whereas minimum in C96H-02.4 x C99HT-2-32.17 (1.6). In the year 2067, the data did not show significant difference. It ranged from 2.5 to 1.8 stem per plant. The maximum number of stem/plant was counted in C95HA-01.2 x C959HT2-32.17 (2.4) and minimum in Kufri Sinduri (1.8).

Late blight scoring

The late blight scoring was taken at 20 days before harvesting on 1-9 scale. The analysis of individual year results showed a significant difference among the tested families. In the year 2066, minimum disease was observed in C95HA-01.2 x C959HT2-32.17 (1.8) and maximum in Kufri Sinduri (3.3). In

the year 2067, minimum disease was observed in family C96H-02.4 x C99HT-2-32.17 (1.5) and maximum in Kufri Sinduri (3.0). The two years mean data showed that the minimum late blight reading was found in C95HA-01.2 x C959HT2-32.17 (1.9) and maximum in Kufri Sinduri (3.2).

Under size tuber number per plot

Significant differences observed in the under size tuber number in both the years among the tested families. In the year 2066, significantly maximum number per plot was recorded in Kufri Sinduri (144.3) followed by C96H-02.4 x C99HT-2-32.43 (135.0) and minimum in C95HA-01.2 x C959HT2-32.17 (87.3). Also in the year 2067, the differences were found significant. The minimum number of under size tuber was counted in C95HA-01 x C99HT-2-32.43 (73.0) and maximum in C96H-02.4 x C99HT-2-32.43 (163.5). The two years' mean data revealed that the minimum number of under size tuber was found in C95HA-01 x C99HT-2-32.43 (89.4) and maximum in C96H-02.4 x C99HT-2-32.43 (149.3).

Under size tuber weight

In the year 2066, mean data table showed significant difference among the tested families. Maximum under size weight per plot was recorded in family C96H-02.4 x C99HT-2-32.17 (1.4 kg) and Kufri Sinduri (1.4 kg) and minimum was in C95HA-01.2 x C959HT2-32.17 (0.9 kg). In the year 2067, data did not show any difference. Maximum under size weight was recorded in C96H-02.4 x C99HT-2-32.43 (1.5 kg) and minimum weight per plot in C95HA-01 x C99HT-2-32.43 (0.8 kg). The two year mean data revealed that the highest under size yield recorded in Kufri Sinduri (1.4 kg) and minimum in C95HA-01.2x C959HT2-32.17 (0.9 kg).

Seed size tuber number per plot

In both the years, the differences on seed size tuber number were significant among the tested families. In the year 2066, maximum seed size number was counted in Kufri Sinduri (193.8) followed by family C96H-02.4 x C99HT-2-32.17 (181.8) and minimum in C95HA-01.2 x C959HT2-32.17 (109.5). In the year 2067, significantly maximum seed size number was harvested in C96H-02.4 x C99HT-1-58.1 (407.0) followed by C96H-02.4 x C99HT-2-32.17 (400.0), and minimum in Kufri Sinduri (193.8). The two years' mean data showed that the maximum seed size number was given by family C96H-02.4 x C99HT-2-32.17 (290.9) and minimum by Kufri Sinduri (193.8).

Seed size tuber weight per plot

In both the years, all the tested families were found significantly different. In the year 2066, maximum seed size tuber weight per plot was found in C96H-02.4 x C99HT-2-32.17 (8.6 kg) followed by C95HA-01 x C99HT-2-32.43 (8.3) and minimum in C95HA-01.2 x C959HT2-32.17 (4.7 kg). In the year 2067, maximum weight was recorded in C96H-02.4 x C99HT-2-32.43 (18.4 kg) followed by C96H-02.4 x C99HT-2-32.43 (16.2) whereas minimum in Kufri Sindhuri (7.5). The two years' mean data showed maximum seed size tuber weight per plot was found in C96H-02.4x C99HT-2-32.17 (12.4 kg) and minimum in Kufri Sinduri (7.5 kg).

Over size tuber number per plot

In the year 2066, data did not show significant difference. Maximum over size tuber number was recorded in C96H-02.4 x C99HT-1-58.1 (43.31) and minimum in Kufri Sinduri (19.0). In the year 2067, significantly maximum over size tuber number was found in C96H-02.4 x C99HT-2-32.17 (22.0) followed by C95HA-01.2 x C959HT2-32.17 (21.0), and minimum in C95HA-01 x C99HT-2-32.43 (10.8). The two years' mean data showed that the maximum over size tuber number was recorded in C96H-02.4 x C99HT-1-58.1 (28.9) and minimum in Kufri Sinduri (19.0).

Table 1. Yield and yield attributing characters

Genotypes	Plant uniformity (1-5)			Ground cover (%)			Plant height (cm)			Stem number/plant			Late blight (1-9)		
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean
C96H-02.4xC99HT-2-32.43	2.3	2.8	2.5	35.0	47.5	41.3	44.2	64.3	54.3	1.9	2.5	2.2	2.3	2.3	2.3
C96H-02.4xC99HT-2-32.17	2.5	3.3	2.9	33.8	42.5	38.2	40.5	61.0	50.8	1.6	2.0	1.8	2.7	1.5	2.1
C96H-02.4xC99HT-1-58.1	2.5	2.3	2.4	31.0	35.0	33.0	42.0	53.0	47.5	1.7	1.9	1.8	2.3	2.3	2.3
C5HA-01.5xC99HT-2-32.17	2.5	2.3	2.4	30.8	41.3	36.1	37.7	57.3	47.5	2.3	1.9	2.1	2.5	1.8	2.2
C95HA-01xC99HT-2-32.43	2.3	2.3	2.3	34.3	33.8	34.1	40.1	51.0	45.6	1.7	2.0	1.8	2.5	2.3	2.4
C95HA-01.2xC959HT2-32.17	2.3	2.5	2.4	34.5	42.5	38.5	44.1	57.8	50.9	2.4	2.1	2.3	1.8	2.0	1.9
Kufri Sinduri	2.5	2.3	2.4	31.3	31.0	31.2	37.2	37.0	37.1	1.7	1.8	1.8	3.3	3.0	3.2
F-Test	NS	NS		**	**	**	**	**		*	ns		*	*	
LSD (0.05)	-	-		1.7	5.31		2.6	6.5		0.5	-		0.7	0.8	
CV (%)	24.4	20.0		3.4	9.9		4.4	8.0		19.1	19.0		21.0	26.0	

***, significant at 1% and 5% level, respectively; ns, not significant

Table 2. Tuber number and weight (kg)/plot by size class

Genotypes	Under size <25g			Seed size 25-50g			Over size >50g		
	Tuber number			Tuber weight(kg)			Tuber weight(kg)		
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean
C96H-02.4xC99HT-2-32.43	135.0	163.5	149.3	1.1	1.5	1.3	129.3	367.8	248.6
C96H-02.4xC99HT-2-32.17	117.8	132.3	125.1	1.4	1.1	1.3	181.8	400.0	290.9
C96H-02.4xC99HT-1-58.1	104.0	119.0	111.5	1.1	1.2	1.2	155.0	407.0	281.0
C5HA-01.5xC99HT-2-32.17	119.3	136.3	127.8	1.2	1.1	1.2	133.3	322.5	277.9
C95HA-01xC99HT-2-32.43	105.8	73.0	89.4	1.1	0.8	1.0	168.0	251.0	209.5
C95HA-01.2xC959HT2-32.17	87.3	96.5	91.9	0.9	0.9	0.9	109.5	280.0	194.8
Kufri Sinduri	144.3	144.3	144.3	1.4	1.4	1.4	193.8	193.8	193.8
F-Test	*	*		NS	NS		*	**	
LSD (0.05)	30.5	45.2		0.39	-		52.5	114	
CV (%)	18	25		23	28		23	24	

***, significant at 1% and 5% level, respectively; ns, not significant

Over size tuber weight per plot

In year 2066, the mean data did not show significant difference among the tested family. Maximum over size tuber per plot was produced by family C96H-02.4 x C99HT-1-58.1 (4.7 kg) followed by C96H-02.4 x C99HT-2-32.43 (4.5 kg) and Kufri Sinduri produced minimum (1.5 kg). In the year 2067, data showed highly significant difference among the tested family, maximum was recorded in C95HA-01.2 x C959HT2-32.17 (4.3 kg) followed by C96H-02.4 x C99HT-2-32.17 (4 kg), and minimum by Kufri Sinduri (1.5 kg). The two years mean data showed maximum weight was in family C96H-02.4 x C99HT-2-32.17 (4.1 kg) and minimum in Kufri Sinduri (1.5 kg).

Total tuber number per plot

The total tuber number/plot of both years was found significantly different among all the tested families. In the year 2066, significantly maximum tuber number per plot was recorded in Kufri Sindhuri (357.5) followed by family C96H-02.4 x C99HT-2-32.17 (333.5) whereas C95HA-01.2 x C959HT2-32.17 produced minimum (226.8). In the year 2067, maximum total tuber number was harvested in C96H-02.4 x C99HT-2-32.17 (549.8) followed by C96H-02.4 x C99HT-2-32.43 (545.0), and minimum in C95HA-01 x C99HT-2-32.43 (3348). The two years mean data showed that the maximum total tuber number per plot was in C96H-02.4 x C99HT-2-32.17 (441.7) and minimum in C95HA-01.2 x C959HT2-32.17 (312.2).

Total tuber weight (kg/plot)

The tuber weight kg per plot of both years was found significantly different among the tested family. In the year 2066, maximum weight was recorded in C96H-02.4 x C99HT-2-32.17 (14.3 kg) followed by C96H-02.4 x C99HT-1-58.1 (13.7 kg), and minimum in C95HA-01.2 x C959HT2-32.17 (8.8 kg). In the year 2067, significantly maximum tuber yield was in C96H-02.4 x C99HT-2-32.43 (22.5 kg) followed by C96H-02.4 x C99HT-2-32.17 (21.1 kg) and minimum in Kufri Sindhuri (10.3 kg). The two years mean data table showed that the maximum yield was recorded in C96H-02.4 x C99HT-2-32.17 (17.7 kg) and minimum in Kufri Sinduri (10.3 kg).

Tuber yield

In the year 2066, significantly highest yield ton per hectare was recorded in the family C96H-02.4 x C99HT-2-32.17 (19.8 t/h) followed by C96H-02.4 x C99HT-1-58.1 (19.0 t/h), and minimum yield was recorded in C95HA-01.2 x C959HT2-32.17(12.2 t/h). In the year 2067, significantly highest yield was produced by C96H-02.4 x C99HT-2-32.43 (31.2 t/h) followed by C96H-02.4 x C99HT-2-32.17 (29.2 t/h), and minimum by Kufri Sinduri (14.4 t/h). The two years mean data showed maximum yield was given by C96H-02.4 x C99HT-2-32.17(24.5 t/h) and minimum by Kufri Sinduri (14.4 t/h).

Tuber uniformity

In the year 2066, in respect of tuber uniformity mean data did not show significant difference. Maximum uniform tuber was produced by C95HA-01 x C99HT-2-32.43 (2.8) and Kufri Sinduri (2.8) whereas less uniform tubers were produced by C96H-02.4 x C99HT-2-32.43 (2.0). In the year 2067, highly uniform tuber was produced by C95HA-01 x C99HT-2-32.43 (3.0) whereas less uniform tuber was produced by family C96H-02.4 x C99HT-2-32.43 (1.5). The two years mean data showed that maximum uniform tuber was produced by C95HA-01 x C99HT-2-32.43 (2.9) whereas less uniform tuber was produced by family C96H-02.4 x C99HT-2-32.43 (1.8).

Table 3. Yield and yield attributing characters

Genotypes	Tuber number/plot		Tuber weight, kg/plot		Yield, t/ha		Tuber color	Tuber shape
	2066	2067	Mean	2066	2067	Mean	2066	2067
C96H-02.4xC99HT-2-32.43	307.3	545.0	426.2	11.1	22.5	16.8	15.4	31.2
C96H-02.4xC99HT-2-32.17	333.5	549.8	441.7	14.3	21.1	17.7	19.8	29.2
C96H-02.4xC99HT-1-58.1	302.3	540.5	421.4	13.7	17.8	15.8	19.0	24.7
C5HA-01.5xC99HT-2-32.17	283.3	471.5	377.4	10.4	19.4	14.9	14.3	26.9
C95HA-01xC99HT-2-32.43	312.8	334.8	323.8	13.4	13.9	13.7	18.7	19.2
C95HA-01.2xC959HT2-32.17	226.8	397.5	312.2	8.8	19.4	14.1	12.2	27.0
Kufri Sinduri	357.5	357.5	357.5	10.3	10.3	10.3	14.4	14.4
F-Test	*	**		*	**		*	**
LSD (0.05)	60.6	127.1		3.4	3.4		4.7	4.8
CV (%)	13	19		20	13		20	13

**, * significant at 1% and 5% level, respectively

Tuber colour and shape

All the tested TPS families bear white color and Kufri Sinduri bear red color. Similarly, C96H-02.4 x C99HT-2-32.43, C96H-02.4 x C99HT-2-32.17, C96H-02.4 x C99HT-1-58.1, C5HA-01.5 x C99HT-2-32.17 bear round shape tubers, whereas C95HA-01 x C99HT-2-32.43, C95HA-01.2 x C959HT2-32.17 bear oblong shape and Kufri Sinduri bear round shape tubers. The TPS family C96H-02.4 x C99HT-2-32.17 (24.5 t/ha) and C96H-02.4 x C99HT-2-32.43 (23.3 t/ha) were promising for tuber (F1C1) production in mid-western terai of Nepal. However for recommendation, it requires further verification.

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Juice Extraction and Quality Evaluation of Malbhog Harichal and Athiya Varieties of Banana

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ABSTRACT

Matured banana of varieties Malbhog, Harichal and Athiya were collected from Chitwan, Balkhu and Dharan, respectively. Combs separated from bunch were allowed for ripening. During ripening, average pH and acidity (%) were observed daily till fully ripened and was found increased gradually with different treatments for ripening. The average pH, acidity and TSS of ripened Malbhog, Harichal and Athiya were found 4.5, 0.684 and 21.53, 4.44, 0.7538 and 20.76 and 4.7, 0.4422 and 25.63, respectively. Analysis for moisture content was recorded to be 70.25, 71.72 and 68.65%; total sugar was recorded as 18.43, 17.24 and 20.36%; protein as 1.44, 1.10 and 1.62%; pectin as 0.95, 0.73 and 0.85%; crude fiber as 0.38, 0.39 and 0.66%, respectively. Ash was recorded as 0.89, 0.96 and 1.15%; vitamin C as 15.74, 12.09 and 11.88 mg/100 g; iron 0.4, 0.55 and 0.72 mg/100 g; calcium 11.96, 12.10 and 18.34 mg/100 g; phosphorus 0.31, 0.28 and 0.26 mg/100 g; and fat 0.39, 0.43 and 0.30%, respectively. In addition, ripened banana, juice was extracted by using pectinase enzyme incubating at 32°C for 2 hours followed by squeezing. The juice was then clarified, filled in glass bottle, sealed, pasteurized and stored for self life observation. Sensory evaluation of all juices was carried out according to hedonic rating method and liked by majority of panelists. The pasteurized juice was found in good sensorial condition up to 6 months.

INTRODUCTION

Banana, *Musa sapientum*, is one of the world's most important fruits. It is consumed extensively throughout the tropics, where it is grown, and in the temperate zone, where it is popular because of its flavor, its food value and its availability at all times of the year. There are 100 or more varieties of the banana in cultivation in different parts of the world with diverse names applied to same varieties.

Banana is one of the most used fruits in the Mediterranean diet. Therefore, banana appear to be especially important in terms of public health as they are consumed in large quantities and are rich in several compounds believed to provide protection from or reduce the risk of contracting chronic degenerative diseases (Carlo 2002). When ripe, the fruit contains as much as 22% of carbohydrate, mainly sugar; it is high in ash and a good source of several vitamins. So, from the banana several value added products such as nectar, candy, chips etc. can be made (Encyclopedia 1960).

In Nepal, Chitwan, Nawalparasi, Jhapa, Morang and Saptari districts are the main producers and Kathmandu, Pokhara, Birgunj and Biratnagar are the major areas of banana consumption. Now a days, banana cultivation is in increasing trend. In Nepal, with different climatic conditions, some of the popular varieties of banana having local name are Malbhog, Harichal, Jhapri, Dhusure, Chini champa, Bhandari, Kurkure, Tin kesre, Marche, Jahaji, Mungri, Ghu kera and Athiya.. Among them Malbhog and Harichal are high yielding and largely available in market (Personnel communication with 5 banana farmers and entrepreneurs of Chitwan on 15 August 2010).

MATERIALS AND METHODS

Ripening, candying and juicing

Malbhog was collected from farms of Chitwan, Harichal was collected from fruit collection center Balkhu, Kathmandu and Athiya was collected from Dharan market at matured stage. The maturity was observed externally by its shape, size and color. Individual combs were separated from bunch. Majority part of separated banana combs were left for ripening with different treatments such as sample M_A, H_A and A_A ripening was carried out by hanging in air without any treatment, sample M_B, H_B and A_B, ripening was carried out by wrapping in polyethylene bag. Similarly sample M_C, H_C and A_C, ripening was carried out by wrapping with green leaves of *Dhusmeto* (herb) and packed in polyethylene bag. The ripened banana was taken for juicing by treating with enzyme pectinase (0.05% in water by weight) by the rate of 5 ml per 100 g of peeled banana. The general outline for juice preparation is shown in Figure 2.1.

Physicochemical analysis

Ripened banana of different treatments were analyzed for pH, acidity and total soluble sugar from the day of changing the color of peel, yellowish, in every day till optimum ripening conditions. Proximate and some ultimate compositions such as moisture, fat, total sugar, protein, pectin, crude fiber, total ash, vitamin C, iron, calcium and phosphorus contents of all three varieties of banana were analyzed. The testing procedures for all parameters were determined according to Ranganna (1997).

Sensory evaluation

Sensory evaluations of banana juices from all three varieties were carried out by 15 panelists according to hedonic rating test. This rating relates to pleasurable or non-pleasurable experiences in choosing and eating a food. Panelist was asked to rate the acceptability of the product on a scale usually of 9 points, ranging from like extremely like (1) to dislike extremely (9). The results were analyzed statistically for preference with data from panels (Ranganna 1997).

RESULTS AND DISCUSSION

Physicochemical changes

Ripening of Malbhog varieties' samples started from 3rd day of treatment at room temperature 27°C with yellow color appearance. The samples M_B and M_C were started ripening from 3rd day of the treatment but sample M_A was started from 4th day of the treatment. The chemical changes of Malbhog variety is shown in Table 1.

Table 1. Chemical changes on first, second and third day of ripening (var. Malbhog)

Samples	pH	Acidity	TSS (°Bx)
On first day			
Sample M _A (4 th day of treatment)	5.0±0.1	0.41±0.03	10.2±0.2
Sample M _B (3 rd day of treatment)	4.7±0.1	0.43±0.04	13.2±0.2
Sample M _C (3 rd day of treatment)	4.8±0.1	0.43±0.03	11.8±0.1
On second day			
Sample M _A (5 th day of treatment)	4.6±0.1	0.54±0.04	16.4±0.2
Sample M _B (4 th day of treatment)	4.5±0.1	0.67±0.03	19.2±0.1
Sample M _C (4 th day of treatment)	4.6±0.1	0.54±0.03	16.5±0.2
On third day			
Sample M _A (6 th day of treatment)	4.4±0.1	0.78±0.03	21.8±0.2
Sample M _B (5 th day of treatment)	4.5±0.1	0.67±0.03	21.5±0.2
Sample M _C (5 th day of treatment)	4.6±0.1	0.61±0.03	21.3±0.2

Values are the mean of three determinations, ± standard deviation

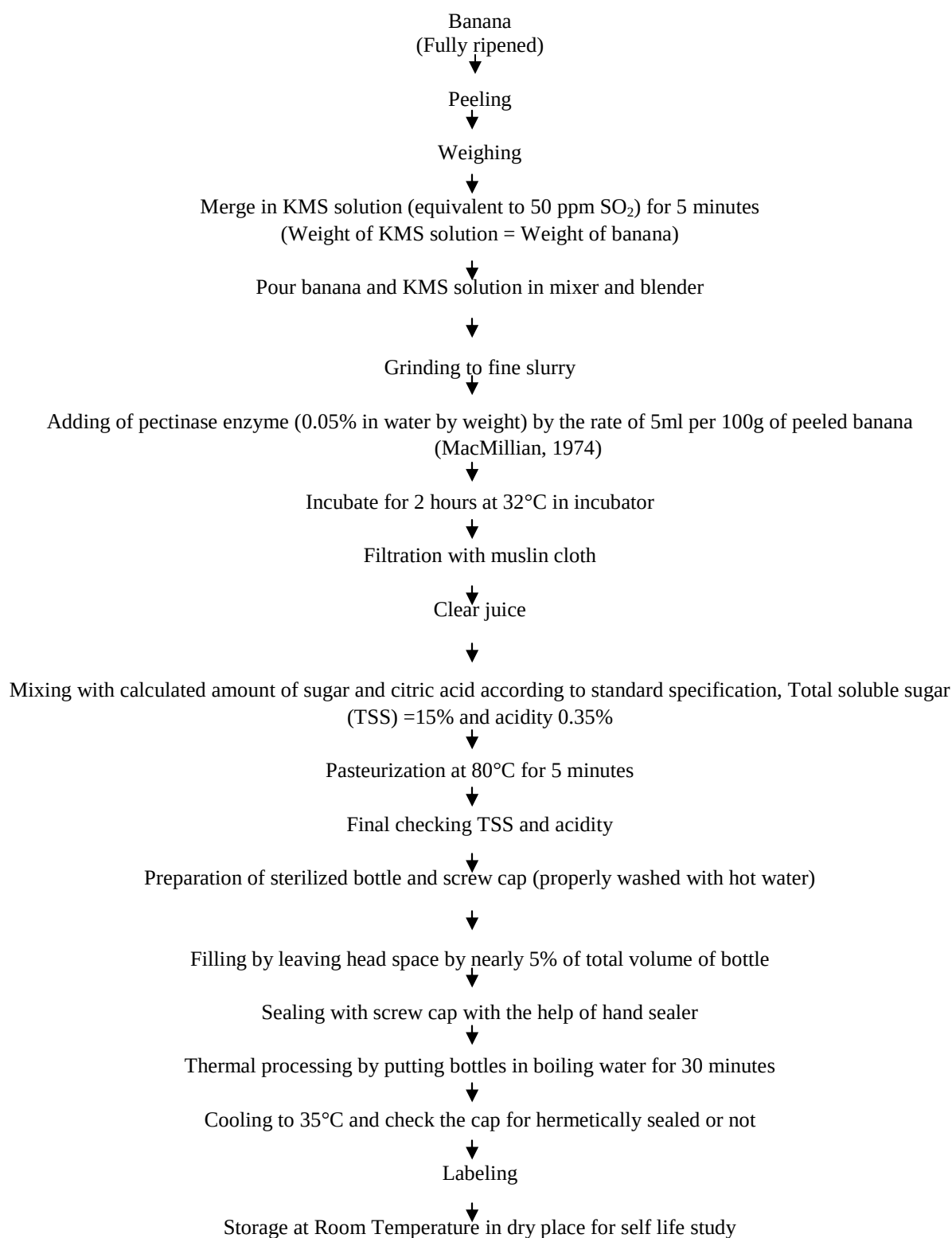


Figure 1. Flow diagram to prepare Banana juice (Lal Girdhari 2000)

Response of Different Organic Manures on Fresh Cherry Yield of Coffee

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ABSTRACT

A three year (2008-2010) collaborative study was conducted on response of organic manures on fresh cherry yield of coffee at Agriculture Research Station (Horticulture), Malepatan, Pokhara. Farm yard manure (FYM), pig litter, mustard oil cake and poultry manure were evaluated on four coffee varieties (Pacamara, Pacas, Tekisic and Chhetradeep). Poultry manure @ 5 t ha⁻¹ gave the highest fresh cherry yield (1805.85 kg ha⁻¹) followed by mustard oil cake @ 2.5 t ha⁻¹ (1731.83 kg ha⁻¹), pig litter @ 10 t ha⁻¹ (1538.24 kg ha⁻¹) and FYM @ 10 t ha⁻¹ (1458.77 kg ha⁻¹). However, the differences were not significant. The highest mean yield of fresh cherry (2290.14 kg ha⁻¹) was found in 'Tekisic' variety followed by Chhetradeep (1683.76 kg ha⁻¹), Pacas (1520.12 kg ha⁻¹) and Pacamara (1040.66 kg ha⁻¹). The 'Tekisic' variety and 'Chhetradeep' (locally grown coffee) recorded as promising coffee varieties for the fresh cherry production under Malepatan conditions.

INTRODUCTION

Coffee, a evergreen and perennial shrub, which is a new cash crop cultivating since 1995 B.S. (Devkota 2061) in the hilly districts of western and central region of Nepal. The province 'Kaffa' in Ethiopia is considered to be the original habitat of Arabica coffee. In high value plantation commodities like coffee, there is a very good scope for organic farming. It has high potential to get higher returns from unit quantity exported, when produced by organic means (CCRI 2000). More than 270 mt of coffee was exported during last fiscal year (2010/2011) from Nepal to abroad on the understanding of organic-based production.

The productivity of green bean coffee in Nepal is 300 kg ha⁻¹, which is very low as compared to other countries (Dhakal 2061). The area under coffee cultivation is increasing each year and more than 25000 farmers are involved in the coffee farming. The total area and production (parchment) during the F.Y. 2066/067 were 1630 ha and 417 mt, respectively (NTCDB 2068). The production of coffee is not enough to run the existing coffee-based industries smoothly. Shrestha (2004) expressed that lack of research, unavailability of high quality sapling of coffee of known origin have become major constraints to increase the productivity and quality of coffee. Among different species of coffee, only the Arabica coffee is performing well under Nepalese conditions.

Coffee is grown on hilly ranges coming under high rainfall regions (CCRI 2000). Arabica coffee prefers a deep, well drained, slightly acidic loamy soil, rich in humus and exchangeable bases, particularly potassium. The total amount of phosphorus seems to be of less importance (Wrigley 1988). Therefore, there is suitable climate and soil existed for the better organic coffee farming in Nepal. In addition to soil and climate, it is necessary to identify the efficacy of type and amount of organic manures for better coffee production. Thapa et al (2009) reported that the most efficient combination of organic manure and chemical fertilizers for proper plant growth and development of

coffee was the application of FYM @ 10 t ha⁻¹ + N:P₂O₅:K₂O :: 100:30:60 kg ha⁻¹, respectively. Keeping these points in view, Agriculture Research Station (ARS), Horticulture at Malepatan, Pokhara in collaboration with National Tea and Coffee Development Board (NTCDB) conducted a study on "Response of different organic manures and varieties on fresh cherry yield of coffee" at Malepatan conditions during the years 2065-2067 BS with the objectives to identify effective organic manure for increases fresh cherry production of coffee and to identify the high yielding varieties of coffee.

MATERIALS AND METHODS

The characteristics of research site are as follows – site: ARS (Hort.) Malepatan, Pokhara, Kaski; altitude: 848 masl, aspect: south-west, plain; latitude: 28° 13' 6.18'' N; longitude: 83° 58' 27.72'' E; maximum temperature (2066 BS) : 32.0°C (June); minimum temperature: 7.6°C (January); Annual precipitation: 3323.8 mm (highest in August i.e., 1026.2 mm). About 80 percent rainfall occurs within four months (June to September) of rainy season. The site sometimes receives hailstone damages from February to May.

The experimental plots were laid out in factorial randomized complete block design in four replications covering 2500 m² of land under shade (Litchi plantations) during Mangsir, 2062. The size of each pits prepared was 0.45 m x 0.45 m at the distance of 2.0 m and 256 pits prepared in total. These pits were filled with four types of organic manures (farmyard manure, pig litter, mustard oil cake and poultry manure) as treatments given below. Manure was applied on the basis of 2000 plants per hectare. Seedlings of four varieties of coffee were planted during Chaitra, 2062. The preliminary cherry bearing was observed for the first time in the year 2064. Data of fresh cherry yield was collected for three years (2065-2067) and analyzed with the help of STATISTIX and MSTAT-C.

Varieties

V₁ – Pacamara
V₂ - Pacas
V₃ - Tekisic
V₄ - Chhetradeep

Treatments

T₁ - FYM @ 5.00kg/plant (10.00 t ha⁻¹) as control
T₂ - Pig litter @ 5.00 kg/plant (10.0 t ha⁻¹)
T₃ - Mustard oilcake @ 1.25 kg/plant (2.5 t ha⁻¹)
T₄ - Poultry manure @ 2.50 kg/plant (5.0 t ha⁻¹)

RESULTS AND DISCUSSION

Effect of treatments on fresh cherry yield of coffee

The effect of different treatments was not significant (Table 1). However, the maximum yield of fresh cherry (1805.85 kg ha⁻¹) was found in the treatment with poultry manure @ 5.0 t ha⁻¹ followed by mustard oil cake @ 2.5 t ha⁻¹ (1731.83 kg ha⁻¹). The minimum cherry yield (1458.77 kg ha⁻¹) was in the control treatment (FYM @ 10.0 t ha⁻¹). The mean values on fresh cherry yield due to application of mustard oil cake and poultry manure observed the higher than grand mean (i.e., 1633.67 kg ha⁻¹). The results, though not statistically significant, indicates that application of mustard oil cake and poultry manure could be better in fresh coffee production compared with farmyard manure and pig litter.

Effect of varieties on fresh cherry yield of coffee

The mean values on fresh cherry yield of coffee of different varieties for three years are presented in table 1. Mean yield varied from 1040.66 kg ha⁻¹ to 2290.14 kg ha⁻¹. Varietal response to fresh cherry yield was highly significant. The variety Tekisic gave the highest fresh cherry yield (2290.14 kg ha⁻¹) followed by the locally grown variety Chhetradeep (1683.76 kg ha⁻¹). The lowest yield (1040.66 kg

ha⁻¹) was found in Pacamara. Thus, coffee variety 'Tekisic' and local coffee 'Chhetradeep' were found promising for the fresh cherry production of coffee at Malepatan conditions.

Table 1. Fresh cherry yield⁺ of coffee varieties under different manuring

Variety/Treatment	Fresh cherry yield of coffee (kg ha ⁻¹)				Mean
	Pacamara	Pacas	Tekisic	Chhetradeep	
FYM @ 10 t ha ⁻¹ /Control	792.9	1534.7	1828.0	1682.5	1458.8
Pig litter @ 10 t ha ⁻¹	1204.2	1326.2	1930.9	1691.7	1538.2
Mustard oil cake @ 2.5 t ha ⁻¹	1163.9	1544.1	2583.3	1636.0	1731.8
Poultry manure @ 5.0 t ha ⁻¹	1001.7	1678.4	2818.5	1724.8	1805.9
Mean	1040.7c	1520.1b	2290.1a	1683.8b	
	LSD (0.05)	F-test	CV (%)		
			44.83		
Year (A)	371.7	**			
Replication (B) ⁰	429.2	ns			
Variety (C)	429.2	**			
Treatment (D)	429.16	ns			
S. E.	217.49				

+, Mean values for 3 years (2065, 2066 and 2067); **, Difference of means is significant at 1% level; ns, not significant; , Means in the row (variety mean) with similar letters are not significantly different by LSD (0.05); 0: Means due to replications are significantly different by LSD (0.10)

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Effect of Lime Application on Major Plant Nutrient Dynamism in Acidic Soils

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ABSTRACT

Acidic soil in cultivating farmland is considered to be a major problem in Nepal. A four-year experiment was conducted in acidic soil at Malepatan, Pokhara to identify the ways to solve the problem since 2007. Four doses of lime (0, 2, 4 and 6 t ha⁻¹), farmyard manure and with or without application of recommended dose of fertilizers were used in the experiment. Altogether, nine treatments were included in randomized complete block design with three replications. Cauliflower (Kathmandu Local) and Cowpea (Malepatan-1) were grown in the plots. The soil samples were collected after the harvest of cauliflower crop each year to study the plant nutrient dynamics in the soil. The pH of the soil increased from 5.17 to 5.61 (0.44 units up). The available phosphorus and potassium observed the highest (137.34 kg ha⁻¹ and 221.46 kg ha⁻¹, respectively), when agricultural lime applied @ 6 t ha⁻¹. However, the trend of phosphorus content of the soil observed decreased with time whereas, that of potassium increased. The percent organic matter and the nitrogen content of the soil observed the highest (3.87% and 0.174%, respectively) when farmyard manure alone applied @ 25 t ha⁻¹ in the soil.

INTRODUCTION

Soil is a vital natural resource for sustainable agriculture. Desertification as physical, chemical and biological degradation of soil is a serious problem of today's agriculture in the absence of proper soil ameliorative practices to counter the effect of soil degrading process (Kanwar 2002). There are number of reasons, why soils are acidic in the middle mountains. The geology of Nepalese mountains consists of granite, schist, quartzite, gneisses, phyllite and limestone. Soil formed from these parent materials except limestone is acidic in nature (Tripathi 2058, Schreier et al 1995). Use of acid forming fertilizers (ammonium sulphate and urea), pine leaves as a source of organic manure and leaching of bases at high rainfall areas are other reasons of soil acidification. Therefore, soils of hills and mountains are generally slightly acidic to acidic in reaction (Panday et al 1995). Inadequate supply of organic manure and cultivation practices without application of lime in acid soil tends to increase in acidity (Schreier et al 1995) and decline in potentials of production. Increase in soil acidity is the major factor of declining production in Nepal (Turton et al 1996). Therefore, problematic acid soil of Nepal needs amelioration to boost up the agricultural production. The major constraints to agricultural production in acid soils are toxicity of Al, Fe, Mn and H and deficiency of Ca (Jackson 1967). When soil is more acidic than 6.0, the availability of plant nutrients such as N, P, K, Ca, Mg, S, and Mo may be low for satisfactory plant growth.

Most of the microbial processes, such as beneficial activities of *Azotobacter* and nodule forming bacteria of legumes are adversely affected as the soil acidity increases (Mohsin et al 1995). The optimum soil pH range for the majority of agricultural crops is 5.5 to 6.5 (Schreier et al 1995) and soil consisting pH value 5.5 or less is considered as problematic acid soil (Tripathi 2058). The application of lime and manure is one possible solution to avoid further increase in soil acidity (Schreier et al 1995). There is no standard

pH for liming acid soil. It varies from soil to soil and with crop species. Liming not only increases the yields of crop but also enhances the efficiency of fertilizers used. The leaching of bases, Ca and Mg, building of toxicity by H and Al, deficiencies of B and Mo and low cation exchange capacity (CEC) are major factors affecting the productivity (Palaniappan and Varalakshmi 1999).

Farmers at different parts of Nepal are suffering from low agricultural production due to problematic acid soils. There is very limited study on recommendation of lime amount and other amending materials to different crops grown under acidic soil conditions of Nepal. There is no consistency on amount of lime application to amend the acid soils in Nepal. So, amount of amending materials based on soil and its acidity (pH) is needed to quantify in the Nepalese context. Keeping these points in view, a study was carried out to identify suitable dose of lime to increase the productivity of the soil, and to identify the effect of lime application on plant nutrient dynamics of the soil. The on-station study site, Agriculture Research Station (Horticulture) Malepatan of Kaski, lies at the altitude of 848 m above sea level with 28° 13' 6.18" North (latitude) and 83° 58' 27.71" East (longitude); slope of 3-5% (nearly plain); and south-west aspect. The meteorological records averaged for 15 years (1991-2005) showed that mean maximum temperature ranged from 19.2°C to 30.5°C; mean minimum temperature ranged from 6.6°C to 22.1°C. May, June, July and August (30.1°C-30.5°C) are the hotter months, whereas the December and January (6.6°C-7.8°C) are the cooler months. The annual total precipitation is 4112 mm at the site. About 80% of the total rainfall occurs during the four months (June to September) with the highest in July (1015 mm). The station also receives hailstone damages during February-May and sometimes in September-October (Annual Report 2063/64).

MATERIALS AND METHODS

A general survey of soil pH was carried out in farmers' fields and within the Station. About 510 m² of land having the soil pH 5.5 or less was selected at the station in 2064 BS. Soil sampling and analysis was done for its texture, pH, organic matter (OM), nitrogen, phosphorus and potassium content before the application of treatments. The texture of the soil varied from silt loam to sandy loam. Based on the available soil pH data (Soil Test Report 2064), the range on amount of agricultural lime requirement for the study was 3.0 t ha⁻¹ to 7.0 t ha⁻¹. Nine treatments comprising different level of lime (0, 2, 4 and 6 t ha⁻¹) along with recommended dose of chemical fertilizer (N: P₂O₅: K₂O @ 200:120:80 kg ha⁻¹ for cauliflower) and farmyard manure (25 t ha⁻¹) were included in the experiment. Lime was applied twice, the first in the beginning of 2064 and the second in 2066. The agricultural lime used had 80% calcium. The experimental plots were laid out in randomized complete block design and replicated three times. The size of individual treatment plot was 10.5 m² (3.5 m x 3.0 m). Altogether, there were 27 individual plots. Cauliflower (cv. Kathmandu Local) was grown in the plots. Twenty-five cauliflower seedlings per plot were planted during Aswin in each year. Soil sampling was done before the experiment start and after the harvest of cauliflower each year (2064, 2065, 2066 and 2067). All the soil samples were analyzed for pH, organic matter, nitrogen, phosphorus and potassium content in the soil. The data were analyzed using STATISTIX and MSTAT-C as appropriate.

The details of the treatments are as follows:

Treatment	L : R : F	Treatment	L : R : F	Treatment	L : R : F	Treatment	L : R : F
T ₁	0 : 0 : 25	T ₃	2 : 0 : 25	T ₅	4 : 0 : 25	T ₇	6 : 0 : 25
T ₂	0 : R : 25	T ₄	2 : R : 25	T ₆	4 : R : 25	T ₈	6 : R : 25

- L: Lime application @ 0, 2, 4, 6 t ha⁻¹ (Ca content 80 %).
- R: Recommended dose of chemical fertilizer (N:P₂O₅:K₂O 200:120:80 kg ha⁻¹, respectively)
- F: Farmyard manure @ 25 t ha⁻¹ (It is common to all treatment except control /T₉)
- Treatment (T₉) – L:R:F 0:0:0

RESULTS AND DISCUSSION

Change in soil pH

The mean pH values for four years are presented in table 1. The highest mean pH value (5.61) was found in the plots applied with lime @ 6 t ha⁻¹ and farmyard manure followed by the plots applied with lime @ 6 t ha⁻¹ with chemical fertilizer and FYM (5.40). The lowest pH value (5.04) was found in the plots without lime. The pH increased from 5.17 to 5.61 (0.44 unit) when agricultural lime applied @ 6 t ha⁻¹. Bhattarai (2006) observed that the pH of soil increased from 4.7 to 5.8 (1.1 unit up) when lime applied @ 225 kg per ropani at Chambas area. Significant difference in mean pH value was not found between the application of lime @ 4 and 6 t ha⁻¹. In the year-wise comparison, the mean soil pH increased from 5.0 in 2064 to 6.15 in 2067. The difference of means with time was highly significant. These results showed that application of lime @ 4 to 6 t ha⁻¹ is sufficient to raise the pH of acidic soil.

Table 1. Change in soil pH status of the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	5.17	4.43	5.33	6.07	5.25 ^{bc}
0 : R : 25	4.80	4.37	5.20	5.80	5.04 ^{c, L}
2 : 0 : 25	5.13	4.77	5.37	5.73	5.25 ^{bc}
2 : R : 25	5.10	4.43	5.37	5.77	5.11 ^{bc}
4 : 0 : 25	4.87	4.93	5.40	6.30	5.37 ^{abc}
4 : R : 25	5.00	4.83	5.40	6.23	5.36 ^{ab}
6 : 0 : 25	5.17	5.0	5.53	6.73	5.61 ^{a, 1}
6 : R : 25	4.93	4.87	5.47	6.33	5.40 ^{ab, 2}
0 : 0 : 0	4.83	4.33	5.37	6.40	5.23 ^{bc}
Mean	5.0 ^c	4.66 ^{d, L}	5.38 ^{b, 2}	6.15 ^{a, 1}	GM=5.29
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	0.165	**	12.26		
Replication (B)	0.143	*			
Treatment (C)	0.247	*			
A*B*C	-				
S. E.	0.124				

*, difference of means is significant at 5% level; **, difference of means is significant at 1% level; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Change in organic matter content

The mean values on percent organic matter content of the soil of the experimental site are presented in table 2. The highest mean organic matter content (3.87%) was found in the plots applied with farmyard manure alone @ 25 t ha⁻¹, but there was no significant difference between the treatments, even with no application of farmyard manure. However, there was significant increase of organic matter content in the following years compared with the base year (2067). The results indicated that percent organic matter content of the soil can be increased through the use of higher doses of organic manure that enhances the fertility of soil.

Change in nitrogen content

The four year's mean values on percent nitrogen content of the soil are presented in table 3. The highest mean nitrogen content (0.174%) of the soil was found in the plots applied with farmyard manure alone @ 25 t ha⁻¹ and followed by the plots applied with lime @ 6 t ha⁻¹ without the use of chemical fertilizer (0.169 %). The percent nitrogen content of the soil correlates directly to percent organic matter content of the soil. However, there was no significant difference between the

treatments. In the year-wise comparison, the mean nitrogen content significantly increased from 0.156 in 2064 to 0.189 in 2066, and decreased significantly in 2067.

Table 2. Change in the status of organic matter in the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	2.57	5.16	3.71	4.05	3.87 ^{a. 1}
0 : R : 25	2.16	4.61	3.79	3.75	3.58 ^{ab}
2 : 0 : 25	2.51	4.00	3.71	3.88	3.52 ^{ab}
2 : R : 25	2.13	3.92	3.36	3.71	3.28 ^{b. L}
4 : 0 : 25	2.25	3.79	3.88	3.53	3.36 ^b
4 : R : 25	2.35	4.31	3.88	4.27	3.70 ^{ab. 2}
6 : 0 : 25	2.37	4.65	4.05	3.71	3.69 ^{ab}
6 : R : 25	2.31	4.26	3.97	2.67	3.30 ^b
0 : 0 : 0	2.99	4.30	3.79	3.02	3.52 ^{ab}
Mean	2.40 ^{c. L}	4.33 ^{a. 1}	3.79 ^{b. 2}	3.62 ^b	GM=3.54
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	0.331	**	27.29		
Replication (B)	0.287	**			
Treatment (C)	0.498	ns			
A*B*C	-				
S. E.	0.250				

*, difference of means is significant at 5% level; **, difference of means is significant at 1% level; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹); Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹); FYM (t ha⁻¹)

Table 3. Change in percent nitrogen content in the soil of the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	0.168	0.189	0.185	0.156	0.174 ^{a. 1}
0 : R : 25	0.143	0.173	0.189	0.146	0.163 ^{ab}
2 : 0 : 25	0.164	0.155	0.185	0.151	0.164 ^{ab}
2 : R : 25	0.140	0.153	0.168	0.146	0.152 ^{b. L}
4 : 0 : 25	0.148	0.149	0.193	0.141	0.158 ^{ab}
4 : R : 25	0.154	0.164	0.193	0.162	0.168 ^{ab}
6 : 0 : 25	0.155	0.174	0.202	0.146	0.169 ^{ab. 2}
6 : R : 25	0.152	0.162	0.198	0.116	0.157 ^{ab}
0 : 0 : 0	0.181	0.164	0.189	0.132	0.166 ^{ab}
Mean	0.156 ^{bc}	0.165 ^{b. 2}	0.189 ^{a. 1}	0.144 ^{c. L}	GM=0.163
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	0.013	**	18.53		
Replication (B)	0.011	**			
Treatment (C)	0.019	ns			
A*B*C	-				
S. E.	0.009				

*, difference of means is significant at 5% level; **, difference of means is significant at 1% level; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹); Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹); FYM (t ha⁻¹)

Change in available phosphorus content

The four year's mean values on available phosphorus content are presented in table 4. The highest mean available phosphorus content (137.34 kg ha⁻¹) was found in the plots applied with lime @ 6 t ha⁻¹ along with chemical fertilizer and FYM. There was no significant difference between the treatments.

In general, the plots applied with chemical fertilizer had higher content of available phosphorus. In the year wise comparison of the means, the maximum amount of available phosphorus (178.04 kg ha⁻¹) was found observed in the first year (2064) and reduced significantly in the following two years and increased significantly (135.18 kg ha⁻¹) in 2067. These results showed positive correlation between higher pH and availability of available phosphorus (Table 1). In acidic soil, phosphate binds with Fe and Al and forms iron and aluminum phosphate, which is unavailable to plant.

Table 4. Change in status of available phosphorus (kg ha⁻¹) in the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	205.00	85.00	55.50	109.37	113.72 ^{ab}
0 : R : 25	199.87	95.67	58.10	167.47	130.28 ^{ab.2}
2 : 0 : 25	187.90	94.00	55.87	133.19	117.74 ^{ab}
2 : R : 25	172.57	92.00	57.23	133.30	113.77 ^{ab}
4 : 0 : 25	142.87	93.67	53.80	123.07	103.35 ^{b.L}
4 : R : 25	239.27	100.33	60.52	129.70	119.79 ^{ab}
6 : 0 : 25	174.27	96.33	53.68	95.73	105.00 ^b
6 : R : 25	169.10	96.33	55.04	228.90	137.34 ^{a.1}
0 : 0 : 0	162.23	111.67	51.27	95.90	105.27 ^b
Mean	178.04 ^{a.1}	96.11 ^c	55.67 ^{d.L}	135.18 ^{b.2}	GM=116.25
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	19.79	**	51.31		
Replication (B)	17.14	*			
Treatment (C)	29.69	ns			
A*B*C	-				
S. E.	14.95				

*, significant; **, highly significant; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K: Lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Table 5. Change in status of available potassium (kg ha⁻¹) in the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	173.50	145.60	93.88	100.94	139.16 ^{bc}
0 : R : 25	178.13	172.00	122.70	190.23	203.96 ^{ab}
2 : 0 : 25	195.50	149.33	140.27	151.76	175.36 ^{abc}
2 : R : 25	130.47	214.67	144.73	213.24	216.05 ^{a.2}
4 : 0 : 25	105.70	169.67	97.67	112.58	135.34 ^{bc}
4 : R : 25	75.57	248.33	143.30	208.90	207.80 ^a
6 : 0 : 25	169.90	143.00	120.00	136.00	158.31 ^{bc}
6 : R : 25	96.70	279.67	123.47	207.48	221.46 ^{a.1}
0 : 0 : 0	101.30	152.00	112.73	98.37	118.76 ^{bc.L}
Mean	136.31 ^c	186.03 ^{b.2}	122.08 ^{c.L}	257.72 ^{a.1}	GM=175.13
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	38.29	**	53.25		
Replication (B)	33.16	ns			
Treatment (C)	57.43	*			
A*B*C	-				
S. E.	28.93				

*, significant; **, highly significant; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Change in available potassium content

The four years' mean values on available potassium are presented in table 5. The highest amount of available potassium (221.46 kg ha⁻¹) was found in the plots applied with lime @ 6 t ha⁻¹ along with chemical fertilizer and FYM. The lowest amount of available potassium content (118.76 kg ha⁻¹) was found in controlled plots (without application of lime, fertilizer and manure). The plots applied with chemical fertilizer had significantly higher content of available potash. The year-wise comparison of means showed that the available potash content significantly increased from the base year 2064 (136.31 kg ha⁻¹) to 2065 (186.03 kg ha⁻¹) reached maximum (257.72 kg ha⁻¹) in 2067. These results indicated that available potassium can be increased by balance application of lime, chemical fertilizer and farmyard manure.

CONCLUSION

- The pH of the soil increased from 5.17 to 5.61 (0.44 units up), when lime applied @ 6 t ha⁻¹ in acidic soil of Malepatan. The application of lime @ 4-6 t ha⁻¹ is sufficient to raise the pH of acidic soil.
- The available phosphorus and potassium found the highest (137.34 kg ha⁻¹ and 221.46 kg ha⁻¹, respectively), when agricultural lime applied @ 6 t ha⁻¹. However, the trend of phosphorus content of the soil found to be decreasing with time whereas, that of potassium was increasing.
- The percent organic matter and the nitrogen content of the soil found the highest (3.87% and 0.174%, respectively), when farmyard manure alone applied @ 25 t ha⁻¹ in the soil. The percent organic matter content of the soil can be increased through the use of higher dose of organic manure that also enhances the fertility of soil.

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Performance of Organic Orthodox Tea (*Camellia sinensis*) Genotypes in Nepal

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ABSTRACT

A total of 12 existing tea genotypes were evaluated at Agriculture Research Station, Pakhribas, Dhankuta in 2010 and 2011. On the basis of two years' data, the highest production of green tea leaves (1701 kg/ha) and made tea (405 kg/ha) was found in the genotype Tinali, and the lowest production green leaf tea (363 kg/ha) and made tea (13.4 kg/ha) was found in Banokbarna-157. Average productivity of tea genotypes were found 1526 kg/ha for green leaf tea and 401.5 kg/ha for made tea. Percentage of dry tea from green tea was 26.3% where as highest 30.4% was found in Tagda-135. Highest caffeine (4.17%) was observed in Ghumti selection and highest crude fiber (12.30%) was observed in Tagda-135. The results showed that the highest tea was produced by Tinali and the highest percentage of made tea was produced by Tagda-135 genotype.

INTRODUCTION

Tea (*Camellia sinensis* L.) is an important industrial crop. It is grown in wide altitudinal range from 150 to 2200 meter above sea level (masl) in the eastern region of Nepal. It belongs to the family Theaceae. Tea is grown in more than 100 countries of the world but major tea producing countries are China, India, Sri Lanka, Indonesia, Malaysia, Singapore and Japan (San 1999). About 200 different tea species are reported to be cultivated around the world (Shanley 1991). It is one of the important crops to improve the national economy of the African countries such as Cameroon, Senegal (Alawi and Tanania 1998 and Ireland 1995). Tea is one of the popular consumed beverages in the world and it is estimated that about one billion cups of tea are being drunk in a day (Shanley 1991). The probable reason for its popular consumption is that it has medicinal value and used against some diseases such as cancer, stroke, osteoporosis and heart attack as well as tooth decay (Shanley 2000). Over 2.5 million tons of tea is produced around the world, most of them in Asian countries. Now a day, the scope of the tea industries is of worldwide economic importance.

Tea plant is evergreen nature. It has thick leaves, dark green in color and strong stem. The tea flowers bloom in white or pink and have a delicate fragrance. The total area under tea cultivation in Nepal is 11,210 ha and production is 112,000 kg and it accounts 0.3% of world production (Shanley 2004). It provides direct employment opportunity to 10 thousand people. There are 10 registered Tea estates and 10 Tea processing factories in private sectors in Nepal which contribute 85% of the national production volume. The production potentiality of tea is about 5000 kg/ha/year but in Nepal productivity of tea is 750-1477 kg/ha (Anonymous 2009) where as in Darjeeling and Assam, it is 1300-2000 kg/ha. Low production of tea in Nepal is due to limitation of high yielding clone and narrow genetic base of the existing plant materials (Sharma 1999). On the other hand, tea is grown in marginal land where the multiple cropping is not possible. However, profitability of tea is four times greater than maize and millet in the hills of Nepal.

epal has wide range of climate from terai to higher hills which is suitable for the production of Orthodox tea in hill range and Terai. Favorable climatic conditions mainly rainfall, temperature and soil pH are critical determining factors for the success of tea cultivation (Filani and Okelana 1980). The soil that is acidic, deep and well drained, with high organic matter content and average annual rainfall with low average daily temperature is favorable for tea cultivation (Moss 1957). Two distinct tea species: the small leaves are "China bush" (*Camellia sinensis*) and large leaved are "Assam bush" (*Camellia asamica*). Chinese bush are grown in hilly areas and Assam bush are grown in terai. Generally Assam bush yields higher than China bush.

The research work on selection, breeding and location specific genotype study could not be carried out in the past in Nepal (Gupta 1985). Introduction and evaluation of high yielding clone of tea is required to improve the production, productivity and quality of tea in Nepal. Farmers are demanding high yielding variety and low cost production technology of tea for commercialization. In this study, quality and yield performance of existing genotypes was studied for the selection of elite genotypes.

MATERIALS AND METHODS

An experiment was carried out in Agriculture Research Station Pakhribas, Dhankuta at 1600 to 1750 masl during 2010-2011. Twelve existing genotypes were selected for evaluation and replicated 3 times in randomized complete block design. Total of 21 plants (7 plants per treatment) were included in each treatment (genotype). Two kg of well rotted compost with one kg vermin compost were applied in each plant per year. Age of the plant was 8 years and plucking was started from March to October. Generally, 4-5 plucking was done per month. After plucking the green leaves were processed manually. The following steps were followed for the preparation of orthodox tea.

Weathering

In this process, 2-3 true leaves of tea picked-up and collected in the basket, then they were sun-dried till about 50-60% moisture be removed.

Rolling

Leaves were rolled by hands for releasing the liquids from the leaf in order to allow the fermentation and oxidization.

Fermentation

In this step, the enzymes within the leaves are bound with oxygen as a result the leaves turned into brown colour and created typical flavor of the tea. This stage takes about 3 hours.

Drying

After stopping the oxidization process, the tea is sun dried till around 12% moisture is maintained. At the end of this process a long-lasting, stable product is produced.

Parameters

Plucking time, green tea weight, made tea weight and percentage of made tea were recorded and analyzed using simple statistical procedures. About 200 g of end product of tea sample was sent to the Food Research Unit of NARC at Khumaltar, Lalitpur for chemical analysis of crude fiber on moisture basis.

RESULTS AND DISCUSSION

Production of green leaf tea

The plucking of first flush was started from March. The first tea crops of every year are called "new tea" and it is rich in flavor and aroma (FAO 2011). The two years yield data revealed that the highest production of green leaves (533 g) (21 plants) was recorded in March from the genotype Tinali and the lowest (53 g) production was from Tagda-78. The highest production of green leaf tea was observed (1701 kg/ha) from Tinali and the lowest (363 kg/ha) from Banokbarna-157 (Table 1). High variation of green leaf production was observed and that could be due to the variation of soil fertility and plant number. Normally, production of tea started from March to September and it gradually decreased from October. That might be due to the decrease in temperature.

Table 1. Total production of green leaf orthodox tea from different genotypes at ARS Pakhribas in 2011

Month	Quantity of green leaf (g)											
	Tagda -78	Phoob shring- 312	Am- bari- 135	Tagda -135	Tara- pur	Happy Valley	Tagda -383	Tinali	Phoob shring- 1404	Banok Barna- 157	Bala- san	Ghumti selec- tion
March	53	173	69	178	342	390	335	533	238	71	115	245
April	160	42	81	16	183	145	158	236	128	8	53	223
May	149	98	90	24	113	191	192	205	126	17	90	204
June	349	224	135	79	145	233	390	499	238	45	149	290
July	155	181	164	143	220	252	111	170	161	163	63	312
August	245	100	73	90	207	308	264	151	96	49	50	91
Sept.	141	109	135	41	291	245	268	258	155	72	158	160
October	91	71	88	48	107	159	151	84	110	37	59	212
Total (g)	1820	998	835	619	1608	1923	1869	2136	1252	462	737	1274
Total (kg/ha)	1430	784	655	486	1265	1511	1468	1701	984	363	579	1001
Average (kg/ha)	179	98	82	61	158	182	184	213	123	45	72	125

Production and percentage of made tea

Production of made tea started from March with plucking of new green leaves. The two years' yield data revealed that highest production of made tea (141 g) from 21 plants was recorded in March from the genotype Tinali and the lowest (2 g) production was recorded from Banokbarna-157 in April. The highest productivity of made tea was observed in Tinali and lowest in Banokbarna-157 genotypes (Table 2). The highest percent of made tea (30.4%) was in Tagda-135 and lowest (22.8%) in Happy Valley genotypes (Table 2). The highest amount of made tea was produced in March and lowest production month is October in a year.

Table 2. Production of orthodox (made) tea from twelve genotypes at ARS Pakhribas in 2011

Month	Tagda -78	Phhoob Shring -312	Am- bari-2	Tagda -135	Tara- pur	Happy Valley	Tagda -383	Tinali	Phoob Shring -1404	Banok Barna -157	Bala- san	Ghumti Selec- tion	Total
March	123	48	22	47	85	107	90	141	69	21	32	63	848
April	44	14	24	4	50	41	43	61	36	2	16	64	399
May	49	25	23	7	31	59	68	47	35	3	22	66	435
June	94	61	48	25	61	61	97	109	62	15	43	81	757
July	40	50	56	44	81	14	27	37	41	48	18	87	543
August	47	23	16	20	46	53	51	29	24	13	11	22	355
Sept.	37	27	32	13	71	61	58	67	43	20	38	35	502
October	27	17	25	11	32	43	51	24	32	13	17	46	338
Total (g)	461	265	246	188	457	439	485	515	342	135	197	361	4091
Total (kg/ha)	327	208	193	148	359	345	381	405	269	106	155	284	3214
Average (kg/ha)	45.5	25.9	24.4	18.9	44.8	43.2	47.9	50.3	33.8	13.4	19.6	35.4	401.5
% of mac tea	25.3	26.6	29.3	30.4	28.4	22.8	25.9	24.1	27.3	29.2	26.7	28.3	26.3

Chemical composition of tea genotypes

Chemical composition of orthodox tea depends on the genotypes, maturity of leaves, growing conditions, harvesting period and processing techniques. Caffeine and polyphenols (flavanols, flavonoids and phenolic acids) are natural substances found in tea plants. Catechins, a group of flavonoid, is a powerful antioxidant that is easily oxidized and have health benefits. The average amount of caffeine from brewed tea leaves depends on the type of tea (generally black tea contains more caffeine than green tea), the brewing duration, and the water temperature (the higher the temperature greater the amount of caffeine drained from the leaves). In the present study, the average amount of caffeine found in 12 genotypes was 3.74% where as the highest caffeine 4.17% was found in Ghumti selection and lowest 2.93% in Phoobsering-312. Similarly, amount of crude fiber was 12.30% in Tagda and lowest 9.92% in Happy Valley. A healthy individual can consume up to about 350 mg of caffeine per day without any concern. Including the yield parameter we also evaluated the colour and perfume of made tea. The colour of made tea was observed pale green in Tinali and Ghumti selection where as dark black colour was observed in Banokbarna and Happy Valley.

Table 3. Chemical composition (%) of 12 genotypes of tea

Variety	Total ash	Alkalinity of soluble acid	Water soluble ash	Acid insoluble ash	Caffeine	Crude fiber
Phoobsering-312	5.61	1.62	3.77	0.07	2.93	12.03
Phoobsering-1404	5.29	1.41	3.41	0.03	4.06	11.56
Tukdah-383	5.25	1.40	3.31	0.07	4.02	10.37
Tukdah-78	5.45	1.42	3.43	0.08	3.53	10.92
Tukdah-135	5.21	1.37	3.28	0.07	3.63	12.30
Tinali	5.24	1.48	3.26	0.13	4.07	11.37
Happy valley	5.32	1.52	3.70	0.02	3.64	9.92
Tarapur	5.18	1.49	3.57	0.04	3.90	11.16
Banockburn-157	4.86	1.30	3.09	0.06	3.39	10.13
Balasun	6.28	1.61	3.18	0.06	3.50	11.44
Ghumti selection	5.42	1.53	3.59	0.09	4.17	11.25
Ambari-2	4.85	1.23	3.25	0.03	4.07	11.44
Total	63.97	17.37	40.85	0.73	44.91	133.89
Mean	5.33	1.45	3.40	0.06	3.74	11.16

On the basis of two years' evaluation data the highest production of green leaf tea (1701 kg/ha) and made tea (405 kg/ha) was found in the genotype Tinali and the lowest green leaf tea (363 kg/ha) and made tea (13.4 kg/ha) was found in Banokbarna-157 at ARS Pakhribas, Dhankuta. Average percentage of dry tea from green tea was 26.3% where as highest (30.4%) was found in Tagda-135 genotype. Highest caffeine and crude fiber was observed in Ghumti selection and Tagda

genotypes. In this study, production of green and made tea was found higher in Tinali genotype but percentage of made tea was higher in Tagda-135 genotype and caffeine percent in Ghumti selection genotype. Evaluation should continue for confirmation of these results.

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Market Assessment Survey of Apple Grown in JUMLA

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ABSTRACT

A survey was carried out during June 2011 to provide a concise picture of entire value chain of apple in order to identify the constraints and opportunities. Primary data were collected by individual interviews, PRA and focus group discussion whereas secondary data were collected from various publications. The results revealed that 11,332 households were involved in apple farming in the district. Six agrovet, 33 nursery owners and Agriculture Research Station (Horticulture), Jumla were major input suppliers. Tatopani, Chandannath and Shinjha were major pockets covering 1574 ha of land producing 3500 mt apple fruits/annum with an productivity of 6.6 mt/ha. Out of total production, 43%, 11% and 15% have been used for local consumption, processing and export, respectively whereas 31% fruits were lost due to decay. Altogether 10 collection centres and 8 cellar stores were operating. Karnali Fruit Company, District Cooperative Federation, local collectors, vendors at the airport and R. K. Apple Processing and Horticulture Distillery are the major collectors in the district whereas B. H. Enterprise, Kathmandu was major contractor for trading organic-certified apples. The price of organic-certified apple fixed by District Cooperative Federation at Jumla airport ranged from NRs 15 to 35 per kg whereas for non-organic apples depending on grade ranged from NRs 15 to 30/kg. Transportation cost via aeroplane was NRs 25 per kg whereas via truck was NRs 4/kg. Bhatbhateni supermarket, fruit stalls, vendors were major retailers of Jumla apple. R. K. Apple Processing and Horticulture Distillery supplies organic brandy, organic juice, jam and dried apple slice to Jumla Kosheli Ghar, Jumla Organic Multipurpose Cooperative and Anurag Trade Concern at Kalanki in Kathmandu. The results revealed that despite of high potentiality, apple growers were not able to obtain optimum benefit due to low productivity of existing varieties (6.6 mt/ha), poor orchard and nursery management practices, infestation of apple orchards by various insect pests, high losses in quality and quantity during post harvest handling period.

INTRODUCTION

At present, production of deciduous fruits in Nepal is limited compared with tropical fruit thus substantial quantities are imported to meet domestic demand. Among deciduous fruits, apple is the most important crop in terms of area, production and household economy in remote mountain districts. Apple cultivation in Karnali region has been a major source of income enhancing the livelihood of poor farmers. Considering this fact, Agriculture Perspective Plan (APP) and Three Years Interim Development Plan have given number one priority to apple as high value cash generating commodity for high-hill farmers of Nepal. A total of 54 districts grow apple, however, only 12 major apple producing districts mainly from high mountain regions. Of them, Karnali zone is the major apple producing area and Jumla ranked first among the apple producing districts of Nepal in terms of area (1574 ha) and production (3500 mt). Although this is a considerable amount, production is very scattered and mostly consumed locally

Despite of high potentiality of apple cultivation, apple growers particularly in Jumla have not been able to obtain optimum benefit from this crop due to low productivity of existing varieties, poor orchard management practices, infestation of apple orchards by various insect pests resulting less

attractive fruit colour, high losses in quality and quantity during post harvest handling period. Due to lack of storage, transportation and proper marketing facilities, Indian and Chinese apple fruits arrive in Nepalese market after November. Nepal produce 41755 mt apple/annum, however, most of them are being consumed locally whereas Nepal imports 37400 mt apple, out of which 92% of apple demand in urban markets is being met from imports i.e., China (65%), India (22%) and other countries (5%). Nepal has potentiality and comparative advantage of exporting apple fruits to Bangladesh market due to high quality fruits. Thus, the main objectives of this investigation was to draw a concise picture of entire value chain of apple in order to identify constraints and opportunities that can be exploited for promoting income and employment for rural pro-poor.

MATERIALS AND METHODS

Study is based both on secondary and primary information. Primary data were collected from various groups viz producers, LARPs, input suppliers, local traders, processors, etc. by individual semi-structured questionnaire fills up (Annex 1), PRA, focus group discussion at cluster level and interaction and sharing from concerned stakeholders whereas secondary data collected from documents and publications of various government and non-government organizations. Technicians of Agriculture Research Station (Horticulture), Jumla, District Agriculture Development Office, business communities, processors, traders and exporters were interviewed to come up with more realistic data on production as well as value additions and value chains (N=87).

RESULTS AND DISCUSSION

Value chain map

Figure 1 illustrates the value chain map of various actors involved in the Jumla apple value chain, from input suppliers and producers at the bottom all the up to the final consumers. On the left side, various functions are shown of these primary value chain actors, while on the right side various service providers or support organisations can be seen. Especially the government support organisations have a strong role in determining the enabling environment through policies, subsidies, etc.

Nursery management and input supply

There are a total of 33 registered apple nurseries which were organised in a “Fruit Nursery Association” since February 2008. However, more than 100 apple nurseries were not registered and many of them supported by NGOs and INGOs. In 2010/2011, a total of 300 thousand apple saplings @ NRs 2 were distributed by DADO with subsidy of NRs 23 per sapling. Similarly, eight agrovets are currently selling agricultural inputs such as organic pesticides, bio fertilizers, sprinklers and other inputs. These agrovets need to be trained in delivery of organic services.

Major challenges for the nurseries were related to improving the quality of their saplings:

- 1) Most nursery owners were not aware which varieties and some of them do not have mother plants
- 2) No access to supply new and improved varieties
- 3) Transmission of graft transmissible insects and pests
- 4) *Edimail* and *surkilo* are used as apple rootstock however, seed is too expensive (10,000-15,000 per kg)

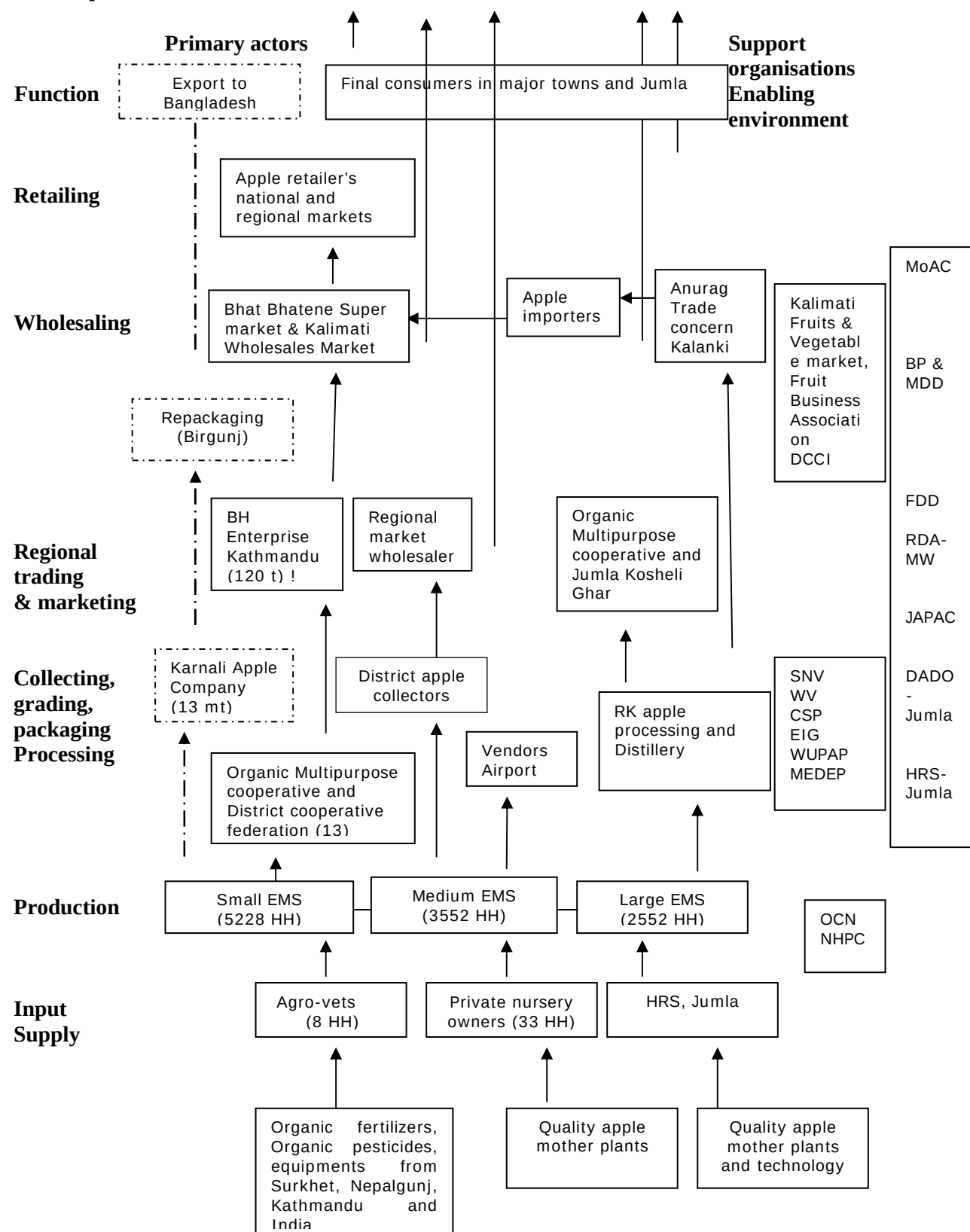
Consumption**Figure 1. Value chain map for Jumla apples**

Table 1. List of registered private nurseries in Jumla

Name of the nurseries	Name of nursery owner	Address
Shivapuri Fruit nursery	Purinath Neupane	Kartikswami 2
Priyabari Fruit nursery	Govinda Rawat	Chumchaur 2
Uccha Himali fruit nursery	Toyanath Yogi	Mahat 2
Navadip fruit nursery	Navraj Rawal	Talium 4
Basantapani fruit nursery	Gopal Acharya	Depalgaun 7
Uccha Himali fruit nursery	Suka Nepali	Dillichaur 8
Dolkati fruit nursery	Lachiman Bohora	Dillichaur 6
Mahadev fruit nursery	Khadka Bahadur Buda	Patmara 7
Mahesh fruit nursery	Mahesh Bahadur Bhandari	Depalgaun 8
Sundari fruit nursery	Sankhu Khatri	Kartikswami 4
Malika fruit nursery	Man Bahadur Buda	Kanakasundari 7
Hasta fruit nursery	Hasta Bahadur Buda	Kanakasundari 7
Dipak fruit nursery	Birkha sarki	Depalgaun 7
Himali fruit nursery	Hira Bahadur Shahi	Chandannath 5
Chandannath temperate fruit nursery	Hari Bahadur Rokaya	Talium 9
Satra Khamba fruit nursery	Ambar Bahadur Rawal	Talium 2
Kalika fruit nursery	Ratan Bahadur Rawat	Talium 2
Ghumkhola fruit nursery	Khadka Bahadur Buda	Talium 7
Chimara fruit nursery	Purna Bahadur Bohora	Dillichaur 6
Devdhara fruit nursery	Laxmi Buda	Dillichaur 3
Tularam fruit nursery	Tularam Buda	Garjankot 2
Mahadev fruit nursery	Khadka Bahadur Buda	Chandannath 2
Mahadev fruit nursery	Hira Bahadur buda	Dillichaur 7
Ganesh fruit nursery	Durga Prasad Pandey	Hanku 5
Jalpa fruit nursery	Devidatta Pandey	Hanku 7
Chulisanghu fruit nursery	Man Bahadur Rawal	Talium 7
Krushu fruit nursery	Sattal Singh Thami	Dillichaur 7
Rahedeu fruit nursery group	Tek Bahadur Buda	Dillichaur 8
Lache fruit nursery	Lache Bahadur Buda	Dillichaur 4
Doldhunga fruit nursery	Dhan Bahadur Rawat	Chumchaur 2
Him fruit nursery	Bishnumaya Mahat	Mahat 6
Lekali fruit nursery	Lilu Shahi	
Dolkati fruit nursery	Laxmiman Bohora	Dillichaur 3

Table 2. List of agro-vets and input suppliers in Jumla

Agro-vet	Address	Owner	Input Suppliers
Malavid Agro-vet	Chandannath 6	Dhananjaya Khatri	Sagarmatha agrovet-
Dhital Agro-vet	Chandannath 6	Purna Dhital	Kalimati, Annapurna
Dhital Agro-vet	Sanigaun 1		agrovet-Nepalgunj,
Alamdevi Agro-vet	Narakot	Alamdevi	Manakammana agrovet-
Chandannath Agro-vet	Chandannath 6	Kuldev Khatri	Narayangarh, Lucknow,
Kanakasundari Agro-vet	Kanakasundari 8		HRS-Jumla
Purna Agrovet centre	Chandannath 6	JAPAC	
Prem agrovet centre	Badki	Prem B. Shahi	

Apple production

Ten varieties of apple are being cultivated in Jumla: Red, Royal and Golden Delicious constitute approximately 70% of total production. The rest includes Jonathan, Torikulu, sweet Ambri and Macintosh, etc. Area under apple cultivation has almost doubled in 2063 compared to 2057. Altogether 11,332 household have been cultivating apple in Jumla among which 2552 have more than 50 apple trees. Similarly 3552 and 5228 households have 26-50 and less than 25 apples trees, respectively.

Table 3. Pocket area, production and area coverage of apple enterprise in Jumla district

Pocket area	FY 064/065		FY 065/66		FY 066/67	
	Area (ha)	Prod. (mt)	Area (ha)	Prod. (mt)	Area (ha)	Prod. (mt)
Tatopani pocket (Taliun, Lamra, Haku, Tatopani, Kudari, Malikathata, Ghodemahadev)	297	801	345	931	395	1050
Chandanath pocket (Patmara, Chandanath, Depalgaun, Garjyankot, Mahat, Kartikswami)	710	1775	789	1972.2	943	2100
Sinja pocket (Mahabaipatarkhola, Kalikakhetu, Badki, Shannigaun, Narakot, Dhapa, Birat, Pandavgufa, Kanakasundari, Botamalika)	198	297	210	310.5	236	350
Total	1205	2873	1344	3213.7	1574	3500

Cultivation practices

While some apple trees are grown on fertile and irrigated low-lands, most have been planted on the slopes with low soil fertility and little irrigation. Apple is mostly inter-cropped with beans, potato and wheat. The present apple orchard management is very poor. One of the reasons is that farmers do not have adequate knowledge on when or how to efficiently irrigate, fertilise, and prune their apple trees.

Diseases and insect pests

The common diseases reported are: stem black, powdery mildew, scab, Nectria twig blight, Alternaria twig blight, papery bark/pink disease. Similarly, some of the common pests reported are: woolly aphids, San Jose scale, stem borer, root borer, bark borer, twig eating beetle, etc.

Organic apple production and certification

Important factor which has limited quality production is that declaration of Jumla as an organic district was not sufficiently combined with awareness and knowledge of apple growers and agrovets. Pine litter is the main constituent of farm yard manure, which increases acidity and decreases nutrient availability. SNV Nepal, World Vision and DADO-Jumla agreed to support organic certification in 2009. In 2010/2011, Organic Certification Nepal (OCN) trained three organic apple producer groups formed in Mahat, Kartikswami and Patmara VDCs; inspected their orchards; and certified "Organic in Conversion". Thus, there is an opportunity for the Jumla organic apple to be directly sold to supermarkets in Kathmandu with a premium price. Nevertheless, the market for organic products is still very scattered. Organic Village has various organic outlets.

Organization of producers

Apple producers in Jumla are hardly organised and are selling apple independently, therefore, they do not have the bargaining power for better prices. They do not have direct contact with major apple wholesalers in urban markets and depend on apple sales to local traders. Due to the organic apple certification initiative, where organisation is necessary to receive group certification, three organic apple producer groups were initiated in 2009: Kartikswami Organic Group, Malika Organic Agriculture Production Group and Janachetana Organic Group. For the marketing in 2010, these 3 groups organised an apple management committee which signed a contract with CCI-Jumla. However, the entire certified apples were marketed by District Cooperative Federation, Jumla in 2011.

Harvesting and post harvest management

Despite of high potentiality of apple cultivation, the apple growers particularly in the Karnali region especially in Jumla district have not been able to obtain optimum benefit from this crop due to high

losses during the post harvest handling period. Reduction of post harvest losses is a complementary means for increasing production. The cost of preventing losses after harvest in general is less than the cost of producing a similar additional amount of apple fruits of same quantity.

Harvesting, sorting, grading, packaging and storage

Apple producers do not have much knowledge on the appropriate techniques for proper picking, grading and packing. Apples are harvested in a most haphazard manner – including shaking the tree and picking from the ground. Without grading they are transported to Jumla airport in *dokos*, especially by women. Grading is done by the traders – usually three grades depending on size alone for export to Surkhet, Nepalgunj and Kathmandu. The district headquarter traders would use the worst apples for processing or for the local market. Traders have till 2008 also not properly prepared themselves by bringing packaging material before the monsoon starts. A lot of losses occur due to improper packaging; old boxes are used without any wrapping or separation material and a considerable amount gets damaged. Farmers store apples underground inside the house, a pit in the ground filled with barely straw and covered with a stone or wooden slab.

Table 4. List of Cellar stores in Jumla

Ownership	Address	Capacity (mt)	Established year	Existing condition	Supporting institution
Navayuba farmer's group	Chandannath 3	10	2051	Good	SEBED
Raj Bahadur Bhakri	Chandannath 3	5		Good	Farmer group
Sidda Bhawani farmers group	Talium 7	5	3063	Fair	DADO
Agriculture production group	Talium 8	5	2062	Good	DADO
Depak Shahi	Kartik Swami 6	10	2059	Good	Farmer group
Krishna Bahadur Shahi	Kartik Swami 6	5	2059	Good	Farmer group
Purinath Neupane	Kartik Swami 1	6	2064	Good	Private
NA	Depalgaun 4	5	2064	Fair	RDGP

Marketing

The local traders collect apples in major collection and market centres and supply them out district market centres like Surkhet, Nepalgunj and Kathmandu.

Table 5. List of Major market centres in Jumla

Major market centres	Covered VDCs
Talium Bazaar	Talium and Lamra
Tatopani Bazaar	Tatopani and Lamra
Kudari Bazaar	Kudari, Tamti and Raralihi
Nagma Bazaar	Ghodemahadev and Kalikakhetu VDC
Narakot Bazaar	Narakot, Dhapa, Shannigaun and Kanakasundari
Haatsinjha Bazaar	
Urthu Chautara	Patmara and Dillichaur
Dillichaur Bazaar	Dillichaur, Chumchaur and Pataransi
Manisangu Bazaar	Gothichaur
Airpot/Chandanath	Chandanath, Kartikswami, Mahat, Garjangkot and Depalguan

Chart 1: Production and distribution of Jumla apple (mt) during 2010

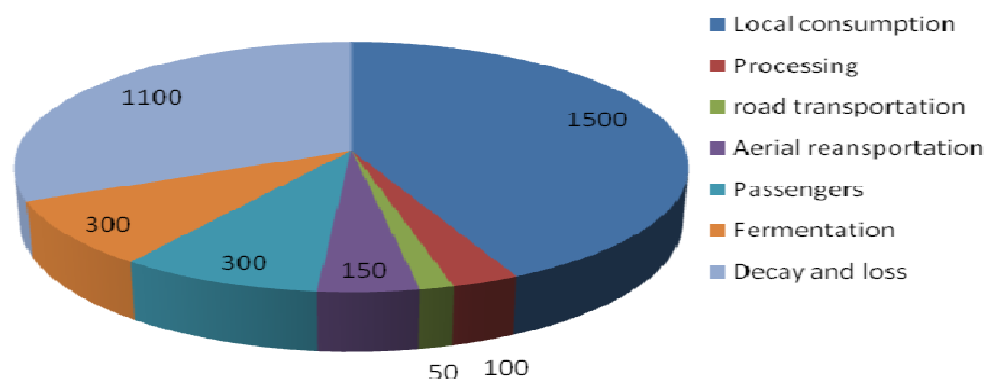


Table 6. List of collection centres at Jumla

Name	Address	Command VDCs	Capacity (mt)
Hanuman mandir hat bazaar	Chandannath 6	Chandannath, Depalgaun, Garjankot, Mahat, Tallium, Patmara, Kartikswami	NA
Apple collection centre and selling centre, airport	Chandannath 1	Chandannath, Mahat, Patmara, Kartikswami	125
Organic apple Collection centre, Airport	Chandannath 1	Chandannath, Mahat, Patmara, Kartikswami	150
Chandannath collection centre and selling centre	Chandannath 1	Chandannath, Depalgaun, Garjankot, Mahat, Tallium, Patmara, Kartikswami	NA
Urthu-Chauthara Collection centre	Patmara 3	Patmara	10
Fruit and vegetable collection and selling centre	Chandannath 6, 7	Chandannath, Mahat, Patmara, Kartikswami	140
Fruit and vegetable collection and selling centre	Tatopani 1,2	Tatopani, Kudari, Hanku	NA
Fruit and vegetable collection and selling centre	Narakot 4	Narakot, Dhapa, Sanigaun	45

Trade from Jumla

Track of Karnali Highway from Surkhet to Jumla (232 km) was opened in 2007. This has greatly increased the perceived future perspectives for the Jumla apple sector. World Bank is supporting the blacktopping of 132 km - it still will take few years for the road to be all weather proof all the way to Jumla. Most apple transport takes places by air, not just a very costly business but also quite unreliable as flights depend on weather conditions.

Table 7. Price of apple determined by District Cooperative Federation during 2011

Description	Grade	Price (NRs/kg)
Organic certified	A	35
Organic certified	B	30
Organic certified	C	20
Non-organic	A	30
Non-organic	B	25
Non-organic	C	15

Table 8. Transport costs

Route	Mode of transport	Transport cost per kg (NRs.)
Jumla-Nepalgunj/Surkhet	Air	25.00 (traders with access to DADO subsidies can reclaim 7.00 after the apples have reached Surkhet).
Jumla-Surkhet	Truck/tractor	4.00
Nepalgunj/Surkhet- Jumla	Air	95.00 (excess luggage) 75.00 (cargo separate) 42.00 (charter)
Surkhet-Jumla	Truck/tractor	10.00 depending on the volume

Those 10% apples which do reach the market outside Jumla mostly serve the cheaper market segment in the terai: poor management, all the way from orchard management to packaging and transport, make these relatively small and often bruised apples less attractive. Nevertheless, in comparison to Chinese and Indian apples, Jumla apples are widely recognised as tasty and crispy apples in Nepal, but size, colour and general condition have a big influence on consumers' liking.

Various marketing or trade modalities are currently in operation in Jumla:

- 1) District Cooperative Federation collects organic certified apples at Jumla airport and send to contractor (BH enterprise, Kathmandu)
- 2) Large apple producers who bring their produce to Surkhet and Nepalgunj themselves.
- 3) Growers, especially in Jumla's Sinja belt - who collect from other farmers as well and the produce to the terai.
- 4) District headquarter traders with a storage at the Jumla airport who either a) 'rent' orchards and organise the harvest themselves, or b) buy at the airport from farmers.

Regional apple traders

There are fruit traders in Nepalgunj, Surkhet, Narangarh (Chitwan) who are all interested to trade with Jumla apples. These traders have market networks to major urban cities/towns across the country, including Kathmandu. In the past, local traders and even some local apple producers delivered Jumla apples to regional traders.

Apple wholesalers

Wholesale traders at Nepalgunj and Surkhet buy and put their apple fruits mainly on night buses to various destinations, where they sell to retailers. There are many wholesale traders in Kathmandu and other market hubs of Kathmandu, who trade mainly Indian and Chinese apples. Recently B.H. Enterprise, Kathmandu has become the main contractor of Jumla organic certified apples who trade apples to Kalimati Fruits and Vegetable Market, BhatBhateni Super Market as well as to the retailers in Kathmandu.

Table 9. Number of wholesalers in major towns of Nepal

Towns	Number of wholesale dealers	Towns	Number of wholesales dealers
Bhairhawa	2	Itari	4
Biratnagar	5	Janakpur	8
Birgunj	3	Kakarbitta	3
Butwal	6	Lahan	3
Dhangadi	4	Nepalgunj	4
Dhankuta	3	Pokhara	10
Dharan	3	Narayangarh	4

In the past, some local apple producers delivered Jumla apples to wholesalers in Kathmandu. The wholesalers in Kathmandu found Jumla apples very tasty and juicy, but complained about their poor

appearance and colour. Presently, they are mainly importing apples from China and India to meet urban demand of apples. In case of the organic certified apples of Jumla, Organic World & Fair Future, a distributor specialised in organic products, delivered to various supermarkets. The Naryangarh Fruit Cooperative also took up wholesale of certified apples.

Retailer

Very high quality apples from overseas are directly imported and sold by supermarkets such as Bhatbateni and Salesway. Similarly, there are several fruit stalls at different towns that trade Jumla apples. Likewise, there are more than 30 fruit vendors at Jumla airport, and other towns involving trading of Jumla apples seasonally.

Processing

One of the largest enterprise established in 2011 at Mahat-1, Jumla called R.K. Apple Processing and Horticultural Distillery Pvt. Ltd., have started production and trading of brandy, dried slice, juice and jam on commercial scale to Anurag Trade Concern at Kalanki. Likewise, Organic Multipurpose Cooperative Ltd., Jumla has also contracted with Saugat Griha of Tripureshwor for marketing of apple processed products. However, there are more than hundred unregistered apple processing enterprises involved in production of *rakshi* (alcohol), dried slice, juice and jam. The collection and marketing is mainly being carried out by Jumla Kosheli Ghar and Organic Multipurpose Cooperative Ltd.

Table 10. Demand of diversified apple products and their price at R.K. Apple Processing and Horticultural Distillery Pvt. Ltd., Jumla

Apple products	Annual demand		Annual supply	Whole sell price (NRs)
	Local level	National level		
Organic Brandy (42.5%)*	2400 litre	1,00,000 litre	7000 litre	400 per 750 ml
Cider	-	-	-	-
Jam	-	100 kg	100 kg	225 per kg
Jelly	-	-	-	-
Dried apple slices	1000 kg	5000 kg	1500 kg	800 per kg
Organic juice	5000 litre	45000 litre	10,000 litre	150 Per litre

*Chiraito is used for fermentation instead of commercial yeast

Supporting agencies

Agriculture Research Station (Horticulture), Rajikot, Jumla amongst others have been providing technical and other supports in apple value chain in Jumla. The agencies with their role are given in Table 11.

Table 11. Organizations promoting and supporting apple sub-sector in Jumla

Lead organizations	Role
Agriculture Research Station (Horticulture), NARC, Rajikot	Provide primary mother stocks of apple, technologies and various trainings on nursery and orchard management
SNV-Nepal	Trainings related to nursery and orchard management, organic certification, facilitation of Jumla Apple Development Plan
World Vision	Supporting with organic certification promotion and training of LARPs
Community Support Program (CSP)	Supporting the promotion of LARP
Education for Income Generation and Conflict Mitigation (EIG-CM)	Implemented a consortium led by WINROCK is providing support for apple packaging
Western Upland Poverty Alleviation Project (WUPAP)	Supporting mainly on promotion of apple production in leaseholds forestry
Micro Enterprise Development Programme (MEDEP)	Promoting the production of bio-pesticides, marketing and resource survey on apple
Nepal Horticulture Promotion Centre (NHPC)	National level NGO is providing nursery, orchard management and harvest/post-harvest management trainings through SNV
Organic Certification Nepal (OCN)	Providing organic certification for the apple growers in 6 VDCs of Jumla
Chamber of Commerce and Industry (CCI)	CCI is running <i>Khoseli Ghar</i> viz souvenir shop, which sells various local produced food stuffs like dried apple slice, apple juice, etc
Fruit Development Directorate (FDD)	Carry out various activities aimed at developing the fruit sector in the country
Agribusiness Promotion and Marketing Development Directorate (ABP & MDD)	Agribusiness promotion and marketing of various agricultural commodities like vegetables, fruits, species, cash crops and other agricultural products
Agribusiness Promotion and Statistics Division	Planning, monitoring, evaluation, policy formulation for agribusiness and trade
District Development Committee	Policy formation such as “Every household one apple orchard”, “Employment through Apple and Tourism, Declaration of organic district
Jumla Apple Processing Centre (JAPC)	Training and input packages for processing of apple and necessary materials and equipments
District Agriculture Development Office (DADO)	Key role in promoting apple sub-sector

Market trends and competitiveness

Area under apple cultivation is drastically increasing every year. Although there is demand for apples, the competitiveness of the Jumla value chain with other supply chains of apple to the major markets will in the end determine whether the Jumla farmers will be able to sell their produce. Taste of Jumla apples is considered best in terms of its juiciness, crunchiness and sweetness compared to Chinese and Indian apples. Jumla apples can fetch NRs 20 to 25 higher price per kg than Chinese and Indian apples provided they can be improved in terms of size, appearance and colour. Traders' suggestions are to train apple growers in proper picking, handling, sorting, grading, storing and improved orchard and nursery management practices by which quality of Jumla apple can be improved to a greater extent.

Domestic production

There are 11 major apple producing districts in Nepal producing 41755 mt of fresh apple during 2066/2067; most of them are being consumed locally. Nepal imports 37400 mt of apple, out of which 92% of the apple demand in the urban markets is being met from imports i.e. 65% is from China, 22% from India (22%) and 5% from developed countries. Mustang apples are mostly sold in

Baglung, Myagdi and Pokhara and Kathmandu during apple harvesting season. Jumla organic apples are mostly sold in Kathmandu whereas non-organic apples are mostly sold in Surkhet and Nepalgunj.

Imported apples

About 20-25 Chinese apple wholesale dealers based in Kathmandu import apples from China covering a distance of 2200 to 3000 km and supply to Kathmandu wholesalers who get a 3-4% commission. Transport costs are NRs 200/crate containing 7 to 10 kg. Indian apples are cheaper during harvesting season, so traders prefer to deal with Indian apples from Himachal Pradesh and Kashmir from a distance of 1200 to 1500 km. Transport cost is NRs 4/kg, tax and other duties are NRs 25,000/truck. Wholesale price for Indian apples range from NRs 50 to 80/kg depending upon the variety, quality and grade of apple where as retailers sell at a price ranging from NRs 60 to 120/kg. During the peak season Indian apples becomes cheaper than Chinese apples. High quality apples from imported from other countries (Australia, New Zealand and US) are being sold in big supermarkets. Wholesalers have stopped importing apples from countries other than China and India because of high cost in recent years.

Observation visit to apple growing areas of Himanchal Pradesh and China must be arranged for all the stakeholders. Private nursery owners need to improve their orchard management practices and capacity enhancement of agrovets through training is needed. Apple growers should improve their orchard management practices to produce quality apples as per market demand and big campaign is needed to disseminate improved technologies. On the spot trainings are required for production of home-brewed organic pesticides. Production of quality compost and intercropping of grain legumes in apple orchards are required. Technologies for water conservation and utilization, harvesting, handling, sorting, grading, waxing, packaging, storage and transportation should be developed. Supply of packaging material should be well organised. District traders should work towards reliable market channels with sufficient flexibility to adapt to price changes of apple in the major markets. Apple cooperatives need to be formed which could take over tasks from district traders and deal directly with wholesalers. Stable marketing channel for organic certified apples should be developed to reach niche markets where apples can fetch premium prices.

Response of Different Manure and Fertilizer Combinations on Nutrient Status of Soil and Fresh Pod Yield of Cowpea under Acidic Soil Conditions

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ABSTRACT

A four-year study was conducted at Malepatan, Kaski on different combinations of manure and fertilizers to improve the productivity of acidic soil. Nine treatments with three replications were given in the soil and cowpea was grown. Soil analysis was done each year (2064-2067) to know the status of soil pH, organic matter, nitrogen, phosphorus and potassium content in the soil. The data on fresh pod yield of cowpea was collected and analyzed. The mean value on soil pH observed the highest (5.19) when FYM applied alone @ 10 t ha⁻¹. The percent organic matter and nitrogen content of the soil observed the highest (3.56 and 0.177, respectively) due to the application of FYM @ 5 t ha⁻¹ + N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively. The available phosphorus content of the soil observed the highest (68.42 kg ha⁻¹) when poultry manure applied alone @ 2 t ha⁻¹ and followed (64.0 kg ha⁻¹) by the application of N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively + poultry manure @ 1 t ha⁻¹. The amount of potassium content of the soil observed the highest (130.58 t ha⁻¹) due to application of N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively. The fresh pod yield of cowpea was the highest (5197.6 kg ha⁻¹) due to the application of poultry manure @ 1 t ha⁻¹ + N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹, respectively. This study revealed that the application of higher dose of FYM helps to improve the soil pH. The application of higher dose of chemical fertilizer in addition to FYM helps to increase the percent organic matter and nitrogen content in the soil. The phosphorus status and fresh pod yield of cowpea can be improved through the use of poultry manure in combination with chemical fertilizer.

INTRODUCTION

The continuous soil mining through the use of high yielding varieties, intensive multiple cropping systems and inadequate and imbalance fertilization further contributes to decline of soil fertility and crop productivity (Panday et al 1995). As in cereal crops, soil acidity is a serious problem for horticultural crops also as the soil have low pH, low base saturation and high exchangeable H and Al, where rainfall is high (Palaniappan and Varalakshmi 1999). The desertification as physical, chemical and biological degradation of soil is serious problem of today's agriculture in the absence of proper soil ameliorative practices to counter the effect of soil degrading process (Kanwar 2002).

The optimum soil pH range for the majority of agricultural crops is 5.5 to 6.5 (Schreier et al 1995) and soil consisting pH value 5.5 or less is considered as problematic acid soil (Tripathi 2058). About 49 per cent of the total geographical area of Nepal consist acidic soil. The application of lime and manure is one possible solution to avoid further increase in soil acidity (Schreier et al 1995). It is very important to focus the research on ameliorative management of acid soils to encourage the farmers and agro-based industries for sustainable agricultural production. For sustaining agricultural production, research programs should also focus on long term effects of different systems of farming including crops, soil fertility, manurial and other aspects of agricultural practices (Mohsin et al 1995). There is a lack of enough study on management of problematic acid soils at crop growing areas of Nepal.

Keeping these points in view, this study was conducted since 2064 with the objectives of identifying suitable combination of manure and fertilizer to increase the productivity of acidic soil and evaluating the fertility status of the acidic soil after different treatments.

Site characterization

- Site: ARS (Hort.), Malepatan, Kaski
- Latitude: 28° 13' 6.18" North
- Longitude: 83° 58' 27.71" East
- Altitude: 848 M masl
- Slope: 3-5 % (Nearly plain)
- Aspect: South-West
- Climate : Sub-tropical

The meteorological records averaged for 15 years (1991-2005) indicated that mean maximum temperature ranged from 19.2°C to 30.5°C. Similarly, mean minimum temperature range is 6.6°C to 22.1°C. May, June, July and August (30.1°C to 30.5°C) are the hotter months, whereas the December and January (6.6°C to 7.8°C) are the cooler months in a year. The annual total precipitation (averaged for 15 years) is 4112 mm at the site. About 80% of the total rainfall appears during the four months (June to September) and the highest in July (1015 mm). The Station also receives hailstone damages during February to May and sometimes in September to October (Annual report, 2063/64).

MATERIALS AND METHODS

About 400 m² of land consisting acidic soil was selected within the ARS (Horticulture) Research Station during 2064. The different sources of plant nutrients were selected during the preparation of treatments. The lower dose of chemical fertilizer constituted N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹, respectively and higher dose constituted N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, based on recommended dose of fertilizer for leguminous crops. The single dose of FYM was taken @ 5.0 t ha⁻¹ and double dose as 10.0 t ha⁻¹. Similarly, the single dose of poultry manure taken @ 1.0 t ha⁻¹ whereas, that of double dose given as 2.0 t ha⁻¹. Therefore, lower and higher dose of chemical fertilizer, single and double doses of FYM and poultry manure were selected during the preparation of treatment combinations. Altogether nine treatments were given in the soil to identify the better treatment combination that helps to correct the soil acidity and enhance the crop productivity. The experimental plots was laid out by following random complete block design and replicated three times and cowpea (Malepatan-1) was selected as indicator crop. The size of individual treatment plot was 9 m² (3 m x 3 m). Altogether, there were 27 individual plots. About half kg of soil sample was taken from each plot before the start of the experiment and after the harvest of cowpea in each year (2064 to 2067). In total, 27 soil samples were taken in each year and analyzed them for soil pH, percent organic matter, percent nitrogen, available phosphorus and available potassium content in the soil at "Regional Soil Testing Laboratory", Pokhara by following standard procedures.

Two to three seeds of the cowpea planted in a hill and there were 10 plant hills per row. The plant to plant distance was 30 cm and row to row distance was maintained 60 cm. There were five rows in a plot and 50 plant hills of cowpea maintained in each plot. The data on fresh pod yield of cowpea was collected during each harvest in each year. The data relating to soil and fresh pod yield of cowpea were collected for four years (2064, 2065, 2066 and 2067). The data were analyzed with the help of STATISTIX and MSTAT-C, statistical computer software.

Treatments

- T₁: Control (without any manure and fertilizer)
- T₂: Poultry manure @ 2.0 t ha⁻¹ (double dose)
- T₃: Farm yard manure @ 10.0 t ha⁻¹ (double dose)
- T₄: N:P₂O₅:K₂O @40:20:40 kg ha⁻¹, respectively (lower dose)

- T₅: T₄ + Poultry manure @ 1.0 t ha⁻¹ (single dose)
 T₆: T₄ + FYM @ 5.0 t ha⁻¹ (single dose)
 T₇: N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively (higher dose)
 T₈: T₇ + Poultry manure @ 1.0 t ha⁻¹
 T₉: T₇ + FYM @ 5.0 t ha⁻¹

The OM used during the preparation of treatment combinations were analyzed in the soil laboratory (Soil Science Division, Khumaltar) for their nutrient content and given in table 1.

Table 1. Nutrient content in the soil

Source of organic manure	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Farm yard manure	1.51	0.85	2.0
Poultry manure	2.06	0.78	1.0

Source: Joshi (2064)

RESULTS AND DISCUSSION

The mean pH value for the four years varied from 4.75 to 5.19, which is strong acidic in reaction (rating) and presented in table 2. The mean pH value observed the maximum (5.19) due to application of double dose of FYM only (@ 10.0 t ha⁻¹) and followed (5.05) by the application of lower dose of chemical fertilizer in combination with single dose of FYM (N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹ and 5 t ha⁻¹, respectively).

Table 2. Response of different manure and fertilizer combinations with time on pH status of the experimental site

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure/fertilizer)	4.50	4.20	5.33	6.00	5.00 ^{ab}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	4.27	4.27	5.33	5.67	4.93 ^{ab}
T ₃	FYM (@ 10 t ha ⁻¹)	4.60	4.33	5.50	6.33	5.19 ^{a.1}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	4.30	4.33	5.20	5.97	4.95 ^{ab}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	4.47	4.50	5.43	5.43	4.96 ^{ab}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	4.57	4.23	5.37	6.03	5.05 ^{ab.2}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	4.37	4.07	5.07	5.53	4.75 ^{b.L}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	4.43	3.97	5.30	5.33	4.75^{b.L}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	4.20	4.10	5.50	5.80	4.90 ^{ab}
Mean		4.41 ^c	4.22 ^{c.L}	5.36 ^{b.2}	5.79 ^{a.1}	GM=4.94
LSD (0.05)		F-test		C.V. (%)		
Year (A)		0.234	**	16.13		
Replication (B)		0.203	**			
Treatment (C)		0.352	ns			
A*B*C		-				
S. E.		0.177				

*, significant; **, highly significant; ns, not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

The minimum value (4.75) of soil pH was observed due to higher dose of chemical fertilizer and/or in combination with single dose of poultry manure (N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹ and 1.0 t ha⁻¹, respectively). The overall pH scale seemed increasing due to different treatment imposed. However, the effect of treatment observed to be insignificant. In the year-wise comparison, the mean pH value observed the maximum (5.79) in 2067 and followed (5.36) by 2066. The lowest value on mean soil pH (4.22) was observed in 2065. The difference of means observed highly significant with time. The range of increment increase in soil pH varied from 0.38 to 0.59 units due to treatment and up to 1.57

units with time (year). The reaction of the soil of the experimental site changed from very strongly acidic to strong acidic in reaction before and after the experiment in that acidic soil.

These results indicated that application of different combination of manures and fertilizer showed positive response to increase the pH of the acidic soil. The mean values on percent organic matter content of the soil of the experimental site varied from 2.83% to 3.56% and are presented in table 3. This range of percent organic matter falls under medium in rating. The mean value on percent organic matter content of the soil observed the highest (3.56%) due to application of higher dose of chemical fertilizer in addition to single dose of farm yard manure and followed (3.42%) by control (without any manure and fertilizer application).

The percent organic matter content of the soil was the lowest (2.83%) due to application of poultry manure alone (@ 2.0 t ha⁻¹). However, the effect of treatment observed to be insignificant. The increment change in percent organic matter content of the soil found inconsistent. In the year-wise comparison of means, the highest amount of percent organic matter content (3.56%) was in the year 2067 and followed (3.09%) in the year 2065. The difference of means with time observed to be significant. The increment increase in percent organic matter with time is found to be 0.52%. The trend of percent organic matter content of the soil with time is increasing.

Table 3. The status of percent organic matter content in the soil of the experimental site due to different manure and fertilizer combinations with time

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure / fertilizer)	3.70	3.03	3.17	3.80	3.42 ^{ab.2}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	2.19	3.10	2.70	3.33	2.83 ^{c.L}
T ₃	FYM (@ 10 t ha ⁻¹)	3.53	3.17	2.90	3.50	3.27 ^{abc}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	1.99	3.10	2.93	3.33	2.84 ^c
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	2.26	3.17	3.10	3.30	2.96 ^{bc}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	2.71	3.33	3.13	3.57	3.19 ^{abc}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	3.86	2.87	2.90	3.63	3.31 ^{abc}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	2.84	3.17	3.17	3.80	3.24 ^{abc}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	4.26	2.87	3.33	3.73	3.56 ^{a.1}
Mean		3.04 ^{b.L}	3.09 ^{b.2}	3.04 ^{b.L}	3.56 ^{a.1}	GM=3.18
LSD (0.05)		F-test		C.V. (%)		
Year (A)		0.368	*	22.54		
Replication (B)		0.319	ns			
Treatment (C)		0.552	ns			
A*B*C		-				
S.E.		0.278				

*, significant, ns: not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

These results indicated that percent organic matter content of the soil can be increased through the adoption of higher dose of fertilizer with combination of organic manure. The four-year mean values on percent nitrogen content of the soil are presented in table 4. These values varied from 0.141% to 0.177% and medium in rating. The maximum amount of percent nitrogen content (0.177%) of the soil was observed due to application of higher dose of chemical fertilizer in addition to single dose farm yard manure and followed (0.173%) due to control (without any manure and fertilizer application). The minimum amount of percent nitrogen content (0.141%) observed due to application of poultry manure (@ 2.0 t ha⁻¹). However, the differences of means due to treatment observed to be insignificant.

The distribution of mean values on percent nitrogen content of the soil observed inconsistent and the trend is similar to percent organic matter content of the soil. In the year-wise comparison of means, the maximum amount of percent nitrogen content (0.177%) observed in the year 2067 and followed (0.154%) in the year 2065. But the value was lowest (0.152%) in the year 2066. The increment increase in percent nitrogen content of the soil over time is 0.024%. The difference of means with time observed to be significant.

These results indicated that the overall trend of percent nitrogen content of the soil over time is increasing due to addition of more amounts of farm yard manure as compared to first soil data (2064).

Table 4. Status of percent nitrogen content in the soil of the experimental site with time due to different combinations of manures and fertilizer

Treatment	Year				Mean ^K
	2064	2065	2066	2067	
T ₁ Control (w/o manure/fertilizer)	0.187	0.153	0.160	0.190	0.173 ^{ab,2}
T ₂ Poultry manure (@ 2 t ha ⁻¹)	0.107	0.153	0.137	0.167	0.141 ^{c,L}
T ₃ FYM (@ 10 t ha ⁻¹)	0.177	0.157	0.147	0.177	0.164 ^{abc}
T ₄ N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	0.100	0.157	0.143	0.167	0.142 ^c
T ₅ T ₄ + Poultry manure (@ 1 t ha ⁻¹)	0.113	0.157	0.153	0.167	0.147 ^{bc}
T ₆ T ₄ + FYM (@ 5 t ha ⁻¹)	0.137	0.170	0.157	0.177	0.160 ^{abc}
T ₇ N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	0.197	0.143	0.147	0.180	0.167 ^{abc}
T ₈ T ₇ + Poultry manure (@ 1 t ha ⁻¹)	0.143	0.157	0.157	0.190	0.162 ^{abc}
T ₉ T ₇ + FYM (@ 5 t ha ⁻¹)	0.213	0.143	0.167	0.183	0.177 ^{a,1}
Mean	0.153 ^b	0.154 ^{b,2}	0.152 ^b	0.177 ^{a,1}	GM=0.159
	LSD(0.05 F-test C.V. (%))				
Year (A)	0.018	*	22.61		
Replication (B)	0.016	ns			
Treatment (C)	0.0277	ns			
A*B*C	-				
S.E.	0.014				

*, significant; ns, not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

The four-year mean values on available phosphorus varied from 33.92 kg ha⁻¹ to 68.42 kg ha⁻¹ and presented in table 5. This range of availability of available phosphorus varied from medium to high in its rating. The mean value observed the highest (68.42 kg ha⁻¹) due to the application of double dose of poultry manure (@ 2.0 t ha⁻¹) and followed (64.50 kg ha⁻¹) by the application of higher dose of chemical fertilizer in combination with single dose of poultry manure. The minimum amount of available phosphorus (33.92 kg ha⁻¹) was observed due to application of lower dose of chemical fertilizer with combination of single dose of FYM. The effect due to treatment observed to be highly significant. In acidic soil, phosphate binds with Fe and Al and it forms iron and aluminum phosphate, which is unavailable to plant.

In the year-wise comparison of means, the maximum amount of available phosphorus (72.96 kg ha⁻¹) observed in the beginning (2064) and followed (60.70 kg ha⁻¹) in the year 2065. The difference of means with time observed to be highly significant. These results indicated that the application of poultry manure either double or single (@ 2.0 t ha⁻¹ or 1.0 t ha⁻¹) is efficient in combination with chemical fertilizer to increase the availability of available phosphorus. The overall trend of availability of phosphorus is decreasing with time.

Table 5. Status of available phosphorus content (kg ha⁻¹) in the soil of the experimental site with time due to different combinations of manures and fertilizer

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure/fertilizer)	80.30	60.67	12.33	26.67	45.00 ^{bcd}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	104.33	79.67	11.00	78.67	68.42 ^{a.1}
T ₃	FYM (@ 10 t ha ⁻¹)	53.00	51.33	4.00	38.33	36.67 ^{bcd}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	66.67	35.67	11.00	65.33	44.67 ^{bcd}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	64.00	54.33	3.67	56.00	44.50 ^{bcd}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	42.67	51.33	4.67	37.00	33.92 ^{bcd.L}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	64.00	57.67	7.33	38.67	41.92 ^{bcd}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	77.33	89.00	21.67	70.00	64.50 ^{ab.2}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	104.33	66.67	5.33	62.00	59.58 ^{abc}
Mean		72.96 ^{a.1}	60.70 ^{ab.2}	9.00 ^L	52.52 ^b	GM=48.79
		LSD(0.05)	F-test	C.V. (%)		
Year (A)		13.43	**	73.24		
Replication (B)		11.63	ns			
Treatment (C)		20.15	**			
A*B*C		-				
S. E.		10.15				

**, highly significant; ns, not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

The data relating to mean values on available potassium varied from 86.67 kg ha⁻¹ to 130.58 kg ha⁻¹ and presented in table 6. The observed range of available potassium falls under low to medium in its rating. The highest amount of available potassium (130.58 kg ha⁻¹) was observed due to application of higher dose of chemical fertilizer and followed (129.25 kg ha⁻¹) by the combined application of higher dose of chemical fertilizer and single dose of FYM.

The lowest amount of available potassium content of the soil (86.67 kg h⁻¹) was observed in controlled plot (i.e., without application of lime, fertilizer and manure). The difference of means due to treatment observed to be significant. The year-wise comparison of means showed that the maximum amount of available potassium (242.41 kg ha⁻¹) was observed in the year 2064 and followed (1186.15 kg ha⁻¹) in 2067. The lowest amount of available potassium (17.30 kg ha⁻¹) was observed in 2066. The difference of means with time was highly significant.

These results indicated that the availability of available potassium can be increased with the application of higher dose of chemical fertilizer.

The data relating to mean values on fresh pod yield of cowpea for the four years is presented in table 7. Mean values varied from 3032.90 kg ha⁻¹ to 5197.60 kg ha⁻¹. The highest pod yield (5197.60 kg ha⁻¹) of the cowpea was observed due to application of lower dose of chemical fertilizer with combination of single dose of poultry manure (N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹ and 1.0 t ha⁻¹, respectively). The yield was followed (4925.90 kg ha⁻¹) by double dose of poultry manure (@ 2.0 t ha⁻¹). The lowest pod yield (3032.90 kg ha⁻¹) of the cowpea was observed due to control treatment (without application of any manure and fertilizer). All the mean values on fresh pod yield of cowpea due to treatment observed the higher than that of controlled treatment.

The effect due to treatment observed highly significant. In the year-wise comparison of means, the maximum pod yield (6976.30 kg ha⁻¹) observed in the year 2064 and followed (4820.30 kg ha⁻¹) in 2065. The lowest yield (2322.76 kg ha⁻¹) observed in 2066. The difference of means with time

observed to be highly significant. However, the trend of the fresh pod yield of cowpea is decreasing with time.

Table 6. Response of different manure and fertilizer combinations on status of available potassium (kg ha⁻¹) with time in the soil of the experimental site

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure/fertilizer)	223.00	65.00	10.67	48.00	86.67 ^{bc.L}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	211.00	105.67	16.33	119.33	113.0 ^{abc}
T ₃	FYM (@ 10 t ha ⁻¹)	239.67	62.00	13.67	72.00	96.83 ^{bc}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	252.33	72.33	15.33	136.00	119.0 ^{ab}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	270.67	71.33	16.33	136.00	123.58 ^{ab}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	201.33	70.67	17.33	96.00	96.33 ^{bc}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	281.33	75.33	13.67	152.00	130.58 ^{a.1}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	245.00	72.67	23.33	160.00	125.25 ^{ab}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	257.33	86.67	29.00	144.00	129.25 ^{a.2}
Mean		242.41 ^{a.1}	75.74 ^c	17.30 ^{d.L}	118.15 ^{b.2}	GM=113.4
		LSD (0.05	F-test	C.V. (%)		
Year (A)		19.53	**	80.57		
Replication (B)		16.91	ns			
Treatment (C)		29.29	*			
A*B*C		-				
S. E.		14.75				

*, significant; **, highly significant; ns, not significant; ^{K, m} means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); ^{a, b} means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

This study revealed that the application of lower dose of chemical fertilizer (i.e. N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹) in addition to poultry manure (1-2 t ha⁻¹) is the most suitable combination to grasp the higher yield of fresh pod yield of cowpea.

Table 7. Response of different manure and fertilizer combinations on fresh pod yield (kg ha⁻¹) of cowpea in the experimental site

Treatment		Year				
		2064	2065	2066	2067	Mean ^K
T ₁	Control (w/o manure / fertilizer)	4749.73	2866.30	3437.87	1077.78	3032.9 ^{cd.L}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	7125.40	5926.29	3055.53	3596.29	4925.9 ^{ab.2}
T ₃	FYM (@ 10 t ha ⁻¹)	6892.27	4690.18	3195.53	2511.11	4322.3 ^{abc}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	6212.33	4653.70	2046.47	2814.81	3931.8 ^{bc}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	8454.40	5094.81	2191.13	5048.14	5197.6 ^{a.1}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	7112.60	5209.62	1996.73	3592.59	4477.9 ^{abc}
T ₇	N:P ₂ O ₅ :K ₂ O(@ 60:40:60 kg ha ⁻¹ re	6745.73	5129.25	2890.93	3192.59	4489.6 ^{abc}
T ₈	T ₇ + + Poultry manure (@ 1 t ha ⁻¹)	7806.80	5281.47	1733.47	4107.40	4732.3 ^{abc}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	7687.40	4531.11	357.13	4125.92	4175.4 ^{bc}
Mean		6976.30 ^{a.1}	4820.3 ^{b.2}	2322.76 ^{d.L}	3340.74 ^c	GM=4365.1
		LSD (0.05)	F-test	C.V. (%)		
Year (A)		661.60	**	50.03		
Replication (B)		572.96	ns			
Treatment (C)		992.40	**			
A*B*C		-				
S. E.		499.82				

*, significant; **, highly significant; ns, not significant; ^P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); ^{a, b} means in the row (year mean) with similar letters are not significantly different by LSD (0.05).

The application of different combination of manures and fertilizer showed positive response to increase the pH of the acidic soil. The overall trend of percent organic matter and nitrogen content of the soil over time is increasing due to addition of more amounts of farm yard manure as compared to first soil data (2064). The application of poultry manure (@ 1.0 to 2.0 t ha⁻¹) in addition to chemical fertilizer is efficient to increase the availability of available phosphorus. The overall trend of availability of phosphorus is decreasing with time. The availability of available potassium can be increased with the application of higher dose of chemical fertilizer. The fresh pod yield of cowpea can be increased through the use of poultry manure (@ 1.0 to 2.0 t ha⁻¹) in combination with lower dose of chemical fertilizer (N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹, respectively).

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Public Private Partnership Model for Agricultural Research and Development in Nepal

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ABSTRACT

Among different strategies of development implementation, public private partnership (PPP) model is drawing attention of present policy makers and politicians in recent years. This concept is complicated in case of agricultural research and innovation in a country like ours where most of the farmers are small and marginal. Two cases were studied in 2010 in order to identify constraints and opportunities of PPP use in agriculture research, i) the Commercial Agriculture Development Project for the promotion of high value crops in the eastern region, and ii) trout fisheries research and promotion in Rasuwa and Nuwakot districts. Research respondents included respective research and development workers, farmers, officials from respective PPP partners. This study employed qualitative approach of analysis to gather information from key stakeholders through interview and review of reports, websites, and other publications. Constraints of PPP use were identified as lack of coordination among partners, less interest of private sectors in agricultural research, and inefficiency in attaining the objectives of social inclusion and employment generation. This paper also i) proposes a broad PPP modality of implementation of Nepalese agricultural research projects which can address the resource scarcity in public research institutions in order to attain the developmental goal of equity and efficiency; and ii) suggests appropriate policy measures accordingly.

INTRODUCTION

Wikipedia defines public-private partnership (PPP) as a contractual arrangement between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk in the project. It further defines the role of a government as the contributions in kind, notably the transfer of existing assets in the form of financial, and/or natural resources. In projects that are aimed at creating public goods like in the infrastructure sector, the government may provide a capital subsidy in the form of a one-time grant, so as to make it more attractive to the private investors. With the use of PPP approach a government manages to carry out an economic activity which cannot be done, in general, based on market mechanism of neo-liberal economics due to low return to investment or presence of high risk or lack of capacity of the government of developing countries. Recent studies has shown higher research return from investments in agricultural research and development in the country, and also the country has scarcity of required resources, the partnering between private and public sector for the growth of the economy seems a rational development strategy.

Public-private partnership model is drawing attention of present policy makers and politicians in recent years. This concept is simpler in delivery of scientific information to the recipients, however, it is equally complicated in case of agricultural research and innovation in a country like ours where most of the farmers are small and marginal. Planners and policy makers of the country are starting to rethink about the state role in conducting agricultural research. Public-private partnership has been started to take as an alternative model of development in different sectors. In this context, identifying issues for PPP modality in agricultural research and development was urgent. This analysis provides

important issues of PPP modality and its constraints and opportunities in agricultural research in the country. This study uses the concept as used by Ferroni and Castle (2011), who have used PPP as a bilateral collaboration between a government and a private sector as well as “Hybrid Value Chains” encompassing private companies, non-governmental organizations (NGO), university, and research institutes. Private companies include growers, processors, and traders in our context. Present study has identified constraints and opportunities for promoting PPP in agricultural research in Nepal. This study employed qualitative approach of analysis. Information was gathered from key stakeholders through semi-structured interview schedule and review of reports, websites, and other publications. Two cases were studied, i) a bilateral collaboration with Commercial Agricultural Alliance for (CAA) for the promotion of high value crops, and ii) “Hybrid Value Chains” for trout promotion. Thus, the research respondents included relevant research and development workers, farmers, officials from Department of Agriculture, CAA and Agriculture Enterprise Centre (AEC) of Federation of Nepalese Chamber of Commerce and Industries (FNCCI).

Existing policy framework

In order to promote PPP modality in agricultural research in the country, all the relevant laws and regulations of the government should be conducive. Policy review comes to the analysis that there is no specific PPP policy in Nepal. However, many policies in agriculture are directly related to this concept. Nepal Agricultural Policy, 2004 has spelt out promotion of participatory and competitive agricultural research and development system involving the private and the non-government sectors. Such participatory activities include agricultural production, collection, grading, storage and packaging of agricultural products. The policy also envisages development, expansion and dissemination of a market information system in partnership with the private and cooperative sectors and the local bodies. The policy further envisages providing support to the development and expansion of collection centers near potential production sites with the participation of private and cooperative sectors by sharing cost and management. The National Fertilizer Policy, 2002 supports agricultural production by ensuring supplies of quality fertilizer (production, import and distribution) in the country, one of the key features of which is to ensure and sustain the participation of the private sector in the importation and distribution of the fertilizers. Other policies like National Seeds Policy, 1999; National Tea Development Policy, 2000; National Coffee Development Policy, 2003; and Agricultural Biodiversity Policy, 2003 have recognized the role of the private sector and included several provisions to attract private sector investment in agribusiness and value chain development.

Case of Commercial Agricultural Alliance for promoting high value crops

Commercial Agricultural Alliance (CAA) is a not-for-profit sharing company established in 2006 for the implementation of commercial investment and management component of Commercial Agricultural Development Project (CADP) in high value crops through managing fund on cost sharing term. The alliance, with an elected board and a management team headed by a general manager, has branches in each of the 11 project districts headed by a branch manager. CAA has been established to manage the Commercial Agricultural Fund (CAF), and more importantly to facilitate sub-project linkages and the networking of agricultural stakeholders within the project area. The CAF finances (i) community-based market infrastructure investments, and (ii) non-infrastructure investments. Only the general members of the CAA and District Development Committees (DDCs) within the project area are eligible to receive financing. To receive CAF financing as a grant on a costs sharing basis, the proposed investment must (i) incorporate public good content, (ii) add value to agricultural products, (iii) benefit other agricultural stakeholders and the community as a whole, (iv) improve market-chain efficiency, and (v) provide a strong demonstration impact for the community.

Only the DDCs are eligible to apply for community-based market infrastructure investments. Farmer communities, through their Village Development Committee (VDC), identify needs in a participatory manner and the DDCs screens VDC requests before submitting the proposal to the CAA to ensure (i) no duplication with other development programs in the district, and (ii) adequate appraisal of the

technical and financial feasibility of the proposal. In this type of investment, the CAF finances a maximum of 75% of the investment cost, with the community providing a minimum of 10% of the investment cost in the form of labor and in-kind contributions. The DDC finances the remaining 15% of the investment cost in the form of technical services, field appraisal, and assessment. The range of community-based investments includes small collection centers, small markets, ropeways, small suspension bridges, farm-to-market road improvement including culverts and swing bridges, small-scale cool or cold storage, and small-scale marketing-related water supply. The VDCs and farmer communities assisted by the DDC district technical office are responsible for construction, management, and maintenance of the infrastructure.

The CAF provides financial assistance for non-infrastructure investments of farmer groups and cooperatives, traders, and processors, which are the general members of the CAA. For this type of investment, the CAF finances a maximum of 50% of the investment, with the remainder to be contributed by the direct beneficiaries. Among others, the investments could include (i) group promotion of improved cultivation practices for HVC and emerging crops, (ii) pest management including integrated pest management techniques, (iii) farm machinery and equipment, (iv) greenhouse equipment, (v) agro-processing equipment and machinery, (vi) laboratory equipment for product testing and quality control, and (vii) market-related research and technology development such as pickle making, fruit or vegetable drying or preservation, tomato pulp making, crop diversification into emergent HVCs, and farm-to-market packaging systems. The selected investments must have maximum demonstration impact on the community and other agriculture stakeholders. All farm level investment supports have been provided to farmer groups or cooperatives, not to individuals. Traders and processors must explicitly demonstrate how their proposed investments enhance the agriculture value chain by strengthening linkages between farmer groups and markets. Other non-infrastructure investments by CAA general members include launching promotional and representational activities such as (i) trade fairs and trade promotion, (ii) industry networking on issues requiring joint action for resolving cross-border issues and reducing local red tape, (iii) product labeling and certification arrangements, (iv) product identification, branding, and feasibility studies, (v) quality mark initiatives, (vi) brand and intellectual property right protection, and (vii) specialized skill development and employment strategy formulation. Rest of the components is implemented through farmers' group and local NGOs.

The project outcome is improved efficiency of production, marketing, and processing of HVCs such as vegetables, fruits, tea, and spices, within the project area. However, CAA could not upgrade small and marginal farmers to next ladder of value chain from primary production of fruits and vegetables. Also, the linkage and coordination between producers and processors were loose and weak. Investment in local infrastructure in the form of collection and storage centers, cool stores, access to market information and agribusiness and/or product improvement technology are being provided. Attention is also on traders and processors to improve the quality and regularity of supply of products purchased by them and to encourage their investment in the market chain through linkages to farmers, such as contract farming arrangements.

The Project has envisioned generating employment opportunities for subsistence and marginal farmers by promoting HVC production and marketing, transporting products from the field to storage and processing centers, and assisting small-scale community-based market infrastructure development. The assumption was that CAA fund addresses and reinforces social inclusion and assists subsistent stakeholders to raise their commercial status through developing community-based market infrastructure and implementing the whole range of CAA activities that promote backward and forward linkages. However, it was observed that:

- Processing capacity of the processors has been increased with new installments.
- Farmers are organized in groups and cooperatives (institution building).

- CAA supports to production, processing and marketing are not linked to value chain development, are rather isolated and independent. CAA lacks the mechanism where the financial support to processing promotes linkage among the value chain stakeholders. In the absence of contract law, violation of agreement between producer and processor has been common.
- The inclusion aspect was not attained. Landless people was not linked to skill-based training in areas such as packaging (weaving of baskets for transport of agricultural products), primary processing (product washing and drying), tool making, and servicing (repair of small equipment) as envisioned.

Case of One Village One Product (OVOP) Program of Rainbow Trout

First of all in 1979, "One Village One Product" (OVOP) program was initiated by Mr. Morihiko Hiramatsu – the then Governor of Oita prefecture, Japan. Inspired by successful story of OVOP program in Japan, Thailand and other countries, the OVOP program introduced in Nepal is totally based on the concept of PPP. The Federation of Nepalese Chambers of Commerce and Industry (FNCCI) had worked out a great deal of homework to introduce OVOP program in Nepal. Finally, FNCCI/Nepal has been successful in introducing OVOP in Nepal in partnership with Ministry of Agriculture and Cooperatives, the Government of Nepal. The Finance Minister of the Government of Nepal through his budget speech amidst House of Representatives has announced the launching of OVOP program in Nepal with effect from the very beginning of the fiscal year 2063/64 (Economic Survey, 2006/07).

The overall objective of this program in Nepal is to alleviate poverty in local community and develop their entrepreneurship and other specific objectives are: to develop local product and to add value in the product as per market demand through involvement of local people and their skills; to develop competitive product system identifying the export potential product through specialized product oriented process; to alleviate the local community poverty and to help enhancing economic development; to develop and to promote the branding of the product implementation aspects (FNCCI/AEC website). The overall program has been implemented under a special OVOP working procedure called as "Ek Gaon Ek Utpadan (One Village One Product) Karyakram Karyanoyen Karyabidhi, 2063" that was prepared jointly by the Ministry of Agriculture and Cooperatives and Agro Enterprise Centre (AEC) of FNCCI and then amended in the year 2065. A high level agribusiness promotion committee headed by Minister, MOAC with the secretaries from various ministries including the president of FNCCI/Nepal as member in the policy level committee guides the OVOP committees. There are two central level committees. One is the Implementing Committee that comprises of 20 members from different ministries and other related institutions. The coordinator of the committee is the president of FNCCI followed by two Vice-Coordinators. One is Joint secretary from Agribusiness Promotion and Statistics Division of Ministry of Agriculture and Cooperatives and another one is the Chairman of Agro Enterprise Centre/FNCCI.

As defined in the working procedure, Agro Enterprise Centre has been authorized to work as a Secretariat of OVOP program in Nepal where the Executive Director works as Member Secretary of the Implementing Committee. Another Committee in the central level formed is "Basket Fund" sub-committee. This committee comprises 5 members headed by Joint Secretary of Agri-Business Promotion and Statistics Division of Ministry of Agriculture and Cooperatives as a coordinator. Besides central level committees, there is a provision of district level committee. The number of committees varies as per number of district included in the program. At present, Bhaktapur, Lalitpur, Ramechhap, Sindhuli, Nuwakot, Rasuwa, Bardiya and Kaski are the districts where OVOP is being implemented. This committee would have maximum five members, where the coordinator is the Chairman of district chamber of commerce and industries and the vice coordinator is the District Agriculture Development Officer. Local Development Officer or his representative represent as a core member. This program has been launched as a pilot project. The products selected are: Junar (Sweet Orange) in Sindhuli and Ramechhap, Lapsi (Hog plum) in Bhaktapur, Rainbow Trout Fish in

Nuwakot and Rasuwa, Bael in Siraha, Bardiya and Banke, Orchid in Lalitpur and Agro-Tourism in Lekhnath of Kaski.

This paper describes here this approach with respect to promotion of rainbow trout fish in Nuwakot and Rasuwa districts of Nepal. Rainbow trout fish program has been launched in Nuwakot district from the very beginning of the launching of OVOP program in Nepal. Interventions were in construction of raceway, fingerlings production, technology development and market promotion, among the main activities. The program has helped private sector trout farmers to produce fingerlings in their own raceways. Technical support has been provided to farmers by both the Fisheries Development Directorate and the Fishery Research Division (NARC). District Agricultural Office and the Nuwakot Chamber of Commerce and Industry have been providing all other administrative support to the program under direct supervision of Ministry of Agriculture and Cooperatives and the OVOP Secretariat, AEC/FNCCI.

In Rasuwa, the program was launched in 2064/65. Likewise in Nuwakot, the district program implementing committee has been formed headed by the Chairman of Rasuwa Chamber of Commerce and Industry as a coordinator. The program has been supported by the District Agricultural Development Office, Local Development Office, Fishery Research Station, Chamber of Commerce and Industry in local level and the Ministry of Agriculture and Cooperatives and the line agencies like Department of Agriculture, Fisheries Development Directorate and the Fishery Research Division (NARC) in central level along with OVOP Secretariat – AEC/FNCCI.

Fisheries Research component of NARC has developed technologies on breeding, hatchery management and feed formulation for rainbow trout. Under OVOP program these technologies are being disseminated to trout farmers of Nuwakot and Rasuwa districts. As a result, some of the farmers of these districts have started producing trout feed and fingerlings for their own use as well for supplying to nearby areas. Gurung (2008a) has identified constraints associated with production of trout feed were variation in the quality of raw materials, inadequate knowledge among farmers on feed formulation and quality maintenance, lack of laboratory facility for quality testing of trout feed, storage problem and quality losses during storage, lack of extrusion technology, lack of qualified manpower in private sector, high price for protein supplementation, insufficient infrastructure to fulfill ever growing demand of trout feed and finally, weak feed supply system. After a decade of continuous efforts on research, a complete technology package of breeding, fry nursing, rearing and grow-out of rainbow trout with feed production technology has been developed by NARC. However, the existing fisheries extension activity is not enough to promote “One Village One Product” slogan in Rasuwa and Nuwakot District due to i) the lack of subject matter specialists (SMS) and junior technicians (cold water), ii) employment of participatory extension involving NGOs/INGOs/CBOs and other relevant stakeholders and lack of programme level integration with micro/macro hydro-projects (Gurung 2008b).

Constraints for using PPP model in agricultural research and development

With the lessons learned so far, constraints and opportunities for PPP in Nepal's agricultural research are as follows:

- Lack of coordination and definition of roles and responsibilities among the partners are not still clear.
- Stakeholders limited capacity in updated technical knowledge.
- Public sector organization are not supportive rather critical of private sector.
- Nepal agriculture policy 2004, agribusiness policy 2006, industrial policy 2009 and trade policy 2010 are providing basis for PPP model of development, but still lacks the umbrella policy framework.
- There are unexplored potentialities in agricultural research in the country and proper patenting of research findings triggers private sector investment in agricultural research in the country.

- Lack of clear articulation of the NARC position with regard to the PPP. NARC at the policy level is supportive of the PPP, but it lacks proper arrangement at the local level to attract private sector.
- Interest of the private sector was profit maximization, whereas the interest of public sectors was poverty reduction by the project.

SUGGESTIONS

- Framing proper patent right laws in accordance with World Intellectual Property Rights Organization will open venues for PPP in agricultural research in the country benefiting PPP partners for the public good characteristics of research output and the problem of free riders. In such case subsidy to private sectors is necessary to offset the sector loss by free riders of the technology developed by private entity.
- Contract law should be framed to avoid non-compliance of the role of producer, processor and traders. Lack of the law has been a hindrance to PPP (personal communication, Pradeep Maharjan of FNCCI/AEC, 2011).
- Farming umbrella policy to promote PPP in agricultural research in the country is necessary.
- Patenting facilities for technology developers with a careful regulatory measures so as to value social goals which the neo-liberal economics may undervalue; and to prevent monopoly of patent right, a proper regulatory measures and environmental regulations should be in place at the same time (Fuglie et al 200).
- PPP should involve entire value chain, and before taking decisions about entering into partnerships there should be well-defined modalities for royalty sharing (APCoAB 2007).
- The public sector scientists and other researchers should be provided adequate incentives to drive the partnership towards achieving the desired goals.
- A Senior Level Working Group comprising NARC/DOA/DLS/FNCCI/universities/INGO/NGO should be formed to regularly review the technological developments in the public sector and identify the appropriate ones suitable for commercialization with PPP.
- Possible areas of collaboration at present can be identified as seed production, agricultural extension, fertilizer production, and agricultural research with IPR, quality testing and certification facility, adoption of agricultural technologies, marketing and export promotion.

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Effect of Plant Spacing on the Yield and Quality of Flower, Corm and Cormel of Gladiolus cv. Jester

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ABSTRACT

Gladiolus is the most important cut flower among the bulbous flower, being commercially grown in Nepal. Plant spacing is one of the most important agronomic factors that affect the vegetative growth, yield and quality of flower, corm and cormels. In order to find the optimum plant spacing of gladiolus cv. Jester for mid hills of Nepal, experiments were conducted for two consecutive years 2006 and 2007 at Agriculture Research Station, Pakhribas. There were eight plant spacing as treatment, 20x15, 20x20, 20x25, 20x30, 30x15, 30x20, 30x25 and 30x30 cm with three replications. The experiment was laid out in randomized complete block design. The results showed that earliest spike harvesting days (75.37 d in 2006 and 90.07 d in 2007) in spacing 30x30 cm. First pair of flower opening after spike emergence was found earliest (14.83) from 30x25 cm in 2006 while in 14.57 days in 2007 from 30x30 cm. Largest flower size (10.902 cm) was recorded from 30x30 cm spacing in 2006 and 10.083 cm from 20x30 cm in 2007. In 2006, greater number of florets per spike (18.83) was recorded from 20x30 cm and in 2007 it was insignificant. Similarly, longest spike (104.60 cm and 101.90 cm) was found from 30x30 cm spacing in both 2006 and 2007, respectively. In case of average weight of daughter corm 20x30 cm produced maximum in 2006 while in 2007 it was found from 30x30 cm. Same result obtained for corm size, 20x30 cm gave largest corm in 2006 and by 30x30 in 2007. Finally, higher daughter corm yield (29746 kg/ha in 2006 and 17179 kg/ha in 2007) were acquired from narrower spacing (20x15 cm). Considering all of these results, it can be concluded that spacing 30x30 cm and 20x30 cm are best for both flower quality and corm size of gladiolus cv. Jester for mid hills of Nepal.

INTRODUCTION

Gladiolus is the most popular cut flower in the world. It is the fourth important cut flower after rose, chrysanthemum and carnation in the world. In case of Nepal it is the number one cut flower. According to Devtech (1995) it is the largest grown cut flower in Nepal which occupies 70% of all cut flower sales. It's popularity and demand is increasing day by day. The total demand of gladiolus sticks per day is 3500-4500 and its production per annum is only 80000 sticks in Nepal (Gauchan et al 2009). It clearly showed that there is ample room for area expansion of gladiolus cut flower in Nepal.

Gladiolus is popular among the growers because it is easy to grow and doesn't need any protected structure. It also has dual benefit to growers, which produce spike as well as corms. Gladiolus flower comes with great variability in color, which is the major reason that consumers prefer it for cut flower. The unique nature of gladiolus is its spike which opens one by one in sequence even under room conditions. Furthermore, it is also an important cut flower for both domestic and international market. Yanai et al (2007) reported that gladiolus is the cut flower having export potential for Nepal.

Proper plant spacing is an important agronomic practice which provide space for sunlight, moisture availability and soil nutrients which are vital for successful crop production and its quality (Sanjib et al 2002). Closer spacing occupies more plants but it reduces the quality of the product, while more

spacing produce good quality but at the expense of crop numbers and profit (Ingels 2001). El-Shaikh (2010) also reported that the adjustment of plant density offers a promising mean of reducing the cost of cultivation by increasing the productivity per unit area. Growers always want to gain more profit from per unit area. In order to get both quality spike and high corm yield, suitable plant spacing is necessary. Thus, we started this project with the objective to identify the proper plant spacing to produce maximum quality flower, corm and cormels of gladiolus cv. Jester at Agriculture Research Station, Pakhribas.

MATERIALS AND METHODS

The experiments were conducted for two consecutive years 2006 and 2007 at Agriculture Research Station, Pakhribas. There were eight plant spacing 20x15, 20x20, 20x25, 20x30, 30x15, 30x20, 30x25 and 30x30 cm with three replications. The trials were laid out in randomized complete block design. The plot size was 2.7 m² and 5 kg FYM and 60:30:30 NPK gm/m² were applied. Half nitrogen incorporated as basal dose and half nitrogen as top dress one month after planting. In 2006, planting was done in March 21 while in 2007 it was completed in February 21. Observations were made on spike emergence date, flowering date, flower size, spike length, corm and cormel yield. Data were analyzed by Genstat Discovery edition 4.

RESULTS AND DISCUSSION

Flower parameters for year 2006

There were significant differences for spike emergence days, flowering days, flower size and number of florets, plant height and spike length for 2006. The table 1 showed that the earliest spike emergence was from 30x30 cm spacing followed by 20x30 cm. The delayed emergence was found from 30x15 cm spacing. The flowering day is the day of flower harvesting counted after spike emergence. The earliest flowering was recorded from spacing 30x25 cm² in 14.83 days followed by 30x15 cm and 30x30 cm. More time taken for flowering was from 20x20 cm spacing. Largest flower was found from 30x30 cm spacing followed by 20x30 (Table 1) and smallest flower was from 20x15 cm and 30x15 cm spacings. Similarly, greater number of florets were recorded from spacing 20x30 cm followed by 30x30 cm. The number of florets were at par with spacings 20x30 cm and 30x30 cm with 18.83 and 18.77, respectively. Similarly, spike length which is the major criterium for grading the gladiolus was found longest from spacing 30x30 cm (Table 1) followed by 30x25 cm.

Table 1. Flower parameters in 2006

Treatments (Spacing, cm)	Spike emergence days	Flowering days	Flower size (cm)	No. of florets	Spike length (cm)
20x15	81.70±2.44cd	16.20±0.23abc	9.817±0.53e	17.07±0.80bc	93.43±6.10e
20x20	79.42±0.16abc	17.54±1.57c	10.100±0.25cde	17.83±0.03abc	96.63±2.90de
20x25	78.50±0.76abc	15.90±0.07abc	10.500±0.15abcd	18.20±0.34ab	100.53±1.00bc
20x30	76.57±2.69ab	16.40±0.43abc	10.667±0.32ab	18.83±0.97a	101.60±2.06abc
30x15	84.47±5.21d	15.03±0.93ab	9.983±0.37de	16.80±1.06c	98.07±1.47cd
30x20	80.30±1.04bc	16.80±0.83bc	10.283±0.07bcde	17.37±0.50bc	99.07±0.47bcd
30x25	77.77±1.49abc	14.83±1.13a	10.550±0.20abc	18.03±0.17abc	102.37±2.83ab
30x30	75.37±3.89a	15.03±0.93ab	10.902±0.55a	18.77±0.90a	104.60±5.06a
CV	2.7	6.2	2.8	3.8	2.0

Flower parameters for year 2007

For the year 2007, flower size, plant height and spike length were significantly different with different plant spacings but flowering days and number of florets were insignificant. Corms planted in 30x30

cm spacing emerged the spike in 90.73 days while planted in 30x15 cm spacing emerged in 97.67 days. In same case earliest flowering was recorded from 30x30 cm followed by 30x20 cm. The largest flower was observed from the spacing 20x30 cm (Table 2). Wider spacing provided the longest spike length (101.90 cm).

Table 2. Flower parameters in 2007

Treatments (Spacing, cm)	Spike emergence (days)	Flowering (days)	Flower size (cm)	No. of florets	Spike length (cm)
20x15	95.10±1.51bcd	16.50	9.473±0.28b	17.97	91.10±5.30b
20x20	93.33±0.25abc	19.40	9.660±0.09ab	17.17	98.23±1.83a
20x25	91.10±2.49ab	16.07	9.760±0.10ab	18.63	99.03±2.63a
20x30	91.83±1.75ab	17.87	10.083±0.33a	19.57	100.80±4.40a
30x15	97.67±4.08d	15.97	9.340±0.41b	18.60	89.33±7.07b
30x20	96.17±2.58cd	14.90	9.640±0.11ab	18.37	92.73±3.67b
30x25	92.77±0.82abc	15.13	10.000±9.25a	19.20	98.10±1.70a
30x30	90.73±2.85a	14.57	10.050±0.30a	19.53	101.90±5.50a
CV	2.4	14.5	2.8	2.1	2.9

Flower and its parameters are important for gladiolus for economic point of view. There are earlier spike emergence from 30x30 cm spacing in both years. In 2006, flower size was maximum by 30x30 cm spacing while in 2007 by 20x30 cm. As compared to year 2006, there were late spike emergence in 2007. This was due to early planting in 2007 (in February) and low soil moisture. Similarly, flowering in 2006 was earliest by 30x25 cm. Zubair and Wagir found earlier spike emergence in 20x60 cm spacing, while Ahmed et al (2010) reported the earlier spike emergence in 15x30 cm spacing. According to Bijimol and Singh (2001) spacing 25x30 produced the early emergence of gladiolus flower cv. Red Beauty. There are reports of earlier emergence of gladiolus spike cv. White Prosperity (Bhat et al 2010) and cv. Single (Mane et al 2007) from wider spacing. All these reports clearly showed that there is wide variation in spike emergence days with spacing. These variation in days taken to spike emergence might be due to difference in genetic composition of different cultivars and environment.

In our results we found largest flower size by 30x30 cm in 2006 and 20x30 in 2007. Bhat et al (2010) reported the largest flower diameter by 20x20 cm spacing. Zuber and Wagir did not find any significant difference on the floret size due to different spacings. Greater number of florets per spike in 2007 from 20x30 cm was recorded. Spacing of 20x30 cm gave greater number florets per spike in 2006 in our experiment. Bijimol and Singh (2001) also reported that spacing 25x30 cm increased the number of florets per spike and early emergence of spike. Bhat et al (2010), Zuber and Wagir also found the maximum number of floret with wider spacing. Similarly, Ahmed et al (2010) found the maximum floret of Blad Jack with 15x30 cm, of Arabian Night with 30x30 cm and of Sabu with 15x30 cm spacing. Increasing floret number per spike with increasing spacing might be due to availability of more light and nutrients. According to Zuber and Wagir, wider spacing decrease the competition for nutrients and light and yield more number of florets per spike as the it depends upon the vigor and health of plants and amount of carbohydrates stored in the plants.

Ahmed et al (2010) also found that wider planting distance increase spike length of gladiolus. Longest spike length (80.3 cm) found from 20x30 cm spacing by Ahmed et al (2010). Similarly, Mane et al (2007) found the same result that wider the spacing produced longer the spike of tuberose.

Corm parameters for year 2006

All corm and cormel parameters were significantly different with plant spacings. Highest average weight of daughter corm was measured 149.60 gm from the spacing 20x30 cm followed by 30x30 cm spacing. Rest of the treatments were at par, not significantly different with each others. Maximum

average cormel weight per plant (10.83 gm) was found from 30x30 cm spacings followed by 20x30 cm (10.50 gm). Largest corm diameter (7.68 cm) was recorded from 20x30 cm and spacing 20x 30 cm, but not significantly different with 20x20 cm, 20x25 cm, and 30x30 cm. Utmost corm yield (29746 kg/ha) was observed from 20x15 cm spacing which was significantly highest as compared to rest of all spacings. Similarly, highest cormel yield (989 kg/ha) was produced from 20x15 cm spacing followed by 840 kg/ha from 30x15 cm and 789 kg/ha from 20x20 cm.

Table 3. Corm yield and its parameters for year 2006

Spacings (cm)	Average corm weight (gm)	Average cormel weight/plant (gm)	Corm diameter (cm)	Total corm yield (kg/ha)	Total cormel yield (kg/ha)
20x15	80.8±21.7c	4.29±2.61bc	6.517±0.461c	29746±9583a	989±347a
20x20	93.1±9.4b	5.03±1.87bc	7.028±0.050abc	22647±2484b	789±147abc
20x25	108.1±5.6b	7.70±0.80abc	7.403±0.425ab	22511±2348b	604±38bcd
20x30	149.6±47.1a	10.50±3.60a	7.680±0.702a	17998±2165cd	468±174bcd
30x15	86.0±16.6c	3.60±3.30c	6.463±0.515c	21442±1279b	840±198ab
30x20	87.7±14.9c	4.50±2.40c	6.870±0.108bc	19828±335bc	662±20bc
30x25	99.6±2.9c	8.73±1.83ab	6.843±0.135bc	16184±3979d	490±152cd
30x30	115.3±12.7b	10.83±3.93a	7.020±0.042abc	10948±9215e	293±349d
CV%	18.5	35.7	6.0	9.3	26.5

Corm yield and its parameters for year 2007

In 2007, the effect of spacings on average daughter corm weight, corm diameter and total corm yield and total cormel yield were found significantly different, but average cormel weight per plant was insignificant. Highest average corm weight was produced by 30x30 cm and this spacing was found superior over all other spacings. The results presented in table 4 showed that largest corm (7.27 cm) was found in 30x30 cm followed by 30x25 cm (6.995 cm), while total corm yield (1717 kg/ha) was obtained from 20x15 cm. Average weight of daughter corm and total corm yield were found lower in 2007 as compared to year 2006. This might be due to heavy rainfall in 2007 during the flowering and corm formation stage.

Table 4. Corm yield and its parameters for year 2006

Spacings (cm ²)	Average corm weight (gm)	Average cormel weight/plant (gm)	Corm diameter (cm)	Total corm yield (kg/ha)	Total cormel yield (kg/ha)
20x15	73.8±13.3c	20.7	6.257±0.486c	17179±4196a	1402±41bc
20x20	75.5±11.5bc	21.0	6.563±0.179c	13463±479abc	1438±77bc
20x25	80.2±6.8bc	24.5	6.591±0.151c	12298±686abc	1301±60bc
20x30	85.5±1.5bc	16.9	6.673±0.069c	13901±918abc	1070±291bc
30x15	83.8±3.2bc	17.5	6.737±0.006bc	15463±2479ab	2228±867a
30x20	89.0±1.9bc	23.7	6.853±0.111bc	12290±693abc	1609±247ab
30x25	95.1±8.1b	19.9	6.995±0.254ab	10394±2590bc	1119±242bc
30x30	113.5±26.4a	23.8	7.270±0.527a	8880±4103c	721±640c
Cv%	11.9	36.1	2.5	20.7	28.9

Dana and Lerner reported that spacing of bulbous plants depends upon the size and type of bulb, varying from 3 inches for small bulbs to 5-7 inches for large bulbs. Ahmed et al (2010) also found the increasing weight of gladiolus corms with increasing spacing, which is in agreement of our results. They found 30x30 cm produced maximum weight for Arabian Night and Blad Jack produced more weight with 30x30 cm and Sabu produced more weight by 20x30 cm spacings. Wider spacing produced maximum number of corms, cormels and weight of cormels (Bhat et al 2010).

Ahmed et al (2010) also reported that wider spacing 30x30 cm produced maximum size of cormels. Both years' results showed the closer spacing yielded highest corm yield (kg/ha) and it is due to more plant population in closer spacing.

The present results clearly showed that 30x30 cm spacing resulted best quality of spike and flowers. However, for the corm and cormel parameters both 30x30 cm and 20x30 cm spacings were the best. Thus, it can be concluded that plant spacing 30x30 cm can be recommended for quality flower spike and quality corm and cormels

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Exploration of Appropriate Combination of Plant Nutrients on Onion Seed Production in Mid Hill of Nepal

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ABSTRACT

Plant nutrient management study was conducted on onion seed production through off-season bulbs in two consecutive years 2008 and 2009 in Deurali, Palpa (mid hill) of Nepal. The aim of experiment was to identify the best combination of plant nutrients to obtain optimum seed yield. Randomized complete block design was employed with three replications consisting seven different combinations of organic and inorganic fertilizers coupled with micronutrients as treatments. The plot size was maintained at 5.04 m² with spacing of 40 cm x 30 cm accommodating 42 plants. Agri Found Dark Red variety of onion was used in the study. Observation was taken on number of harvested plants, days to bolting and flowering and seed yield. Highly significant difference was observed for year in all traits. Furthermore, differences due to treatment were highly significant but interaction effect was only significant for days to bolting and seed yield. Pooled mean across years showed that early bolting was observed in 40.17 days and early flowering observed in 77 days by application of 60 kg K₂O ha⁻¹ with FYM 20 t ha⁻¹, 60:60 kg N, P₂O₅ ha⁻¹ and delayed bolting and flowering was observed in 45 and 80.17 days respectively by application of FYM 20 t ha⁻¹. Similarly, pooled mean across the years revealed that highest seed yield of 813 kg ha⁻¹ was observed with application of 40 kg K₂O ha⁻¹, FYM 20 t ha⁻¹ and 60:60 kg N, P₂O₅ ha⁻¹ supplemented with two sprays of Multiplex. It suggested that application of combination of organic and inorganic fertilizers accompanied with micronutrient was essential for better seed yield hence could be recommended to the farmers as viable technology in the western hills.

INTRODUCTION

Onion (*Allium cepa* L.) is important vegetable and leading spice crop of *Allium* group. The area under onion cultivation is gradually increasing in the recent years. According to MoAC (2010), area, production and productivity of onion in Nepal are 18860 hectare, 246584 ton and 13t ha⁻¹, respectively. The fresh onion consumption in Nepal is 7.7 kg per person that is extremely below the standard recommendation of 18 kg per annum. It has been observed that import of dry onion bulbs in Nepal is tremendously rising among which India shares large part of it to fulfill the Nepalese demand (Gautam et al 2006). The domestic production of dry onion bulbs meets very small quantity of total national demand even during the peak production periods in the major market centers and cities. The immature bulbs and green tops used as vegetables and dry bulbs are generally consumed as spices. It has very less risk of post harvest loss during distant transportation even with rough handling. Another advantage is that onion can be stored at harvesting period and can be sold when market price is hiking thus avoids the increasing fear among the grower from the excess production (Rokaya et al 2004). The normal growing season for onion in the hills is during October-November and fresh bulbs harvested during April to May which are available in the market till end of August.

There is no existence of Nepalese onion bulbs after August due to excessive rotting, rooting and sprouting on account of aggravating humidity and temperatures at storage (Budathoki et al 2004; Gautam et al 2006). It has forced farmers to sell their produce at the time of harvesting season thus

unable to fetch reasonable price. In order to mitigate this situation, off-season onion production technology through sets was developed, however, the application of this technology in farmer's level was very limited not only due to two years production period, low yield but also due to high post harvest loss and tedious handling practices for sets (Gautam et al 2006).

Recently, off-season onion bulb production technology has been introduced using short duration cultivars requiring 12 hours photoperiod. Onion bulb production during rainy season (July-November) is being very popular among the commercial growers throughout Nepal ranging from Terai to mid hills. In this connection, seed production is possible through off-season bulbs within one year. However, onion seed is not readily available in the Nepalese market because of production in only limited quantity in few pockets. The most adapted and popular variety Agri-found dark red produced 42.95 kg/ropani seed in Deurali, Palpa (Annual Report 2008). There is not adequate information on recommended dose of plant nutrients for seed production. Therefore, this study was initiated to explore appropriate combination of plant nutrients for better seed yield.

MATERIALS AND METHODS

The plant nutrient management trial was conducted on onion seed production through off-season bulbs produced during August-December season in two consecutive years 2008 and 2009 in mid hill agro-climatic region, Deurali, Palpa. Randomized complete block design was employed with three replications with seven treatments comprising different combinations of organic and inorganic fertilizers as well as micronutrients. The FYM was applied at 20 t ha⁻¹, N and P₂O₅ was applied at 60 kg ha⁻¹ and were kept constant for all the treatments except for control. But K₂O dose was varied at 20, 40, 60 and 80 kg ha⁻¹. The micronutrient treatment was split into two, one at 45 days after and other at 70 days after planting (DAP). The plot size was maintained 5.04 m² with spacing of 40 cm x 30 cm adjusting 42 plants and popular variety Agri Found Dark Red was used in the study. Observations were recorded on days to bolting and flowering, number of harvested plants and seed yield. The statistical analysis was done by Genstat 12th edition software with General analysis of variance method.

Treatment details

- T₁. 20 kg K₂O ha⁻¹ (K₁) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₂. 40 kg K₂O ha⁻¹ (K₂) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₃. 60 kg K₂O ha⁻¹ (K₃) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₄. 80 kg K₂O ha⁻¹ (K₄) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₅. 40 kg K₂O ha⁻¹ + Multiplex once (K₂M₁) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₆. 40 kg K₂O ha⁻¹ + Multiplex twice (K₂M₂) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₇. FYM 20 t ha⁻¹ (Control)

RESULTS AND DISCUSSION

Days to bolting

The statistical analysis showed highly significant difference in days to bolting for treatment and year, however, their interaction was only significant at (p<.011) (Table 1). Earliest bolting was observed in 40.17 days after planting (DAP) from 60 kg K₂O ha⁻¹ (K₃) followed by 40.67 days from 20 kg K₂O ha⁻¹ (K₁). Ali et al (2007) reported earlier scaping at 38 days from 100 kg N ha⁻¹ and 120 kg K₂O ha⁻¹ which is extremely higher dose as was used in this study. Furthermore, they did not obtain significant variation among different potassium doses, which is consistent with the present results. It could be due to balanced combination and optimum level of N, P₂O₅, K₂O required for phenological growth.

However, delayed bolting was obtained in 45 days from FYM @ 20 t ha⁻¹ (control). Early bolting was found in 2009 which could be due to high temperature accelerated by prolonged drought conditions.

Days to flowering

The days to flowering was highly significant for year but was insignificant due to treatment and treatment by year interactions (Table 1). Earlier flowering was obtained in 77 days by application of 60 kg K₂O ha⁻¹ (K₃) followed by 78 days from 40 kg K₂O ha⁻¹. It could be because of proper dose of potassium to enhance and foster the reproductive phase. Variation in potassium levels had no significant effect in relation to flowering that was reflected clearly in Table 1. Longest time of 80.17 days was taken from control treatment which was similar to 80 kg K₂O ha⁻¹ (K₄) and 40 kg K₂O ha⁻¹ (K₂M₂) supplemented with one to two sprays of micronutrient multiplex (Table 1). Delayed flowering was observed with additional potassium level and multiplex, which might be caused by extended vegetative period.

Number of harvested plants

The result was highly significant in relation to harvested plants for year, however, treatment and treatment by year interaction was insignificant (Table 2). Maximum 38 plants were harvested from T₁ (20 kg K₂O ha⁻¹, K₁) and remaining treatments were at par with control (36.17 days) except T₅ (40 kg K₂O ha⁻¹ plus single dose Multiplex (K₂M₁)).

Seed yield

The seed yield was highly significant due to treatments, year and their interactions (Table 2). The results showed that highest seed yield of 813 kg ha⁻¹ was obtained from T₆ (40 kg K₂O ha⁻¹ + Multiplex twice (K₂M₂) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹) followed by 741 kg ha⁻¹ in T₃ (60 kg K₂O ha⁻¹ (K₃) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹) (Table 2). Lowest seed yield of 476 kg ha⁻¹ was produced in control (FYM 20 t ha⁻¹) as reported by Ali et al (2007). However, the findings indicated that application of 40 kg K₂O ha⁻¹ supplemented with two sprays of Multiplex was found superior in terms of seed yield followed by application of 60 kg K₂O ha⁻¹ (T₃). The result obtained from this study contradicted with the findings of Ali et al (2007) where they observed increased seed yield of onion with higher doses of potash. Significantly higher grain yield with 60 K₂O kg ha⁻¹ fertilization in Okra reported by Shubhashree et al (2011) is consistent in onion seed production in this study.

Table 1. Effect of different plant nutrients on days to bolting and flowering in onion seed production

Treatments	Days to bolting			Days to flowering		
	2008	2009	Mean	2008	2009	Mean
T ₁	45.67	35.67	40.67	91	65	78
T ₂	48	36	42	92.33	65.67	79
T ₃	43.67	36.67	40.17	88.67	65.33	77
T ₄	48.67	37	42.83	92.67	66.33	79.5
T ₅	49.67	37.33	43.5	92.33	66	79.17
T ₆	50	38.33	44.17	92	67	79.5
T ₇	50	40	45	90.67	69.67	80.17
Grand mean	47.95	37.29	42.62	91.38	66.43	78.9
CV%	2.9			2.6		
	F-test	LSD _(0.05)		F-test	LSD _(0.05)	
Treatment	**	1.44		ns	2.39	
Year	**	0.77		**	1.28	
Treatment*year	*	2.04		ns	3.38	

ns, not significant; *, significant; **, highly significant

Days to bolting and flowering was observed earlier when 60 kg K₂O ha⁻¹ and FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹ were applied. However, the bolting and flowering behaviour of onion didn't exhibit distinct pattern with variation in potassium levels. Likewise, increase in seed yield was not consistent with increased potassium levels. Highest seed yield of 813 kg ha⁻¹ was obtained from the fertilizer application of 40 kg K₂O ha⁻¹ + double dose of Multiplex. It was obvious that application of micronutrients (Multiplex) is beneficial for better harvest of seed. Furthermore, the fertilizer dose of 60 kg K₂O ha⁻¹ + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹ found most appropriate for all the agronomic traits thus should be practiced as recommended fertilizer dose in the subsequent seed production programs.

Table 2. Effect of different plant nutrients on number of harvested plants and seed yield in onion seed production

Treatments	Harvested plants			Seed yield kg ha ⁻¹		
	2008	2009	Mean	2008	2009	Mean
T ₁	34.0	42.0	38.0	522	516	519
T ₂	33.67	42.0	37.83	608	549	579
T ₃	33.67	41.33	37.5	913	569	741
T ₄	30.0	39.67	34.83	780	608	694
T ₅	29.67	38.67	34.17	767	635	701
T ₆	34.0	38.33	36.17	939	688	813
T ₇	34.0	38.33	36.17	463	489	476
Grand mean	32.7	40.05	36.38	713	579	646.0
CV%	10.4			13.8		
	F-test	LSD _(0.05)		F-test	LSD _(0.05)	
Treatment	ns	4.486		**	0.1056	
Year	**	2.4		**	0.0565	
Treatment*year	ns	6.34		*	0.15	

ns, not significant; *, significant; **, highly significant

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Field Loss Assessment of Potato Leaf Miner Fly (PLMF), *Liriomyza huidobrensis* (Blanchard) (Diptera:Agromyzidae)

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ABSTRACT

With the aim to evaluate actual foliage loss due to potato leaf miner fly (PLMF), *Liriomyza huidobrensis* (Blanchard), survey sites were recognized from commercial potato pockets of Lalitpur, Kathmandu, Bhaktapur, Kavrepalanchok, Sindhupalchok and Makwanpur districts of Mid-Nepal in 2009. In total, 199 farmer's fields from 27 commercial potato pockets were visited and taken damage scores. The survey revealed that potato pockets of Lalitpur were the most prone area (89.3% foliage damage) to this pest followed by Kathmandu (82.6%), Bhaktapur (70%) and Kavrepalanchok (46.5%). But damage level was comparatively lower in Sindhupalchok (12.1%) and Makwanpur (27.9%). Damage level was found more in lower altitudes (790-1568 masl) than in higher altitudes (1560-2610 masl). Similarly, lower leaves were more damaged than the upper ones. So, altitude and plant age were two factors influencing damage by test insect. Since the pest is becoming severe and can withstand chemical sprays, it would be better to develop suitable IPM technique against this pest. Similarly, strict quarantine and awareness campaign against this insect pest are crucial to check its migration to virgin potato pockets.

INTRODUCTION

Potato is second staple food crop after rice in Nepal (FAO 2008, Giri et al 2008). It is grown throughout the country and contributes to national food security (Giri et al 2008). Area under potato cultivation is about 156,737 hectares with an average estimated productivity of 13,110 kilogram per hectare and total national annual production of about 20 million tons (MOAC 2007/08). Average productivity of potato crop is less in Nepal as compared to world's productivity (15.7 mt/ha) (FAO 2008). Agricultural Perspective Plan (APP 1995) of Nepal has identified potato as the priority crop. The per capita consumption of potato in Nepal (30 kg/year) is slightly more than the world average (28 kg/year) (Hidalgo et al 1999), and the trend of consumption is in increasing trend (51 kg/year) (Giri et al 2008) almost doubled since 1990 (FAO 2008). Potato crop loss due to pests and diseases during crop stand and storage is 32% in developing countries (World Potato Congress, 2006). Though Nepal produces potato, its productivity is low as compared to other countries. One of the major constraints of low productivity is the insect pest. It has been reported that more than 40 insect species have been associated with potato crops in Nepal.

According to Berry et al (2008), the major tuber feeding pests of potato are wire worm, flea beetle larvae, white grubs, leatherjacket, western spotted cucumber beetle, variegated cutworm, red backed cutworm, garden symphylan, and the slugs. Sucking insects like green peach aphids, potato aphids, two spotted spider mite, potato leaf hopper, lygus bugs, western flower thrips, and white flies are the major sucking insects of the potato. Among the foliage feeding pests of potato, Colorado potato beetle, variegated cut worms, western yellow striped army worm, red backed cut worm, alfalfa loopers, grass hoppers, blister beetles, flea beetle adults, and slugs are major ones. Blanchard in 1926 first reported the agromyzid fly *Liriomyza huidobrensis* from Argentina and now has attained its

potentiality (Valladares et al 1999) harbouring in many field crops including potato. Among the economically important *Liriomyza* species, *L. sativae*, *L. trifolii*, and *L. huidobrensis* have the most cosmopolitan distributions (Weintraub 2001). The Agromyzid fly *Liriomyza huidobrensis* was first reported from Argentina by Blanchard in 1926 and has attained a height of maximum infestation (Salvo and Valladares 1995, Valladares et al 1996a, 1999b). Its colonization has developed rapidly in Europe and Asia since 1980s (Liping et al 2002). It can be now considered as a cosmopolitan species (Spencer 1973, Shepard et al 1998). According to Scheffer (2002) and Dumont (1988), *Liriomyza huidobrensis* is a major pest of flowers and vegetables in many parts of the world, sometimes causing complete crop loss (Spencer 1973, Shepard et al 1998). Spencer (1990) reported 14 families of host plants harboring by *Liriomyza huidobrensis*, where as Zhang et al in 1999 reported the host plants from 31 families of vegetables, flowers, and weed plants. According to Salvo and Valladares (1995), the pest diffused from central Argentina to new areas of the region. It diffused then to Americas (Sanabria de Arevalo, 1994), then to Europe (Cabello et al 1993), Hawaii (Schreiner 1993) and recently to Israel which is resistant to chemical (Weintraub and Horowitz 1995), and even it is continuing to spread to new areas of the atlas (Weintraub 2001). Leaf miner fly (*Liriomyza* spp.) is the most important harmful insect pest of vegetable crops and flowers. *Liriomyza huidobrensis* and *Liriomyza trifolii* pose a real threat to vegetable crops (Spencer 1973, Martinez, 1993). According to C.R. Olivera and D. Bordat (1996), main cause of the increasing infestation of these pests is the inappropriate use of chemical control methods.

An agriculture newsletter of Nepal (Krishi Patrika 2008) describes it is the 10 years span of time farmers of Nepal are also facing the problem of the same pest, *Liriomyza huidobrensis*. As the pest is migratory in nature and digests the insecticides easily, it is better to develop IPM technique to control the pest reaching the economic damage level and to migrate to the new areas of the country. This study considers field survey from the commercial potato growing areas to assess the foliar damage level due to leaf miner fly specially focussed to assess the foliage damage level of potato due to this insect pest in different agro-ecological zones of Mid-Nepal, and to evaluate the extent of existence in these locations.

MATERIALS AND METHODS

Site selection

Firstly, information regarding the potential potato pockets of mid-Nepal covering 6 districts was collected from the respective District Agriculture Development Offices. The districts surveyed included Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchowk, Sindhupalchowk and Makwanpur. A total of 199 farmers' fields from 27 potato pocket areas from 6 districts were surveyed for scoring of foliage losses caused by leaf miner fly. The name of potato pockets under six districts are given in Table 1.

Rating field damage

From each farmer's field 10 plants were sampled randomly and pinched out the 3 leaves from each plant from bottom, middle and the top portion. While calculating percentage loss, damaged leaflets per total leaflets in a compound leaf was calculated. Average of 3 leaves and 10 plants gives the damage percentage of one farmer's field. Average of the farmers' gives locality damage and averages of locality finally provides the district damage level.

Data collection and analysis

Data regarding the altitude, latitude, longitude, crop history, pesticide use pattern, land orientation, irrigation facility, location, age of the crop and the farmers' preferred varieties were recorded. Recorded data were percent calculated to overlook average field damage district-wise and tested

statistically the factor more responsible for increasing PLMF proportion in the population. Statistics used was Unbalanced Frequency Distribution ANOVA as of Ott and Longnecker (2001). General statistical model was used to see the independent effects of land aspect, irrigation condition, land type, altitude, pesticides application frequency, farmers' preferred varieties and their interactions on the lower, middle and upper leaf damage due to PLMF.

Table 1. Number of farmers fields surveyed under different potato pockets of six districts

District	Potato pockets areas	Farmers' fields selected (Number)	Total farmers' fields (Number)
Kathmandu	Dharmasthali	5	25
	Kavresthali	5	
	Mulpani	5	
	Shankhu	5	
	Sundarijal	5	
Bhaktapur	Duwakot	10	35
	Chhap	5	
	Gundu	10	
	Kharipati	10	
Lalitpur	Khokana	5	21
	Luvu	6	
	Tikathali	5	
	Chhampi	5	
Kavrepalanchwok	Nala	10	79
	Balthali	10	
	Panouti	10	
	Baluwa	10	
	Khanalthok	10	
	Panchkhal	9	
	Patlekheth	10	
	Kuntabesi	10	
	Mudhe	10	
Sindhupalchwok	Thumpakhar	4	24
	Kharidhunga	10	
	Chitlang	5	
Makwanpur	Palung	5	15
	Aghor	5	
		5	
Total	27 (Locations)	199	199

Models used

Model for independent factors

ANOVA model of multiple regressions of land aspect, irrigation condition, land type, altitude, pesticide use frequency and variety on lower leaf, middle leaf and upper leaf damage was:

$$Y = I + K_1X_1 + K_2X_2 + K_3X_3 + K_4X_4 + K_5X_5 + K_6X_6 + M$$

where, Y denotes lower leaf or middle leaf or upper leaf damage, I=over all mean, K_1 =Regression coefficient of land aspect, X_1 =land aspect, K_2 =regression coefficient of irrigation condition, X_2 =irrigation condition, K_3 =regression coefficient of land type, X_3 =land type, K_4 =regression coefficient of altitude (location), X_4 =location (altitude), K_5 =regression coefficient of application frequency of the pesticides, X_5 =application frequency of the pesticides, K_6 =regression coefficient of the variety, X_6 =variety, and M=residuals.

Model for factor interaction

$$Y = I + K_1X_1 + K_2X_2 + K_3X_3 + K_4X_4 + K_5X_5 + K_6X_6 + K_7X_1X_2X_3X_4X_5X_6 + M$$

where, Y denotes lower or middle or upper leaf damage, $\bar{Y}$ =over all mean, K_1 =regression coefficient of land aspect, X_1 =land aspect, K_2 =regression coefficient of irrigation condition, X_2 =irrigation condition, K_3 =regression coefficient of land type, X_3 =land type, K_4 =regression coefficient of altitude (location), X_4 =location(altitude), K_5 =regression coefficient of application frequency of the pesticides, X_5 =application frequency of the pesticides, K_6 =regression coefficient of the variety, X_6 =variety, and M=residuals. Similarly, coefficient of determination was calculated for the altitude and plant age effect on the lower, middle and upper leaf damage by PLMF. This was done because there were not significant effects of other factors except these in increasing population proportion of pest.

$$Y = \bar{Y} + K_1X_1 + K_2X_2 + K_3X_1X_2 + M$$

Where, Y denotes lower leaf damage, $\bar{Y}$ =over all mean, K_1 =regression coefficient of location, K_2 =regression coefficient of plant age, K_3 =regression coefficient of interaction between location and plant age, X_1 =location (altitude), X_2 =age of the plant, and M=residuals.

Coefficient of determination was calculated by the formula again as given by Ott and Longnecker (2001)

$$(R^2) = \{(SS \text{ (Total)} - SS \text{ (Residual)}) / SS \text{ (Total)}\}, \text{ where}$$

SS (Total) denotes Some of Squares of Total row of the ANOVA, and SS (Residual) - Sum of Squares of the Residuals.

RESULTS AND DISCUSSION

PLMF damage level according to the surveyed districts

Among the surveyed six districts for the abundance of *L. huidobrensis* and to score the damage level, Lalitpur district leads all the others in terms of damage level (almost 89.3±1.57%) followed by Kathmandu (81.8±3.5%), Bhaktapur (71.1±3.54%), Kavrepalanchowk (49.1±4.8%), Makwanpur (27.9 ± 5.3%) and the least affected district Sindhupalchowk (12.1±5.3%), respectively. No districts among the surveyed found free from this insect.

The general tendency of the survey result is that the level of damage of the pest is less in case of high altitudes as compared to the low altitudinal locations (Figure 2). This average pattern of the damage due to the test insect reveals that the infestation level is maximum at the lower altitudes and the damage level is quite low at higher altitudes. This percent foliage damage according to districts (which are located at different altitude) are supported by the following ANOVA of Unbalanced Frequency Distribution table which entails that the damage is mainly influenced by altitude and plant age and their subsequent interaction.

In an average the field loss was 53.5% from all these six districts. So, the pest is becoming severe and distributing countrywide in Nepal. This study confirmed that the damage level of this pest was more in lower altitudes (806-1568 masl) than in the higher altitudes (above 1560-2600 masl). So, the infestation level was much less in the commercial potato growing areas of Sindhupalchowk and Makwanpur district. Similar finding was reported by Setiawati and Uhan (1997) who indicated that *Liriomyza* sp. spread out of 1,000 meters to 2,200 meters above sea level with different infestation levels depending on location and plant age leading into early senescence and mortality as confirmed by Chandler and Gilstrap (1987). According to Setiawati and Uhan (1997), the plants of age below 25 days also incur some degree of damage. In case of lower altitudes of surveyed locations, there was little degree of damage of *L. huidobrensis*, which was increased as the plant age was increasing.

Table 2. ANOVA of multiple regression of location, plant age and their interaction

Leaf position	Source of variance	DF	SS	MSS	VR	FPr	R ² Value
Lower	Altitude	26	201875.3	7764.4	41.83	<0.001	0.87
	Plant age	5	38005.5	7601.1	40.95	<0.001	
	Altitude x Plant age	60	48027.8	800.5	4.31	<0.001	
	Residual	224	42286.8	185.6			
	Total	355	333195.3	944.6			
Middle	Altitude	26	196619.2	7562.3	30.25	<0.001	0.84
	Plant age	5	61547	12309.4	49.23	<0.001	
	Altitude x Plant age	60	64538.1	1075.6	4.3	<0.001	
	Residual	244	61005.2	250			
	Total	355	383709.5	1145.4			
Upper	Altitude	26	78529.9	3020.4	14.28	<0.001	0.78
	Plant age	5	49424.5	9884.9	46.74	<0.001	
	Altitude x Plant age	60	55368	922.8	4.36	<0.001	
	Residual	244	51601.2	211.5			
	Total	335	234923.7	701.3			

In brief, the pest under investigation was found in all districts surveyed. It may reach new potato pockets since the farmers are not familiar with this insect and the insect itself is migratory in nature. Unique biological nature of the pest is also influential in increasing its proportion in the natural population that is except adults, all the three stages can escape the pesticides. Since the pest is migratory in nature, strict local, regional and zonal quarantine are essential to check its migration to the virgin areas. As the pest is becoming the pest of global proportion today, it would be better to search the management options against this pest with no time wastage for which governmental, nongovernmental and community approach is at most. The present results of investigation may not represent the whole country, so intensive work in this line is essential and at most to check this devastating pest to migrate to the new areas. It is necessary to assess the existence and level of damage of this pest in each potato pockets throughout the country. The damage caused by PLMF at different days after planting of potato is shown below.

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Efficacy of Commercially Available Safe Pesticides for the Management of Cabbage Aphids, *Brevicoryne brassicae* (L.)

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ABSTRACT

Efficacy of commercially available safe pesticides: Derusom, Agri-Servo, Margosom, Ramban (biopesticide), OSHIN; chemical pesticide: Thiodan, and locally available products: Cattle urine and Geeti-Mal (fermented cocktail mixture of botanicals with cattle urine) were tested against cabbage aphids in cauliflower crops at Khumaltar, Lalitpur in the year 2009 and 2010. The study revealed that OSHIN 20% WP @ 0.4 g/liter water was found as effective as the Thiodan 35% EC @ 1.5 ml/liter against cabbage aphid (*Brevicoryne brassicae* L.). Application of Derusom, Agri-Servo, Margosom and cattle urine was not found effective to suppress aphid population in the cole crops, however, application of Geeti-Mal, AgriServo, Ramban were found better than control (water spray). Application of Geeti-Mal caused yellow patches on the leaf surface.

INTRODUCTION

Of the various vegetable crops, cole crops such as cauliflower, cabbage, broccoli, radish, mustard are economically important in Nepal in term of market value, productivity and area coverage. The productivity and quality of vegetables are greatly depended upon the level of insect pest attack, especially cabbage aphid, *Brevicoryne brassicae* (Linnaeus), Aphididae, Homoptera. Application of hazardous chemical insecticides frequently in higher dose than recommended has been practiced these days. Such application is unsafe to human health and environment as a whole. The problem of insect resistance to insecticides, outbreak of secondary insect pests and toxic residues on edible produce has become major concerns of plant protection. Recently, the use of various locally available materials and resources, local and exotic organic products and bio-control agents are claimed to be effective against aphids but scientific data of these agents against aphid in our diversified farming system is lacking.

Mineral oil with the trade name Agri-Servo, is a water soluble mineral oil. It is reported as non-poisonous and non-toxic to human and plants, bio-degradable and environment friendly. It is said to be effective against insect pests with cell sap sucking mouth parts, such as, aphids, whitefly, mites, thrips, jassids, scales and wooly apple aphids. Similarly, there are some Nepalese farmers who claimed fermented cocktail mixture of botanicals as effective to control over several insect pests and plant diseases. The cocktail mixture is prepared by mixing chopped pieces of different plant parts and cattle urine with water, and the mixture left for fermentation for several days (1-4 weeks). The mixture is then filtered, diluted with water, and then sprayed on plant foliage. However, authentic data regarding degree of effectiveness against pests are lacking. Bio-pesticides like, MargoSom, Derusom and Ramban are commercially available in Nepalese market with different trademarks. Animal urine (mostly cattle urine) diluted with water is being used by farmers to manage various insect pest populations like aphids, mealy bugs, and leaf feeding beetles. With this background, an experiment was carried out to evaluate the efficacy of commercially available safe pesticides for the management of cabbage aphids, *Brevicoryne brassicae* of cauliflower under field conditions at Khumaltar, Lalitpur (mid hill), Nepal.

MATERIALS AND METHODS

Field experiment

Experiment was carried out during November to July, 2009/10 and 2010/11 at Khumaltar, Lalitpur. Cauliflower variety Kathmandu-local was grown as test plants. About 35 days old seedlings were transplanted during 1st week of November. The plant spacing was maintained at 45 cm plant to plant and 60 cm row to row. Sixteen seedlings were maintained in each plot of 4.8 m² area. The experiment was laid in randomized complete block design (RCBD) with 3 replications of treatments. The cultural practices like irrigation, weeding, earthing-up were followed as per requirement in normal practice. Farm yard manure (FYM) was applied @ 4 ton/ha. The chemical fertilizers were applied @ 120:120:110 kg NPK/ha. Treatment application was initiated right from an initial infestation of aphid noticed in the plants. The following treatments were included in the experiment;

1. Agri-Servo @ 10 ml per litre water
2. Cattle Urine @ 1: 4 ratio with water
3. Margosom @ 5 ml per litre water
4. Geeti-Mal @ 1:1 ratio with water
5. Ramban @ 1ml per litre water
6. Derosom @ 3 ml per litre water*
7. Aqueous extract of Chinaberry fruits*
8. Jeebatu @ 50 ml per litre water**
9. OSHIN @ 0.4 g per litre water**
10. Thiodan 35% EC @ 1.5 ml per litre water
11. Water Spray (Control)

The treatments with one asteric were used in 2009/10 only, with two asterics in 2010/11 only, and without asteric in both years.

Criteria for selecting treatment

- Ramban is a biopesticide of *Pongamia pinnata* plant origin.
- Margosom is a biopesticide of *Azadirachta indica* plant origin.
- Derosom is a biopesticide of Derris plant origin.
- OSHIN (Dinotefuran 200 g/kg) is a low toxic insecticide having 1 -3 days of waiting period after application.
- Jeebatu, a Nepalese product, is a mixture of beneficial microorganisms being sold in the Nepalese market as biopesticide.
- Agri-Servo is mineral oil being sold in Nepalese market as a safe product.
- Geeti-Mal is a cocktail mixture locally produced by fermenting locally available succulent plant twigs, stems and leaves with cattle urine.
- Cattle urine is considered to be safe to apply on crops against several insect pests in a dilution form with water.

Observations

Monitoring of insect pests was carried out throughout the crop season before and after application of treatments. During this experiment cabbage aphids remained the destructive insect pest of cauliflower. The magnitude of aphid was recorded by counting number of aphids at top, middle and bottom leaves of each and every plant, and then calculated the mean number of aphids per plant. Based on the number aphids per plant, a qualitative score 0, 1, 2, 3, 4, 5 was given to the number of aphids, such as 0 = no aphids, 1 = 1-100 aphids/plant, 2 = 101-200 aphids/plant, 3 = 201-400 aphids/plant, 4 = 401-800 aphids/plant, 5 = >800 aphids/plant. The qualitative scale for each score was produced as core 0 = None, 1 = Very low, 2 = Low, 3 = Medium, 4 = High, 5 = Very high.

RESULTS AND DISCUSSION

During the whole season, only cabbage aphid appeared to be the serious insect pest of cauliflower. The insect preferred youngest leaves and flowering parts of cauliflower, and underneath cap leaves of curds. The aphids first noticed on 2nd week of November in 2009 and the first treatment was applied on 19th of November just after monitoring the aphids. During 1st week of December, aphid population reached at higher peak in the water-sprayed control treatment as compared to other treated plants. Aphid population was very low in the plants treated with Agri-servo, cocktail mixture and chemical insecticides. Aphid population was low in the plants treated with Ramban and Derosom. Second treatment was given in 4th December, 2009 and aphid was monitored in 23rd December. The aphid population was very low in the plants treated with chemical insecticides; low in the plants treated with Agri-servo and Ramban, and medium in the plants treated with Derosom and chinaberry extract, while very high population was recorded on water-sprayed control treatment. Third treatment was given on 23 December, 2009 and aphid population was monitored on 11th January, 2010. In 11th January, 2010, aphid population was very low in the plants treated with chemical insecticide, medium in the plants treated with Agri-servo as compared to very high in the plants treated with water, chinaberry fruit extracts, Derosom, Cocktail mixture, Margosom and Cattle urine. Treatment application was repeated on 11 and 25 January but aphid population was found very high in the plants treated with all treatments except chemical insecticides. The results showed that only the use of chemical insecticide Thiodan 35% EC @ 1.5 ml per litre was effective to manage aphids while the dose and frequency of application of other treatments were not found effective to manage aphids. The detail results are presented in Table 1.

Table 1. Mean score of cabbage aphids in different treatment plots at different time interval during 2009/10, Khumaltar

Treatment	Mean score of cabbage aphids (0-5 scale)					
	19 Nov '09*	04 Dec '09	23 Dec '09	11 Jan '10	25 Jan '10	5 Feb '10
Agri-Servo	3.3	2.0	2.3	3.0	3.3	4
Cattle urine	3.0	4.0	5.0	5.0	5.0	5
Margosom	2.0	3.0	3.7	4.7	4.7	5
Geeti-Mal	2.0	1.7	4.0	4.7	4.7	5
Ramban	3.0	2.3	2.3	5.0	5.0	5
Derosom	3.0	2.3	4.0	4.0	4.7	4
Extract of chinaberry fruits	2.7	1.7	3.0	4.7	4.3	5
Thiodan	2.7	1.3	1.0	1.0	1.0	1
Control	2.3	4.3	4.7	4.7	5.0	5

*Before treatment application

The Table 2 shows the mean score of cabbage aphids produced under different treatment conditions. The treatments were applied 7 times and aphid population was monitored 8 times. The low level of aphid population was observed during first monitoring of aphids at 1st week of January, 2011 before application of treatment. After application of treatment, the aphid population was very low in the plants treated with cocktail mixture (Geeti-Mal), OSHIN 20% WP and Thiodan 35% EC as compared to other treatments.

Table 2. Mean score of cabbage aphids in different treatment plots at different time interval during 2010/11, Khumaltar

Treatment	Mean score of cabbage aphids (0-5 scale) (n=3)							
	5 Jan'11*	12 Jan'11	20 Jan '11	27 Jan '11	3 Feb '11	10 Feb'11	18 Feb'11	28 Feb '11
Agri-Servo	3.0	3.3	3.7	4.0	2.3	2.3	2.3	3
Cattle urine	3.3	3.3	3.3	3.7	4.7	4.3	3.0	4
Margosom	2.3	2.3	2.7	2.7	4.0	4.0	5.0	5
Geeti-Mal	2.0	1.7	1.7	4.7	5.0	5.0	4.0	5
Ramban	2.0	2.3	2.3	3.3	4.3	4.7	3.3	4
Jeevatu	4.3	3.7	3.7	4.0	5.0	5.0	4.0	5
OSHIN	2.7	1.3	1.0	0.7	0.7	0.3	1.0	0.3
Thiodan	3.0	0.3	0.0	0.0	0.7	0.0	0.0	0.3
Water Spray	2.7	2.3	4.3	3.7	4.7	5.0	5.0	6

*Before treatment application

OSHIN 20% WP @ 0.4 g/liter water was found very effective as chemical insecticide Thiodan 35% EC @ 1.5 ml/liter against cabbage aphid. Sole application of Derusom, Agri-servo, Margosom and Cattle urine at 10-12 days interval was not effective to suppress aphid population in the cole crops. Application of Geeti-Mal, Agri-Servo, Ramban was much better than water spray in managing aphid. Application of Geeti-Mal affected plant vigor causing yellow patches on the leaf surfaces.

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Effects of Fluazinam and Other Eco-friendly Treatments against Clubroot Disease of Cauliflower

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ABSTRACT

Clubroot disease caused by a soil borne pathogen, *Plasmodiophora brassicae* has been appearing as the most devastating disease in Brassica vegetables in Nepal. The use of lime and Nebijin is only the available technologies to manage this disease. In search of new and eco-friendly treatments against this disease, an experiment was conducted in screen house with 12 different treatments including untreated as control during 2009-2010, and the effect of fluazinam was verified in naturally infested farmer's field during 2010-2011 using cauliflower hybrid, MilkyWay. Among 12 treatments, the effect of Fluazinam and copper oxychloride were significant ($P=0.05$), however, Fluazinam was most effective under both screen house and field conditions. The effect of Fosfilombrico-Star (the self defence inducer), mustard cake and Suthochu (EM5) were also significant in reducing clubroot severity as compared to untreated control in both the years. In clubroot incidence, their effects were significantly different from untreated control in first year, but in the second year they were at par. Since, clubroot severity is more important than incidence in reducing yield, these treatments could be promising candidates for integrated management of clubroot disease provided efficacy of these treatments remain stable under field conditions.

INTRODUCTION

Clubroot caused by a soil borne pathogen, *Plasmodiophora brassicae* Woronin, has appeared as a destructive disease in Brassica vegetables growing areas. Cultivation of cabbage and cauliflower has gone down significantly due to the disease and in some pockets, hundred percent yield losses were observed in cauliflower, cabbage and broad leaf mustard, especially in Kathmandu valley and Palung/Daman area of Makwanpur district. So far, the disease has been appeared in cauliflower, cabbage, broad leaf mustard, knolkhol, broccoli, radish (rare), garden cress, mustard and turnip. It is one of the most difficult plant diseases to control once the pathogen gets established in the soil. The resting spores released from the decomposition of clubs or the root tissue can remain infectious for up to 20 years even in the absence of host plant (Lancaster 2006). Resting spores of *P. brassicae* are readily transmitted on or in anything that carries contaminated soil. Repeated cultivation of crucifers in the same land leads to rapid build-up of the pathogen population in the field. Reports showed that mono-cropping of cauliflower increased the disease incidence from 9% in the first year to 50% in the following year causing 62% yield reduction (Shrestha et al 1995). The disease has been spreading in new areas mainly through the movement of seedlings grown in infested fields. Outbreaks have occurred recently in Dhading (Khanikhola) and Solukhumbu. As reported by the farmers, disease has also been spread in eastern Chitwan.

Traditional control methods of clubroot include improving drainage, raising pH of the soil, and rotating susceptible crops with non-cruciferous crops. Nebijin has been identified and recommended as an effective fungicide for the management of disease (Timila and Neupane, 2009). It is the only fungicide available in the market for clubroot disease and it is expensive. For searching effective fungicides and eco-friendly measures, experiments were conducted under screen house and field conditions using different treatments which could be candidates for integrated management of this disease.

MATERIALS AND METHODS

Seedling assay

The experiment was conducted under screen house during 2009-2010 using sterilized field soil. Cauliflower, hybrid MilkyWay was used in the experiment. Three replications, each with 12 plants were maintained. Four-week-old seedlings were transplanted in 3" pots. After the seedlings establishment, 50 ml of resting spore suspension (10^5 spores /ml) was drenched at the base of each seedling. Immediately after inoculation, given treatments were applied as per dose and the rates given in table 2. In 6-7 weeks after inoculation each and every plant was up-rooted and clubroot severity was assessed using 1-6 scale. Rationale and active ingredients (AI) of the treatment selection are given in Table 1.

Table 1. Rationale and active ingredient of the treatments

Treatments	Active ingredient (AI)	Rationale
Aminolom Calcio-boro	Calcium and boron enriched vitamin complex	Calcium- and Boron enriched Amino-vitamin complex.
Fluazinam	Fluazinam SC	Fungicide
Nebijin	Flusulfamide 0.3 DP	Fungicide
Garlic clove extract	Sulphur compound	Known botanical
Aminolom protector	Free amino acids	Self defense inducer (with free amino acids and organic nitrogen)
Fosfilombrico-Star	Potassium phosphate	Self defense inducer (with potassium phosphite)
Mustard cake	Glucosinolates	Bio fumigant
Dhanucop	Copper oxychloride 50 WP	Fungicide
Suthochu (EM5)	EM, molasses, vinegar and spirit	Ecofriendly liquid substance
SoilSheath	<i>Paecilomyces</i>	Biocontrol agent
Kwian Thong	Nutrient elements with <i>Lactobacillus</i> and <i>Bacillus subtilis</i>	Granule bio-organic fertilizer

On-farm evaluation

Fluazinam is wide spectrum fungicide developed by Ishihara Sangyo Kaisha, Ltd. The fungicide is available in different trade names. The experiment on the field verification was conducted in naturally infested field at Bhaktapur during 2010 and 2011. The plot size was 7 m². Experimental Design was randomized complete block (RCB) with three replications and each with 24 plants. Seedlings of MilkyWay variety were raised at Khumaltar to ensure disease free. The chemical fertilizer and compost (Chicken manure) were used as 200:80:60 NPK and 20 mt per hectare, respectively. Transplanting was done during last week of August. Fluazinam was applied at the rate of 100 ml per planting hole as spray/drench of 2 ml/liter of suspension concentrate formulation. Planting bed spray with the same fungicide was also done immediately after transplanting. The control plot was drenched and sprayed with water. Weeding, irrigation and other agronomical practices were given as per need. Clubroot severity and incidence were assessed during harvest by uprooting each and every plants. Yield parameters such as biomass of above ground part of the plant, marketable curd weight, were also recorded. Clubroot severity was measured using the rating scale, 1-6 (modified from Mitani et al (0-4), 2003) as given below.

- 1= no disease or club
- 2= few clubs on lateral roots only
- 3= clubs in lateral or tap root slightly clubbed
- 4= well developed clubs in lateral or tap root but with lateral roots
- 5= > 50% root converted to club with poor lateral roots, tap root clubs decayed or not
- 6= plant death/ entire clubs decayed

Data of both experiments were processed and analyzed using MSTAT-C.

RESULTS AND DISCUSSION

Seedling assay

The results presented in table 2 revealed that the eco-friendly treatments such as, Mustard cake, Suthochu (EM5) and Kwain Thong were effective in reducing clubroot severity in both the years. The self defense inducers, Fosfilombrico-Star and Aminolom protector, however, tested for only one year were also found effective in reducing disease severity. Mustard cake reduced clubroot severity by 45.08%, Suthochu by 45.7%, Kwain Thong by 45% and Fosfilombrico-Star by 60%. Fosfilombrico-Star has been reported to be effective against mildews and *Pythium* Aminolom against a number of fungi such as *Botrytis*, *Rhizoctonia*, *Sclerotinia*, *Colletotrichum* (AlfredoInesta 2006). SoilSheath (*Paecilomyces*) was also found effective against clubroot severity. *Paecilomyces liliacenus* in combination with lime was reported to be effective in reducing clubroot disease (Villanueva and Binaliw 1989) supporting present results.

The chemical fungicides Fluazinam, and Dhanucop were as effective as Nebijin in reducing both the incidence and severity of clubroot. Fluazinam was found comparatively better than Nebijin and Dhanucop, however, all three were statistically similar in their effects on clubroot severity and incidence.

Table 2. Effects of different treatments on clubroot disease of cauliflower under screen house conditions during 2009/10

Treatments	Dose/rate	Clubroot severity index (1-6)		Clubroot incidence %	
		2009	2010	2009	2010
Aminolom calcio-boro	1.5 ml/l	2.6 abc	3.53 ab	73.8 a	73.9 abc
Fluazinam	2 g/l	1.0 c	1.00 c	5.5 b	0.0 d
Nebijin	2 g/l	1.25 bc	1.22 cde	26.1 b	16.7 cd
Garlic clove extract	50 g/l	2.00 abc	2.84 bc	36.4 ab	66.7 abc
Aminolom protector	1 ml/l	2.5 abc	2.77 bc	14.7 b	64.9 abc
Fosfilombrico Star	1 ml/l	1.2 bc	-	17.9 b	-
Mustard cake	20 g/l	1.2 bc	2.83 bc	12.27 b	58.9 abc
Dhanucop	2 g/l	1.3 bc	1.76 bc	18.0 b	28.9 bcd
Suthochu (EM5)	10 ml/l	1.25 bc	2.66 bc	9.64 b	62.8 abc
Soil Sheath	5 g/l	-	2.25 bcd	-	61.3 abc
Kwain Thong	1g/kg soil	1.25 bc	2.77 bc	8.03 b	64.3 abc
Untreated control	-	3.0 a	4.33 a	75.0 a	100.0 a
CV, %		38.1	29.07	63.32	41.59
P-value		0.04	0.0004	0.017	0.0067

Means with the same letter are not significantly different at P= 0.05 by Duncan Multiple Range Test (DMRT)

On-farm verification of Fluazinam

The fungicide, Fluazinam from Ishihara Sangyo Kaisha (ISK), Ltd., Japan was found highly effective as Nebijin, both under screen house and field conditions (Table 2 and 3) in reducing clubroot severity and incidence thereby increasing biomass and the yield significantly. Under field conditions, it reduced clubroot severity and incidence by 51% and 55% respectively and increased yield by 182% over control (Table 3).

Band application of Fluazinam was found effective by Cheah et al (1998). It is one of the registered fungicides for the control of clubroot disease in Western Australia (Lancaster, 2006). Field control of clubroot using Fluazinam has been reported in Australia and other countries as seedling dip (Donald and Porter 2009). Donald et al (2009) reported that band application of Fluazinam was more effective than seedling treatment. But in the present study, application was planting hole spray, that is, spot application which was as effective as Nebijin. The result is supported by the report of Lancaster (2006) who mentioned the effectiveness of Fluazinam when targeted at the root zone during transplanting. However, the cost analysis of Fluazinam is yet to be done, but seems to be more

effective and profitable from its wide spectrum characteristics. It has been reported to be effective against late blight of potato and Phytophthora blight of pepper and other groups of fungal pathogens.

Table 3. Effect of Fluazinam on clubroot disease of cauliflower in infested field at Bhaktapur 2010/11

Treatment	Severity index (1-6)		Incidence (%)		Bio-mass kg/plot		Marketable curd weight (kg/plot)	
	2010	2011	2010	2011	2010	2011	2010	2011
Fluazinam	1.7*	1.28 ns	55.75*	14.56*	35.09	50.78*	21.89*	33.83*
Untreated control	4.45	2.25	99.66	59.43	10.34	22.26	6.59	13.16
t-value	6.8275	2.646	2.1643	7.9828	4.3731	6.999	3.6366	6.9994
P-value	0.0208	0.1181	0.0005	0.0153	0.0119	0.0198	0.0220	0.0229

*, significant at P=0.05 level of significance; ns, not significant

In brief, eco-friendly treatments, such as mustard meal, Fosfilombrico star, Suthochu and Kwain Thong could be the effective components for integrated management of clubroot disease, however, there is need of verification under field conditions. Fluazinam could be alternative chemical fungicide to Nebijin, but needs to be analyzed its cost. Efforts should be given by concerned agencies or traders to make available it in the market. Similarly, the effect of copper-oxchloride needs to be verified under field conditions, which could be organically acceptable and cost effective treatment for the management of clubroot disease.

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Performance of Phalsa (*Grewia asiatica* L.) in Mid Western Terai of Nepal

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ABSTRACT

Performance study of phalsa (*Grewia asiatica* L.) was carried out at the Regional Agriculture Research Station Khajura, Nepalgunj during the fiscal year 2062/63 to 2065/66. Ripe fruits of phalsa variety "Faizabad Local" were collected from Narendara Dev University of Agriculture and Technology, Kumargunj, Faizabad, UP, India. Seeds were extracted immediately, cleaned and shown in nursery bed in July. Seeds require 15-20 days for germination and seedlings get ready for planting in the field by 10-12 months. Saplings were planted in July 2063/64. Plants were pruned annually during December-January, when they were dormant. Twenty pits of 0.5x0.5x0.5 m deep and 2.0 meter distance were dug one month before planting and filled 15 days earlier. Fertilizers were applied @ 15 kg compost, 150 g DAP, 100 g Urea and 100 g MOP per pit annually after pruning. Other cultural practices were followed as recommended. Yield and yield attributing characters were recorded from the second year and eight sample plants were selected for data collection. Plant height of 2.41 meter, fruit weight 0.41 g, yield 2.61 kg/plant, pulp 59.5%, juice 34.25% and 10.12 TSS was recorded. On the basis of four years' visual and numeric observations, it was revealed that the Phalsa fruit was very promising for mid-western terai of Nepal. Further verification is needed for recommendation.

INTRODUCTION

Phalsa (*Grewia asiatica* L.), a sub-tropical fruit, belongs to the family tiliaceae. The genus *Grewia* has 140 species and *Grewia asiatica* is of commercial importance. It is a small bush, bears many small berry-like fruits, which ripen in May-June. Ripe fruits are mild acidic with good source of vitamin A and C, fair source of phosphorous and iron and contains 50-60% juice (Aykroyd 1963). Phalsa is commercially raised by seeds extracted from fresh ripe fruits. Generally, the bushes are planted two meter apart. The most important operation in the cultivation of phalsa is pruning. Plants begin to shed their leaves slowly after the middle of winter. They should be pruned at this stage and annual pruning is necessary. The 0.9-1.0 meter height for pruning is desirable (Hayes 1957). The yield per bush ranges from 5 to 10 kg. The bark-eating caterpillar and the mealy bug are the major pests and leaf spot disease caused by the fungus *Cercospora grewiae* is also found.

Phalsa does have specific soil requirement, thus can be grown on a wide range of soils, even on moderately alkaline soils, and fields where other fruit crops are unsuccessful. The Regional Agriculture Research Station, Khajura is situated in mid western terai of Nepal. Geographically, it lies as 81°37' longitude and 20°06' north latitude at an elevation of 181 meters above sea level. The annual rain fall is 1495 mm, temperature ranges from 5°C to 46°C, relative humidity ranges from 27 to 94%, rain starts 15 days late and stop 15 days earlier compared with other parts of the country. So this region's weather is almost dry and hot. According to the literature review this type of climate is suitable for phalsa fruit. Therefore germplasm was introduced at Nepalgunj from India for performance study.

MATERIALS AND METHODS

An experiment on performance of phalsa was carried out at Regional Agriculture Research Station Khajura, Nepalgunj from fiscal year 2062/63 to 2065/66. Ripe fruits of Faizabad Local variety were collected from Narendara Dev University of Agriculture and Technology Kumargunj, Faizabad UP, India. Seeds were extracted immediately, cleaned and sown in nursery bed in July. Seeds require 15-20 days for germination and seedlings get ready for planting in the field by 10-12 months. Seedlings were transplanted in July 2063/64. Twenty pits of 0.5 x 0.5 x 0.5 m deep and 2.0 m distance were dug one month before planting and filled 15 days earlier. Fertilizers were applied @ 15 kg compost, 150 g di-ammonium phosphate, 100 g urea and 100 g muriate of potash per pit. This dose was applied annually after pruning. Plants were pruned annually during December-January, when they were dormant. Yield and yield attributing characters were recorded only from the second year 2065/2066. Eight plants were selected for data collection.

RESULTS AND DISCUSSION

Flowering

Flowering of phalsa started from February-March and continued till May. Flowers were borne in the axel of leaves. In each axel there were 3-7 peduncles, and each peduncle has 3-6 flowers of yellow colour. The flowers were mostly cross- pollinated.

Plant height

In the fourth year plants were pruned up to the height of 1 m during winter season. At the time of full bloom stage during May-June, plant height (mean) reached 2.41 m.

Leaf surface colour

The colour of the leaves of upper side was waxy green, whereas lower surface of leaves were greenish white.

Fruit colour

Phalsa fruits berry was ready to harvest during June-July. The mature fruits colour was whitish green before ripening and ripe fruits were dark red.

Fruit weight

The phalsa plant beared very small berry-type fruits. The mean weight of berry fruit was 0.41 g.

Table 1. Yield attributing characters of Phalsa under Khajura, Nepalgunj conditions

Characters	Plant sample number								Mean
	1	2	3	4	5	6	7	8	
Lower leaf surface	GW	GW	GW	GW	GW	GW	GW	GW	-
Fruit colour	DR	DR	DR	DR	DR	DR	DR	DR	-
Plant height (m)	2.5	2.5	2.3	2.6	2.4	2.3	2.5	2.2	2.41
Fruit weight (g)	0.42	0.45	0.41	0.39	0.42	0.38	0.39	0.41	0.41
Yield (kg)/plant	2.5	2.4	2.6	2.4	2.5	2.8	2.7	3.0	2.61
Pulp (%)	60	60	59	61	60	58	60	58	59.5
Juice (%)	33	32	35	36	35	35	36	32	34.25
TSS (%)	10	10	11	10	11	10	9	10	10.12

GW - Greenish white, DR - Dark red, TSS – Total soluble solids

Yield

The three years old plants gave 2.61 kg fruits/plant.

Pulp and juice

Fruit pulp was extracted one week after storage of ripe fruits. The average pulp percent was 59.5 and the juice percent was 34.25.

Total soluble solids (TSS)

Total soluble solids (°Brix) of juice was recorded by hand refractometer. The TSS was 10.12 under Nepalgunj conditions. In brief, the weather of this mid-western terai region is almost dry and warm. On the basis of four years visual and numeric observation, phalsa fruit was found very promising in this region. However, further verification is needed for recommendation.

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Selection of Late-blight Resistant High Yielding Potato Cultivars for Central Terai under Rice-based Cropping System

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ABSTRACT

Potato (*Solanum tuberosum* L.) is an important winter vegetable crop in central terai. As compared to India (19.0 t/ha), the productivity of this area (16.59 t/ha) is quite low. The major contributing factors of low productivity are lack of high yielding and late blight resistant varieties. Tubers of 16 cultivars; 4 released check cultivars, 12 superior cultivars from Initial Evaluation Trial in the past were planted in Kartik and grown during winter season in BS 2066 and 2067 in RARS Parwanipur in rice-based cropping system. Experiment was laid out in RCBD with four replications. Tubers were planted on ridges in 60x25 cm spacing fertilized with 1000:100:60 kg NPK + 15 ton compost per hectare. Result showed that cv. Andinita (22.64 t/ha) which had significantly higher yield as compared to the rest of the cultivars and having resistant to late-blight disease was selected and recommended for cultivation in central terai. It was followed by CIP 389660.9 (21.25 t/ha) and CIP 388764.26 LB (19.09 t/ha) having fairly resistant to late-blight showed superior performance should be further evaluated in the farmers' field condition. These three cultivars had increased tuber yield by 25.9%, 18.2% and 6.2%, respectively.

INTRODUCTION

Potato is one of the important food crops in Nepal. At present potato ranks fifth position in area, fourth in total production and first in productivity compared with the main staple food crops such as rice, maize, wheat and millet (APBS 2010). Area under potato is about 1,82,506 ha and total production 24,58,720 tons with an average productivity of 13.47 t/ha (APSD 2010). Out of the total area under potato, approximately 19% is in the high-hills and mountains, 44% in the mid-hills and 37% in the terai (APSD 2010). In central terai region, area under potato crop is 19,272 hectare,

production 319,779 tons and productivity 16.59 tons per hectare (APSD 2010). The yield is much lower than the neighboring country India (19.2 t/ha) (<http://cpri.>). One of the reasons behind the low productivity is the lack of suitable location specific potato varieties. Among the potato diseases, late-blight causes substantially yield loss and adversely affect the livelihoods of potato growing farmers (NPRP 2006). Farmers need late blight resistant varieties to replace traditional and old improved varieties (Qunbao et al 1994).

Most of the land races and introduced varieties during late 70's in Nepal are susceptible to late blight. Many varietal trials conducted under on-station and on-farm conditions in the country for several years had resulted in releasing Kufri Sindhuri, Desiree, and Kufri Jyoti in 1992 and Khumal Rato and Janak Dev for terai region in 1997 (Khatrri et al 1999) and Khumal Laxmi for hills and IPY-8 for terai in 2008 (NPRP 2009) but still not adequate as per the demand of farmers. Hence, the objective of this experiment was to select high yielding and late blight resistant potato varieties suitable for rice-based cropping system.

MATERIALS AND METHODS

Sixteen clones (12 improved and 4 released as check) were evaluated in the Regional Agriculture Research Station, Parwanipur, Bara, Nepal. The improved clones selected from initial evaluation trial (IET) were LBR 40, 388764.26LB, 393280.64, BR 63.65, Kufri Badsah, Andinita, 389660.9, RW 8201.19, 392258.11, Kinigi, 800947, 392261.18. The released clones included as check were Khumal Rato, Kufri Sindhuri, Khumal Laxmi, and IPY8. Field was laid out in randomized completed block design with three replications. The individual plot size was 9.6 m². Planting was done in Kartik and harvesting in mid Magh to early Falgun in 2066 and 2067 BS. Field was prepared after paddy harvest and sprouted tubers were planted on ridges by maintaining ridge to ridge 60 cm and plant to plant 25 cm distance. Chemical fertilizers were applied at the rate of 100:100:60 NPK kg/ha. Fungicide was sprayed for two times during cold wave period. Data were collected on vegetative parameters, pest and disease aspects and tuber yield characteristics.

RESULTS AND DISCUSSION

Vegetative characteristics

Vegetative characteristics are presented in table 1. Plant uniformity ranged from 7.6 (Khumal Laxmi) to 9.6 (393280.64 and Kufri Badsah) followed by Andinita, 388764.26LB and 392258.11. Varietal response to plant vigour was significant in both the years. The most vigorous plants were observed in 393280.64 followed by Andinita, Khumal Rato, 389660.9 and 388764.26LB. Plant height was significant in both the years. The tallest plants were measured in 393280.64 (63 cm) followed by Andinita (49 cm) and 392261.18 (48 cm), whereas the shortest plants were in IPY 8 (34 cm) and Khumal Rato (35 cm). Ground coverage was significant in both the years (Table 2). The highest ground coverage was recorded in Andinita (94%) followed by 389660.9 (92%) and 388764.26LB (90%), whereas the least ground coverage was in LBR 40 (70%).

Varietal response to number of stem was significant in both the years. The highest number of stems per plant was counted in Andinita (3.9) followed by BR 63.65 and Kinigi (3.8), whereas the least number of stems was in LBR 40 (1.8) and Khumal Laxmi (1.9). BR 63.65 and CIP 800947 showed early maturity, and 393280.64, 389660.9, IPY 8, Khumal Laxmi, and Kufri Sindhuri showed late maturity and the others showed medium maturity.

Diseases

Varietal response to late blight was significant. The least affected cultivars by late blight were 393280.64 and 389660.9 followed by RW 8201.19, LBR 40, Andinita and 392258.11. Tubers affected with scab at harvest were observed in cv. 392261.18, Kufri Badsah, 389660.9, Khumal Rato, and Khumal Laxmi.

Table 1. Vegetative characters of 16 potato cultivars at RARS, Parwanipur

Clones	Plant uniformity ^x			Plant vigor ^x			Plant height (cm)			Maturity ^y
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	
CIP 392261.18	10.0	7.7	8.8	8	6	7.0	52	44.2	48	M
RW 8201.19	8.3	9.7	9.0	8	6	7.0	50	36.9	43	M
BR 63.65	9.0	8.7	8.8	8	8.6	8.3	45	35.9	40	E
Kufri Badsah	9.3	10.0	9.6	9	8.6	8.8	42	37.7	40	M
CIP 393280.64	10.0	9.3	9.6	10	10	10.0	70	56.0	63	L
CIP 389660.9	9.3	9.3	9.3	9	10	9.5	47	45.3	46	L
Khumal Rato	8.0	9.3	8.6	8	7.4	9.7	41	29.2	35	M
CIP 800947	9.3	8.7	9.0	8	7.4	7.7	40	31.1	36	E
Kinigi	9.7	9.0	9.3	8	6	7.0	45	36.4	41	M
LBR 40	8.3	8.3	8.3	8	10	9.0	45	46.0	45	M
CIP 388764.26LB	9.7	9.3	9.5	9	10	9.5	46	45.1	46	M
IPY 8	8.0	8.0	8.0	9	7.4	8.2	38	30.8	34	L
Khumal Laxmi	7.3	8.0	7.6	9	8.6	8.8	50	40.7	45	L
Andinita	9.3	9.7	9.5	10	9.4	9.7	54	44.8	49	M
CIP 392258.11	9.3	9.7	9.5	9	8.6	8.8	43	36.8	40	M
Kufri Sindhuri	7.7	9.7	8.7	8	10.0	9.0	49	38.4	44	L
CV%	7.6	12.7	8.04	6.8	9.9	10.8	15.6	13.1	6.96	
F-test (0.05)	**	ns	ns	**	**	**	**	**	**	
LSD (0.05)	0.47	1.85	1.54	1.0	0.7	0.96	12.4	8.27	6.45	
YxA			ns			ns			**	

^x1: poor, 10: excellent; ^yE, early; M, medium; L, late; ns, not significant; **highly significant

Table 2. Vegetative characters of 16 potato cultivars at RARS, Parwanipur

Clones	Ground coverage (%)			Late blight score			No. of stems /plant			Tuber scab (%)
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	
CIP 392261.18	68	80	74	4	5.7	5	1.8	2.9	2.3	15.6
RW 8201.19	72	73	72	5	3.3	4	3.2	3.9	3.6	0
BR 63.65	75	83	79	6	4.7	5	2.9	4.7	3.8	0
Kufri Badsah	78	97	87	5	4.3	5	2.5	3.7	3.1	1.5
CIP 393280.64	77	97	87	2	3.7	3	1.8	3.2	2.5	0
CIP 389660.9	87	97	92	3	3.7	3	2.3	3.1	2.7	0.7
Khumal Rato	68	90	79	7	7.3	7	1.6	3.0	2.3	2.6
CIP 800947	67	93	80	7	8.7	8	2.2	4.2	3.2	0
Kinigi	80	83	81	5	6.3	6	2.3	5.3	3.8	1
LBR 40	60	80	70	6	5.0	5	1.3	1.7	1.5	0
CIP 388764.26LB	83	97	90	5	7.7	6	2.0	4.0	3.0	0
IPY 8	68	90	79	4	6.7	5	1.9	2.8	2.3	0
Khumal Laxmi	67	83	75	4	5.7	5	1.3	2.6	1.9	1.8
Andinita	98	90	94	4	3.3	3	3.0	4.9	3.9	0
CIP 392258.11	80	93	86	4	5.7	5	1.9	3.5	2.7	0
Kufri Sindhuri	58	97	77	4	4.5	4	2.3	4.5	3.4	2.6
CV%	13.2	11.2	9.55	16.6	29.8	20.6		22.3	16.14	209
F-test (0.05)	**	*	*	**	**	*	*	**	**	**
LSD (0.05)	16.4	16.0	16.6	1.29	2.83	2.26	0.97	1.3	0.99	4.85
YxA			**			*				

Tubers yield characteristics

Varietal response to tuber yield was significant in both the years (Table 3). Andinita gave significantly higher tuber yield (22.64 ton/ha) followed by 389660.9 (21.25 ton/ha) and 388764.26LB (19.09 ton/ha). All the released cultivars Khumal Laxmi (12.36 ton/ha), IPY 8 (7.73 ton/ha), and Khumal Rato (11.28 ton/ha) were inferior in tubers yield as compared to Kufri Sindhuri. Number of tubers per plant was highest in 388764.26LB (25.8) followed by Kufri Sindhuri (23.5) and BR 63.65 (21.7), and the least (8.5) in IPY 8. Highest percent of over- sized tubers was recorded in 389660.9 (42.8%) followed by Kufri Badsah (39.3%) and Andinita (26.4%), whereas Kufri Sindhuri had 16.8 percent that was the least among the tested cultivars. Likewise, the highest percent of seed-sized tubers was recorded in Kufri Sindhuri (66.8%) followed by 393280.64 (66.7%) and 388764.26LB (64.9%). The higher percent of under-sized tubers was recorded in IPY 8 (16.6%), Kufri Sindhuri (16.4%) and 800947 (15.8%) (Table 4).

Table 3. Tuber yield of potato cultivars at RARS, Parwanipur

Clones	Yield (t/ha)			No. of tubers/plant			Wt.of tuber (g/plant)			Yield increase (%)
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	
CIP 392261.18	8.2	11.3	9.8 gh	10.0	14.9	12.50	123	223	173	-45.7
RW 8201.19	11.6	19.6	15.6ef	3.5	20.6	12.1	175	310	242	-13.2
BR 63.65	17.2	18.4	17.8 cde	24.0	19.4	21.7	258	288	273	-1.0
Kufri Badsah	20.0	21.8	20.9 abc	14.0	25.2	19.6	305	326	313	+16.2
CIP 392280.64	15.6	19.3	17.5 dc	14.0	20.0	17.0	223	299	261	-2.9
CIP 389660.9	19.2	23.3	21.3 ab	16.0	25.4	20.7	288	382	335	+18.2
Khumal Rato	10.1	12.5	11.3 g	13.0	13.4	13.2	151	201	176	-37.3
CIP 800947	14.9	17.1	16.0 de	16.0	18.6	17.3	220	277	248	-11.1
Kinigi	17.9	18.0	17.9 bcde	18.0	19.6	18.8	268	294	281	-0.3
LBR 40	18.7	18.4	18.6 bcde	10.0	19.6	14.8	161	295	228	+3.2
CIP 388764.26LB	16.5	21.7	19.1 bcd	28.0	23.6	25.8	247	355	301	+6.2
IPY 8	8.3	7.2	7.7 h	9.0	8.0	8.5	125	121	123	-57.0
Khumal Laxmi	10.7	14.0	12.4 fg	3.5	15.3	9.4	161	232	196	-31.3
Andinita	20.6	24.7	22.6 a	13.0	24.9	18.9	309	373	341	+25.9
CIP 392258.11	16.2	19.8	18.0 bcde	10.0	20.4	15.2	243	306	274	+0.1
Kufri Sindhuri	15.9	20.1	18.0 bcde	19.0	28.1	23.5	238	370	304	
CV%	20.6	12.0	9.5			30.7	20.6		11.13	
F-test (0.05)	**	**	**			**	**		**	
LSD (0.05)	5.02	3.51	3.38			7.55	0.08		60.87	
YxA			**			**			**	

Tubers characteristics

Tuber characteristics are presented in table 5. Nine cultivars had round shape tubers, one oblong shape and the rest oval shape. Small-sized tubers were recorded in BR 63.65 and IPY 8, big-sized tubers in 389660.9, 392258.11 and Andinita, and the rest medium-sized tubers. Seven cultivars had white skin tubers, one (388764.26LB) purple skin and the rest red skin tubers. Seven cultivars had medium depth eye tubers, five deep eyed tubers and four shallow depth eyed tubers. Five cultivars had yellow color flesh, six cream color flesh and the rest white flesh tubers.

Table 4. Tuber yield (t/ha) performance of potato cultivars at RARS, Parwanipur

Clones	Under size (%)			Seed size (%)			Over size (%)		
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean
CIP 392261.18	14.4	10.2	12.3	61.8	53.1	57.4	23.9	36.5	30.2
RW 8201.19	6.1	10.8	8.4	73.6	46.8	60.2	20.3	42.4	31.3
BR 63.65	2.1	12.6	7.3	70.2	47.4	58.8	9.7	40.0	24.8
Kufri Badsah	11.8	8.3	10.0	58.7	42.5	50.6	29.5	49.1	39.3
CIP 392280.64	11.5	10.1	10.8	66.0	67.5	66.7	22.5	22.4	22.4
CIP 389660.9	6.1	7.0	6.6	56.9	44.3	50.6	37.0	48.7	42.8
Khumal Rato	8.4	9.9	9.1	67.0	61.6	64.3	24.7	28.6	26.6
CIP 800947	17.0	14.7	15.8	65.5	48.9	51.2	17.4	36.4	26.9
Kinigi	11.5	13.3	12.4	71.9	57.0	64.4	16.6	29.6	23.1
LBR 40	10.5	7.6	9.0	71.5	39.7	55.6	18.0	52.7	35.3
CIP 388764.26LB	14.6	8.9	11.7	67.9	61.9	64.9	17.4	29.1	23.2
IPY 8	13.4	19.7	16.6	69.4	44.2	56.8	17.1	36.2	26.6
Khumal Laxmi	6.4	14.4	10.4	60.5	54.9	57.7	33.1	30.6	31.8
Andinita	16.4	13.4	14.9	64.3	53.1	58.7	19.3	33.5	26.4
CIP 392258.11	9.4	13.1	11.2	64.8	48.1	56.4	25.8	38.7	32.2
Kufri Sindhuri	17.5	15.4	16.4	67.3	66.3	66.8	15.3	18.3	16.8
CV%		39.6	29.2		16.5	11.36		23.84	25.0
F-test (0.05)		*	Ns		**	Ns		**	Ns
LSD (0.05)		8.79	7.13		14.5	14.3		12.83	15.3
YxA			Ns			**			**

Table 5. Tuber characteristics of 16 potato cultivars at RARS Parwanipur in 2066 and 2067

Clones	Shape	Size	Color ^z	Eye depth ^y	Flesh color ^z
CIP 392261.18	Oval	Medium	Red	Deep	White
RW 8201.19	Oval	Medium	Red	Medium	Yellow
BR 63.65	Red	Small	Red	Deep	Cream
Kufri Badsah	Oval	Medium	White	Shallow	Cream
CIP 392280.64	Red	Medium	Red	Medium	Yellow
CIP 389660.9	Oblong	Big	White	Shallow	White
Khumal Rato	Red	Medium	Red	Medium	Yellow
CIP 800947	Oval	Medium	White	Shallow	Cream
Kinigi	Red	Medium	Red	Deep	Cream
LBR 40	Red	Medium	White	Medium	White
CIP 388764.26LB	Red	Medium	Purple	Medium	White
IPY 8	Oval	Small	White	Medium	Yellow
Khumal Laxmi	Red	Medium	Red	Deep	Yellow
Andinita	Oval	Big	White	Shallow	Cream
CIP 392258.11	Red	Big	White	Medium	Cream
Kufri Sindhuri	Red	Medium	Red	Deep	White

CONCLUSION

On the basis of over all performances and farmers' desire, clone 393280.64 is recommended for cultivation under central terai conditions. Pre-basic seed (PBS) production is required for improving the yield and better keeping quality.

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From the analytical results of Malbhog variety banana, it was seen that the pH was decreased where as acidity and total soluble sugar were increased with increasing ripening time. At the start of ripening (peel started to change from green to yellow color) of Malbhog variety M_A (ripening was carried out by hanging in steel air), the pH was decreased from 5.0 to 4.4, acidity and TSS were increased from 0.4102 and 10.2 to 0.7787 and 21.8, respectively at the time of optimum ripening at 6th day. Similarly M_B (ripening was carried out by packing in P.E. bag), the pH was decrease from 4.7 to 4.5, acidity and TSS were increased from 0.4310 and 13.2 to 0.6668 and 21.5, respectively at the time of optimum ripening at 5th day. Similarly, sample M_C (ripening was carried out by wrapping with *dhusmeto* and packed in P.E. bag), the pH was decrease from 4.8 to 4.6, acidity and TSS were increased from 0.4282 and 11.8 to 0.6065 and 21.3, respectively at the time of optimum ripening at 5th day.

Ripening of Harichal varieties' samples were also started from 3rd day of treatment at room temperature 27°C but their color were only slightly changed to yellow. The samples H_B and H_C were started ripening from 3rd day of the treatment but sample H_A was started from 5th day. The chemical changes of Harichal variety is shown in Table 2. From the analytical results of Harichal, it was also seen that the pH was decreased where as acidity and total soluble sugar were increased with increasing ripening time.

Table 2. Chemical changes on first, second and third day of ripening (var. Harichal)

Samples	pH	Acidity	TSS (°Bx)
On first day			
Sample H _A (5 th day of treatment)	4.9±0.1	0.42±0.03	12.4±0.2
Sample H _B (3 rd day of treatment)	4.9±0.1	0.42±0.03	12.7±0.2
Sample H _C (3 rd day of treatment)	5.0±0.1	0.41±0.03	11.4±0.2
On second day			
Sample H _A (6 th day of treatment)	4.6±0.1	0.60±0.03	16.6±0.2
Sample H _B (4 th day of treatment)	4.6±0.1	0.61±0.03	16.4±0.2
Sample H _C (4 th day of treatment)	4.8±0.1	0.53±0.04	15.2±0.2
On third day			
Sample H _A (7 th day of treatment)	4.4±0.1	0.77±0.03	21.0±0.2
Sample H _B (5 th day of treatment)	4.4±0.1	0.76±0.03	20.8±0.1
Sample H _C (5 th day of treatment)	4.5±0.1	0.74±0.03	20.5±0.2

Values are the mean of three determinations, ± standard deviation

At the start of ripening (peel started to change from green to slightly yellow color) of Harichal variety H_A (ripening was carried out by hanging in steel air), the pH was decreased from 4.9 to 4.4, acidity and TSS were increased from 0.4232 and 12.4 to 0.7639 and 21.0, respectively at the time of optimum ripening at 7th day. Similarly, H_B (ripening was carried out by packing in P.E. bag), the pH was decrease from 4.9 to 4.5, acidity and TSS were increased from 0.4220 and 12.7 to 0.7615 and 20.8, respectively at the time of optimum ripening at 5th day. Similarly, sample H_C (ripening was carried out by wrapping with *dhusmeto* and packed in P.E. bag), the pH was decreased from 5.0 to 4.5, acidity and TSS were increased from 0.41512 and 11.4 to 0.7360 and 20.5, respectively at the time of optimum ripening at 5th day.

Ripening of Athiya varieties' samples were also started from 5th day of treatment at room temperature 27°C with color slightly change to yellow. Samples A_B and A_C were started ripening from 5th day of the treatment but sample A_B was started ripening from 6th day of treatment. The chemical changes of Athiya variety is shown in Table 3. From the analytical results of Athiya variety banana, it was also seen that the pH was decreased where as acidity and total soluble sugar were increased with increasing ripening time.

Table 3. Chemical changes at first day of ripening (var. Athiya)

Samples	pH	Acidity	TSS (°Bx)
On first day			
Sample A _A (6 th day of treatment)	4.8±0.1	0.43±0.03	11.8±0.2
Sample A _B (5 th day of treatment)	4.8±0.1	0.43±0.03	11.9±0.1
Sample A _C (5 th day of treatment)	4.9±0.1	0.42±0.03	11.6±0.2
On second day			
Sample A _A (7 th day of treatment)	4.6±0.1	0.58±0.03	17.4±0.1
Sample A _B (6 th day of treatment)	4.6±0.1	0.59±0.03	17.5±0.2
Sample A _C (6 th day of treatment)	4.7±0.1	0.53±0.03	16.8±0.1
On third day			
Sample A _A (8 th day of treatment)	4.5±0.1	0.75±0.03	22.2±0.2
Sample A _B (7 th day of treatment)	4.5±0.1	0.75±0.03	22.6±0.2
Sample A _C (7 th day of treatment)	4.6±0.1	0.75±0.03	21.9±0.1

Values are the mean of three determinations, ± standard deviation

At the start of ripening (peel starts to change from green to slightly yellow color) of Athiya variety A_A (ripening was carried out by hanging in steel air), the pH was decreased from 4.8 to 4.5, acidity and TSS were increased from 0.4282 and 11.8 to 0.7528 and 22.2, respectively at the time of optimum ripening at 8th day. Similarly, A_B (ripening was carried out by packing in P.E. bag), the pH was decrease from 4.8 to 4.5, acidity and TSS were increased from 0.4278 and 11.9 to 0.7536 and 22.6, respectively at the time of optimum ripening at 7th day. Similarly, sample A_C (ripening was carried out by wrapping with *dhusmeto* and packed in P.E. bag), the pH was decreased from 4.9 to 4.6, acidity and TSS were increased from 0.4232 and 11.6 to 0.7475 and 21.9, respectively at the time of optimum ripening at 7th day.

Proximate and ultimate analysis of ripened banana

The proximate and ultimate compositions obtained from chemical analysis of banana are shown in Table 4.

Table 4. Chemical components of banana (fully ripened)

Parameters	Mean values (%) (var. Malbhog)	Mean Values (%) (var. Harichal)	Mean Values (%) (var. Athiya)
Moisture content	70.3±0.5	71.7±0.3	68.7±0.5
TS as invert sugar	18.43±0.22	17.24±0.26	20.36±0.35
Protein content	1.45±0.14	1.10±0.08	1.62±0.16
Pectin as Ca-pectate	0.95±0.05	0.73 ±0.03	0.85±0.02
Crude fiber	0.38±0.44	0.40±0.52	0.66±0.10
Total ash content	0.90±0.04	0.97±0.33	1.15±0.08
Vitamin C content	15.74±0.12 mg/100 g	12.09±0.10 mg/100 g	11.88±0.1 mg/100 g
Iron content	0.40±0.02 mg/100 g	0.55±0.02 mg/100 g	0.72±0.01 mg/100 g
Calcium content	11.96±0.01 mg/100 g	12.10±0.03 mg/100 g	18.34±0.01 mg/100 g
Phosphorus content	37.06±0.02 mg/100 g	34.44±0.04 mg/100 g	26.56±0.08 mg/100 g
Fat content	0.31±0.05	0.29±0.12	0.30±0.26

Values are the mean of three determinations, ± standard deviation

From the chemical analysis, total sugar, protein, total ash, calcium, iron, and crude fibre contents were found higher in Athiya variety. Similarly pectin, vitamin C, phosphorus and fat contents were found higher in Malbhog variety. The only moisture content was found higher in Harichal variety.

Juice extraction rate

The process of juice extraction was carried out as shown in Figure 1. The extraction rate was found optimum by treating with pectinase enzyme (polygalacturonase, CAS No. 9032-75-1, prepared by HiMedia Laboratories Pvt. Ltd. 23, Vadhani Ind. Est., LBS Marg, Mumbai-400086, India), at the rate

of 0.0025 g per 100 g peeled banana, followed by incubating at 32°C for 2 hours. The average yield of juice at above condition is shown in Table 5.

Table 5. Average yield of banana juice

Sample juice	Average Extraction rate / yield
Malbhog	82.24±0.54%
Harichal	80.58 ±0.38%
Athiya	76.32 ±0.82%

Values are the mean of three determinations, ± standard deviation

Sensory analysis

From the statistical analysis of scores obtained from sensorial test of juice, it was found significantly different in terms of flavor of all three varieties of banana but in terms of rest parameters, it was not significantly different at p=0.05.

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Selection of Late-blight Resistant High Yielding Potato Cultivars for Central Terai under Rice-based Cropping System

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ABSTRACT

Potato (*Solanum tuberosum* L.) is an important winter vegetable crop in central terai. As compared to India (19.0 t/ha), the productivity of this area (16.59 t/ha) is quite low. The major contributing factors of low productivity are lack of high yielding and late blight resistant varieties. Tubers of 16 cultivars; 4 released check cultivars, 12 superior cultivars from Initial Evaluation Trial in the past were planted in Kartik and grown during winter season in BS 2066 and 2067 in RARS Parwanipur in rice-based cropping system. Experiment was laid out in RCBD with four replications. Tubers were planted on ridges in 60x25 cm spacing fertilized with 1000:100:60 kg NPK + 15 ton compost per hectare. Result showed that cv. Andinita (22.64 t/ha) which had significantly higher yield as compared to the rest of the cultivars and having resistant to late-blight disease was selected and recommended for cultivation in central terai. It was followed by CIP 389660.9 (21.25 t/ha) and CIP 388764.26 LB (19.09 t/ha) having fairly resistant to late-blight showed superior performance should be further evaluated in the farmers' field condition. These three cultivars had increased tuber yield by 25.9%, 18.2% and 6.2%, respectively.

INTRODUCTION

Potato is one of the important food crops in Nepal. At present potato ranks fifth position in area, fourth in total production and first in productivity compared with the main staple food crops such as rice, maize, wheat and millet (APBS 2010). Area under potato is about 1,82,506 ha and total production 24,58,720 tons with an average productivity of 13.47 t/ha (APSD 2010). Out of the total area under potato, approximately 19% is in the high-hills and mountains, 44% in the mid-hills and 37% in the terai (APSD 2010). In central terai region, area under potato crop is 19,272 hectare,

production 319,779 tons and productivity 16.59 tons per hectare (APSD 2010). The yield is much lower than the neighboring country India (19.2 t/ha) (<http://cpri.>). One of the reasons behind the low productivity is the lack of suitable location specific potato varieties. Among the potato diseases, late-blight causes substantially yield loss and adversely affect the livelihoods of potato growing farmers (NPRP 2006). Farmers need late blight resistant varieties to replace traditional and old improved varieties (Qunbao et al 1994).

Most of the land races and introduced varieties during late 70's in Nepal are susceptible to late blight. Many varietal trials conducted under on-station and on-farm conditions in the country for several years had resulted in releasing Kufri Sindhuri, Desiree, and Kufri Jyoti in 1992 and Khumal Rato and Janak Dev for terai region in 1997 (Khatrri et al 1999) and Khumal Laxmi for hills and IPY-8 for terai in 2008 (NPRP 2009) but still not adequate as per the demand of farmers. Hence, the objective of this experiment was to select high yielding and late blight resistant potato varieties suitable for rice-based cropping system.

MATERIALS AND METHODS

Sixteen clones (12 improved and 4 released as check) were evaluated in the Regional Agriculture Research Station, Parwanipur, Bara, Nepal. The improved clones selected from initial evaluation trial (IET) were LBR 40, 388764.26LB, 393280.64, BR 63.65, Kufri Badsah, Andinita, 389660.9, RW 8201.19, 392258.11, Kinigi, 800947, 392261.18. The released clones included as check were Khumal Rato, Kufri Sindhuri, Khumal Laxmi, and IPY8. Field was laid out in randomized completed block design with three replications. The individual plot size was 9.6 m². Planting was done in Kartik and harvesting in mid Magh to early Falgun in 2066 and 2067 BS. Field was prepared after paddy harvest and sprouted tubers were planted on ridges by maintaining ridge to ridge 60 cm and plant to plant 25 cm distance. Chemical fertilizers were applied at the rate of 100:100:60 NPK kg/ha. Fungicide was sprayed for two times during cold wave period. Data were collected on vegetative parameters, pest and disease aspects and tuber yield characteristics.

RESULTS AND DISCUSSION

Vegetative characteristics

Vegetative characteristics are presented in table 1. Plant uniformity ranged from 7.6 (Khumal Laxmi) to 9.6 (393280.64 and Kufri Badsah) followed by Andinita, 388764.26LB and 392258.11. Varietal response to plant vigour was significant in both the years. The most vigorous plants were observed in 393280.64 followed by Andinita, Khumal Rato, 389660.9 and 388764.26LB. Plant height was significant in both the years. The tallest plants were measured in 393280.64 (63 cm) followed by Andinita (49 cm) and 392261.18 (48 cm), whereas the shortest plants were in IPY 8 (34 cm) and Khumal Rato (35 cm). Ground coverage was significant in both the years (Table 2). The highest ground coverage was recorded in Andinita (94%) followed by 389660.9 (92%) and 388764.26LB (90%), whereas the least ground coverage was in LBR 40 (70%).

Varietal response to number of stem was significant in both the years. The highest number of stems per plant was counted in Andinita (3.9) followed by BR 63.65 and Kinigi (3.8), whereas the least number of stems was in LBR 40 (1.8) and Khumal Laxmi (1.9). BR 63.65 and CIP 800947 showed early maturity, and 393280.64, 389660.9, IPY 8, Khumal Laxmi, and Kufri Sindhuri showed late maturity and the others showed medium maturity.

Diseases

Varietal response to late blight was significant. The least affected cultivars by late blight were 393280.64 and 389660.9 followed by RW 8201.19, LBR 40, Andinita and 392258.11. Tubers affected with scab at harvest were observed in cv. 392261.18, Kufri Badsah, 389660.9, Khumal Rato, and Khumal Laxmi.

Table 1. Vegetative characters of 16 potato cultivars at RARS, Parwanipur

Clones	Plant uniformity ^x			Plant vigor ^x			Plant height (cm)			Maturity ^y
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	
CIP 392261.18	10.0	7.7	8.8	8	6	7.0	52	44.2	48	M
RW 8201.19	8.3	9.7	9.0	8	6	7.0	50	36.9	43	M
BR 63.65	9.0	8.7	8.8	8	8.6	8.3	45	35.9	40	E
Kufri Badsah	9.3	10.0	9.6	9	8.6	8.8	42	37.7	40	M
CIP 393280.64	10.0	9.3	9.6	10	10	10.0	70	56.0	63	L
CIP 389660.9	9.3	9.3	9.3	9	10	9.5	47	45.3	46	L
Khumal Rato	8.0	9.3	8.6	8	7.4	9.7	41	29.2	35	M
CIP 800947	9.3	8.7	9.0	8	7.4	7.7	40	31.1	36	E
Kinigi	9.7	9.0	9.3	8	6	7.0	45	36.4	41	M
LBR 40	8.3	8.3	8.3	8	10	9.0	45	46.0	45	M
CIP 388764.26LB	9.7	9.3	9.5	9	10	9.5	46	45.1	46	M
IPY 8	8.0	8.0	8.0	9	7.4	8.2	38	30.8	34	L
Khumal Laxmi	7.3	8.0	7.6	9	8.6	8.8	50	40.7	45	L
Andinita	9.3	9.7	9.5	10	9.4	9.7	54	44.8	49	M
CIP 392258.11	9.3	9.7	9.5	9	8.6	8.8	43	36.8	40	M
Kufri Sindhuri	7.7	9.7	8.7	8	10.0	9.0	49	38.4	44	L
CV%	7.6	12.7	8.04	6.8	9.9	10.8	15.6	13.1	6.96	
F-test (0.05)	**	ns	ns	**	**	**	**	**	**	
LSD (0.05)	0.47	1.85	1.54	1.0	0.7	0.96	12.4	8.27	6.45	
YxA			ns			ns			**	

^x1: poor, 10: excellent; ^yE, early; M, medium; L, late; ns, not significant; **highly significant

Table 2. Vegetative characters of 16 potato cultivars at RARS, Parwanipur

Clones	Ground coverage (%)			Late blight score			No. of stems /plant			Tuber scab (%)
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	
CIP 392261.18	68	80	74	4	5.7	5	1.8	2.9	2.3	15.6
RW 8201.19	72	73	72	5	3.3	4	3.2	3.9	3.6	0
BR 63.65	75	83	79	6	4.7	5	2.9	4.7	3.8	0
Kufri Badsah	78	97	87	5	4.3	5	2.5	3.7	3.1	1.5
CIP 393280.64	77	97	87	2	3.7	3	1.8	3.2	2.5	0
CIP 389660.9	87	97	92	3	3.7	3	2.3	3.1	2.7	0.7
Khumal Rato	68	90	79	7	7.3	7	1.6	3.0	2.3	2.6
CIP 800947	67	93	80	7	8.7	8	2.2	4.2	3.2	0
Kinigi	80	83	81	5	6.3	6	2.3	5.3	3.8	1
LBR 40	60	80	70	6	5.0	5	1.3	1.7	1.5	0
CIP 388764.26LB	83	97	90	5	7.7	6	2.0	4.0	3.0	0
IPY 8	68	90	79	4	6.7	5	1.9	2.8	2.3	0
Khumal Laxmi	67	83	75	4	5.7	5	1.3	2.6	1.9	1.8
Andinita	98	90	94	4	3.3	3	3.0	4.9	3.9	0
CIP 392258.11	80	93	86	4	5.7	5	1.9	3.5	2.7	0
Kufri Sindhuri	58	97	77	4	4.5	4	2.3	4.5	3.4	2.6
CV%	13.2	11.2	9.55	16.6	29.8	20.6		22.3	16.14	209
F-test (0.05)	**	*	*	**	**	*	*	**	**	**
LSD (0.05)	16.4	16.0	16.6	1.29	2.83	2.26	0.97	1.3	0.99	4.85
YxA			**			*				

Tubers yield characteristics

Varietal response to tuber yield was significant in both the years (Table 3). Andinita gave significantly higher tuber yield (22.64 ton/ha) followed by 389660.9 (21.25 ton/ha) and 388764.26LB (19.09 ton/ha). All the released cultivars Khumal Laxmi (12.36 ton/ha), IPY 8 (7.73 ton/ha), and Khumal Rato (11.28 ton/ha) were inferior in tubers yield as compared to Kufri Sindhuri. Number of tubers per plant was highest in 388764.26LB (25.8) followed by Kufri Sindhuri (23.5) and BR 63.65 (21.7), and the least (8.5) in IPY 8. Highest percent of over- sized tubers was recorded in 389660.9 (42.8%) followed by Kufri Badsah (39.3%) and Andinita (26.4%), whereas Kufri Sindhuri had 16.8 percent that was the least among the tested cultivars. Likewise, the highest percent of seed-sized tubers was recorded in Kufri Sindhuri (66.8%) followed by 393280.64 (66.7%) and 388764.26LB (64.9%). The higher percent of under-sized tubers was recorded in IPY 8 (16.6%), Kufri Sindhuri (16.4%) and 800947 (15.8%) (Table 4).

Table 3. Tuber yield of potato cultivars at RARS, Parwanipur

Clones	Yield (t/ha)			No. of tubers/plant			Wt. of tuber (g/plant)			Yield increase (%)
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean	
CIP 392261.18	8.2	11.3	9.8 gh	10.0	14.9	12.50	123	223	173	-45.7
RW 8201.19	11.6	19.6	15.6ef	3.5	20.6	12.1	175	310	242	-13.2
BR 63.65	17.2	18.4	17.8 cde	24.0	19.4	21.7	258	288	273	-1.0
Kufri Badsah	20.0	21.8	20.9 abc	14.0	25.2	19.6	305	326	313	+16.2
CIP 392280.64	15.6	19.3	17.5 dc	14.0	20.0	17.0	223	299	261	-2.9
CIP 389660.9	19.2	23.3	21.3 ab	16.0	25.4	20.7	288	382	335	+18.2
Khumal Rato	10.1	12.5	11.3 g	13.0	13.4	13.2	151	201	176	-37.3
CIP 800947	14.9	17.1	16.0 de	16.0	18.6	17.3	220	277	248	-11.1
Kinigi	17.9	18.0	17.9 bcde	18.0	19.6	18.8	268	294	281	-0.3
LBR 40	18.7	18.4	18.6 bcde	10.0	19.6	14.8	161	295	228	+3.2
CIP 388764.26LB	16.5	21.7	19.1 bcd	28.0	23.6	25.8	247	355	301	+6.2
IPY 8	8.3	7.2	7.7 h	9.0	8.0	8.5	125	121	123	-57.0
Khumal Laxmi	10.7	14.0	12.4 fg	3.5	15.3	9.4	161	232	196	-31.3
Andinita	20.6	24.7	22.6 a	13.0	24.9	18.9	309	373	341	+25.9
CIP 392258.11	16.2	19.8	18.0 bcde	10.0	20.4	15.2	243	306	274	+0.1
Kufri Sindhuri	15.9	20.1	18.0 bcde	19.0	28.1	23.5	238	370	304	
CV%	20.6	12.0	9.5			30.7	20.6		11.13	
F-test (0.05)	**	**	**			**	**		**	
LSD (0.05)	5.02	3.51	3.38			7.55	0.08		60.87	
YxA			**			**			**	

Tubers characteristics

Tuber characteristics are presented in table 5. Nine cultivars had round shape tubers, one oblong shape and the rest oval shape. Small-sized tubers were recorded in BR 63.65 and IPY 8, big-sized tubers in 389660.9, 392258.11 and Andinita, and the rest medium-sized tubers. Seven cultivars had white skin tubers, one (388764.26LB) purple skin and the rest red skin tubers. Seven cultivars had medium depth eye tubers, five deep eyed tubers and four shallow depth eyed tubers. Five cultivars had yellow color flesh, six cream color flesh and the rest white flesh tubers.

Table 4. Tuber yield (t/ha) performance of potato cultivars at RARS, Parwanipur

Clones	Under size (%)			Seed size (%)			Over size (%)		
	2066	2067	Mean	2066	2067	Mean	2066	2067	Mean
CIP 392261.18	14.4	10.2	12.3	61.8	53.1	57.4	23.9	36.5	30.2
RW 8201.19	6.1	10.8	8.4	73.6	46.8	60.2	20.3	42.4	31.3
BR 63.65	2.1	12.6	7.3	70.2	47.4	58.8	9.7	40.0	24.8
Kufri Badsah	11.8	8.3	10.0	58.7	42.5	50.6	29.5	49.1	39.3
CIP 392280.64	11.5	10.1	10.8	66.0	67.5	66.7	22.5	22.4	22.4
CIP 389660.9	6.1	7.0	6.6	56.9	44.3	50.6	37.0	48.7	42.8
Khumal Rato	8.4	9.9	9.1	67.0	61.6	64.3	24.7	28.6	26.6
CIP 800947	17.0	14.7	15.8	65.5	48.9	51.2	17.4	36.4	26.9
Kinigi	11.5	13.3	12.4	71.9	57.0	64.4	16.6	29.6	23.1
LBR 40	10.5	7.6	9.0	71.5	39.7	55.6	18.0	52.7	35.3
CIP 388764.26LB	14.6	8.9	11.7	67.9	61.9	64.9	17.4	29.1	23.2
IPY 8	13.4	19.7	16.6	69.4	44.2	56.8	17.1	36.2	26.6
Khumal Laxmi	6.4	14.4	10.4	60.5	54.9	57.7	33.1	30.6	31.8
Andinita	16.4	13.4	14.9	64.3	53.1	58.7	19.3	33.5	26.4
CIP 392258.11	9.4	13.1	11.2	64.8	48.1	56.4	25.8	38.7	32.2
Kufri Sindhuri	17.5	15.4	16.4	67.3	66.3	66.8	15.3	18.3	16.8
CV%		39.6	29.2		16.5	11.36		23.84	25.0
F-test (0.05)		*	Ns		**	Ns		**	Ns
LSD (0.05)		8.79	7.13		14.5	14.3		12.83	15.3
YxA			Ns			**			**

Table 5. Tuber characteristics of 16 potato cultivars at RARS Parwanipur in 2066 and 2067

Clones	Shape	Size	Color ^z	Eye depth ^y	Flesh color ^z
CIP 392261.18	Oval	Medium	Red	Deep	White
RW 8201.19	Oval	Medium	Red	Medium	Yellow
BR 63.65	Red	Small	Red	Deep	Cream
Kufri Badsah	Oval	Medium	White	Shallow	Cream
CIP 392280.64	Red	Medium	Red	Medium	Yellow
CIP 389660.9	Oblong	Big	White	Shallow	White
Khumal Rato	Red	Medium	Red	Medium	Yellow
CIP 800947	Oval	Medium	White	Shallow	Cream
Kinigi	Red	Medium	Red	Deep	Cream
LBR 40	Red	Medium	White	Medium	White
CIP 388764.26LB	Red	Medium	Purple	Medium	White
IPY 8	Oval	Small	White	Medium	Yellow
Khumal Laxmi	Red	Medium	Red	Deep	Yellow
Andinita	Oval	Big	White	Shallow	Cream
CIP 392258.11	Red	Big	White	Medium	Cream
Kufri Sindhuri	Red	Medium	Red	Deep	White

CONCLUSION

On the basis of over all performances and farmers' desire, clone 393280.64 is recommended for cultivation under central terai conditions. Pre-basic seed (PBS) production is required for improving the yield and better keeping quality.

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Performance of Phalsa (*Grewia asiatica* L.) in Mid Western Terai of Nepal

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ABSTRACT

Performance study of phalsa (*Grewia asiatica* L.) was carried out at the Regional Agriculture Research Station Khajura, Nepalgunj during the fiscal year 2062/63 to 2065/66. Ripe fruits of phalsa variety "Faizabad Local" were collected from Narendara Dev University of Agriculture and Technology, Kumargunj, Faizabad, UP, India. Seeds were extracted immediately, cleaned and shown in nursery bed in July. Seeds require 15-20 days for germination and seedlings get ready for planting in the field by 10-12 months. Saplings were planted in July 2063/64. Plants were pruned annually during December-January, when they were dormant. Twenty pits of 0.5x0.5x0.5 m deep and 2.0 meter distance were dug one month before planting and filled 15 days earlier. Fertilizers were applied @ 15 kg compost, 150 g DAP, 100 g Urea and 100 g MOP per pit annually after pruning. Other cultural practices were followed as recommended. Yield and yield attributing characters were recorded from the second year and eight sample plants were selected for data collection. Plant height of 2.41 meter, fruit weight 0.41 g, yield 2.61 kg/plant, pulp 59.5%, juice 34.25% and 10.12 TSS was recorded. On the basis of four years' visual and numeric observations, it was revealed that the Phalsa fruit was very promising for mid-western terai of Nepal. Further verification is needed for recommendation.

INTRODUCTION

Phalsa (*Grewia asiatica* L.), a sub-tropical fruit, belongs to the family tiliaceae. The genus *Grewia* has 140 species and *Grewia asiatica* is of commercial importance. It is a small bush, bears many small berry-like fruits, which ripen in May-June. Ripe fruits are mild acidic with good source of vitamin A and C, fair source of phosphorous and iron and contains 50-60% juice (Aykroyd 1963). Phalsa is commercially raised by seeds extracted from fresh ripe fruits. Generally, the bushes are planted two meter apart. The most important operation in the cultivation of phalsa is pruning. Plants begin to shed their leaves slowly after the middle of winter. They should be pruned at this stage and annual pruning is necessary. The 0.9-1.0 meter height for pruning is desirable (Hayes 1957). The yield per bush ranges from 5 to 10 kg. The bark-eating caterpillar and the mealy bug are the major pests and leaf spot disease caused by the fungus *Cercospora grewiae* is also found.

Phalsa does have specific soil requirement, thus can be grown on a wide range of soils, even on moderately alkaline soils, and fields where other fruit crops are unsuccessful. The Regional Agriculture Research Station, Khajura is situated in mid western terai of Nepal. Geographically, it lies as 81°37' longitude and 20°06' north latitude at an elevation of 181 meters above sea level. The annual rain fall is 1495 mm, temperature ranges from 5°C to 46°C, relative humidity ranges from 27 to 94%, rain starts 15 days late and stop 15 days earlier compared with other parts of the country. So this region's weather is almost dry and hot. According to the literature review this type of climate is suitable for phalsa fruit. Therefore germplasm was introduced at Nepalgunj from India for performance study.

MATERIALS AND METHODS

An experiment on performance of phalsa was carried out at Regional Agriculture Research Station Khajura, Nepalgunj from fiscal year 2062/63 to 2065/66. Ripe fruits of Faizabad Local variety were collected from Narendara Dev University of Agriculture and Technology Kumargunj, Faizabad UP, India. Seeds were extracted immediately, cleaned and sown in nursery bed in July. Seeds require 15-20 days for germination and seedlings get ready for planting in the field by 10-12 months. Seedlings were transplanted in July 2063/64. Twenty pits of 0.5 x 0.5 x 0.5 m deep and 2.0 m distance were dug one month before planting and filled 15 days earlier. Fertilizers were applied @ 15 kg compost, 150 g di-ammonium phosphate, 100 g urea and 100 g muriate of potash per pit. This dose was applied annually after pruning. Plants were pruned annually during December-January, when they were dormant. Yield and yield attributing characters were recorded only from the second year 2065/2066. Eight plants were selected for data collection.

RESULTS AND DISCUSSION

Flowering

Flowering of phalsa started from February-March and continued till May. Flowers were borne in the axel of leaves. In each axel there were 3-7 peduncles, and each peduncle has 3-6 flowers of yellow colour. The flowers were mostly cross-pollinated.

Plant height

In the fourth year plants were pruned up to the height of 1 m during winter season. At the time of full bloom stage during May-June, plant height (mean) reached 2.41 m.

Leaf surface colour

The colour of the leaves of upper side was waxy green, whereas lower surface of leaves were greenish white.

Fruit colour

Phalsa fruits berry was ready to harvest during June-July. The mature fruits colour was whitish green before ripening and ripe fruits were dark red.

Fruit weight

The phalsa plant beared very small berry-type fruits. The mean weight of berry fruit was 0.41 g.

Table 1. Yield attributing characters of Phalsa under Khajura, Nepalgunj conditions

Characters	Plant sample number								Mean
	1	2	3	4	5	6	7	8	
Lower leaf surface	GW	GW	GW	GW	GW	GW	GW	GW	-
Fruit colour	DR	DR	DR	DR	DR	DR	DR	DR	-
Plant height (m)	2.5	2.5	2.3	2.6	2.4	2.3	2.5	2.2	2.41
Fruit weight (g)	0.42	0.45	0.41	0.39	0.42	0.38	0.39	0.41	0.41
Yield (kg)/plant	2.5	2.4	2.6	2.4	2.5	2.8	2.7	3.0	2.61
Pulp (%)	60	60	59	61	60	58	60	58	59.5
Juice (%)	33	32	35	36	35	35	36	32	34.25
TSS (%)	10	10	11	10	11	10	9	10	10.12

GW - Greenish white, DR - Dark red, TSS – Total soluble solids

Yield

The three years old plants gave 2.61 kg fruits/plant.

Pulp and juice

Fruit pulp was extracted one week after storage of ripe fruits. The average pulp percent was 59.5 and the juice percent was 34.25.

Total soluble solids (TSS)

Total soluble solids (°Brix) of juice was recorded by hand refractometer. The TSS was 10.12 under Nepalgunj conditions. In brief, the weather of this mid-western terai region is almost dry and warm. On the basis of four years visual and numeric observation, phalsa fruit was found very promising in this region. However, further verification is needed for recommendation.

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Effects of Fluazinam and Other Eco-friendly Treatments against Clubroot Disease of Cauliflower

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ABSTRACT

Clubroot disease caused by a soil borne pathogen, *Plasmodiophora brassicae* has been appearing as the most devastating disease in Brassica vegetables in Nepal. The use of lime and Nebijin is only the available technologies to manage this disease. In search of new and eco-friendly treatments against this disease, an experiment was conducted in screen house with 12 different treatments including untreated as control during 2009-2010, and the effect of fluazinam was verified in naturally infested farmer's field during 2010-2011 using cauliflower hybrid, MilkyWay. Among 12 treatments, the effect of Fluazinam and copper oxychloride were significant ($P=0.05$), however, Fluazinam was most effective under both screen house and field conditions. The effect of Fosfilombrico-Star (the self defence inducer), mustard cake and Suthochu (EM5) were also significant in reducing clubroot severity as compared to untreated control in both the years. In clubroot incidence, their effects were significantly different from untreated control in first year, but in the second year they were at par. Since, clubroot severity is more important than incidence in reducing yield, these treatments could be promising candidates for integrated management of clubroot disease provided efficacy of these treatments remain stable under field conditions.

INTRODUCTION

Clubroot caused by a soil borne pathogen, *Plasmodiophora brassicae* Woronin, has appeared as a destructive disease in Brassica vegetables growing areas. Cultivation of cabbage and cauliflower has gone down significantly due to the disease and in some pockets, hundred percent yield losses were observed in cauliflower, cabbage and broad leaf mustard, especially in Kathmandu valley and Palung/Daman area of Makwanpur district. So far, the disease has been appeared in cauliflower, cabbage, broad leaf mustard, knolkhol, broccoli, radish (rare), garden cress, mustard and turnip. It is one of the most difficult plant diseases to control once the pathogen gets established in the soil. The resting spores released from the decomposition of clubs or the root tissue can remain infectious for up to 20 years even in the absence of host plant (Lancaster 2006). Resting spores of *P. brassicae* are readily transmitted on or in anything that carries contaminated soil. Repeated cultivation of crucifers in the same land leads to rapid build-up of the pathogen population in the field. Reports showed that mono-cropping of cauliflower increased the disease incidence from 9% in the first year to 50% in the following year causing 62% yield reduction (Shrestha et al 1995). The disease has been spreading in new areas mainly through the movement of seedlings grown in infested fields. Outbreaks have occurred recently in Dhading (Khanikhola) and Solukhumbu. As reported by the farmers, disease has also been spread in eastern Chitwan.

Traditional control methods of clubroot include improving drainage, raising pH of the soil, and rotating susceptible crops with non-cruciferous crops. Nebijin has been identified and recommended as an effective fungicide for the management of disease (Timila and Neupane, 2009). It is the only fungicide available in the market for clubroot disease and it is expensive. For searching effective fungicides and eco-friendly measures, experiments were conducted under screen house and field conditions using different treatments which could be candidates for integrated management of this disease.

MATERIALS AND METHODS

Seedling assay

The experiment was conducted under screen house during 2009-2010 using sterilized field soil. Cauliflower, hybrid MilkyWay was used in the experiment. Three replications, each with 12 plants were maintained. Four-week-old seedlings were transplanted in 3" pots. After the seedlings establishment, 50 ml of resting spore suspension (10^5 spores /ml) was drenched at the base of each seedling. Immediately after inoculation, given treatments were applied as per dose and the rates given in table 2. In 6-7 weeks after inoculation each and every plant was up-rooted and clubroot severity was assessed using 1-6 scale. Rationale and active ingredients (AI) of the treatment selection are given in Table 1.

Table 1. Rationale and active ingredient of the treatments

Treatments	Active ingredient (AI)	Rationale
Aminolom Calcio-boro	Calcium and boron enriched vitamin complex	Calcium- and Boron enriched Amino-vitamin complex.
Fluazinam	Fluazinam SC	Fungicide
Nebijin	Flusulfamide 0.3 DP	Fungicide
Garlic clove extract	Sulphur compound	Known botanical
Aminolom protector	Free amino acids	Self defense inducer (with free amino acids and organic nitrogen)
Fosfilombrico-Star	Potassium phosphate	Self defense inducer (with potassium phosphite)
Mustard cake	Glucosinolates	Bio fumigant
Dhanucop	Copper oxychloride 50 WP	Fungicide
Suthochu (EM5)	EM, molasses, vinegar and spirit	Ecofriendly liquid substance
SoilSheath	<i>Paecilomyces</i>	Biocontrol agent
Kwian Thong	Nutrient elements with <i>Lactobacillus</i> and <i>Bacillus subtilis</i>	Granule bio-organic fertilizer

On-farm evaluation

Fluazinam is wide spectrum fungicide developed by Ishihara Sangyo Kaisha, Ltd. The fungicide is available in different trade names. The experiment on the field verification was conducted in naturally infested field at Bhaktapur during 2010 and 2011. The plot size was 7 m². Experimental Design was randomized complete block (RCB) with three replications and each with 24 plants. Seedlings of MilkyWay variety were raised at Khumaltar to ensure disease free. The chemical fertilizer and compost (Chicken manure) were used as 200:80:60 NPK and 20 mt per hectare, respectively. Transplanting was done during last week of August. Fluazinam was applied at the rate of 100 ml per planting hole as spray/drench of 2 ml/liter of suspension concentrate formulation. Planting bed spray with the same fungicide was also done immediately after transplanting. The control plot was drenched and sprayed with water. Weeding, irrigation and other agronomical practices were given as per need. Clubroot severity and incidence were assessed during harvest by uprooting each and every plants. Yield parameters such as biomass of above ground part of the plant, marketable curd weight, were also recorded. Clubroot severity was measured using the rating scale, 1-6 (modified from Mitani et al (0-4), 2003) as given below.

- 1= no disease or club
- 2= few clubs on lateral roots only
- 3= clubs in lateral or tap root slightly clubbed
- 4= well developed clubs in lateral or tap root but with lateral roots
- 5= > 50% root converted to club with poor lateral roots, tap root clubs decayed or not
- 6= plant death/ entire clubs decayed

Data of both experiments were processed and analyzed using MSTAT-C.

RESULTS AND DISCUSSION

Seedling assay

The results presented in table 2 revealed that the eco-friendly treatments such as, Mustard cake, Suthochu (EM5) and Kwain Thong were effective in reducing clubroot severity in both the years. The self defense inducers, Fosfilombrico-Star and Aminolom protector, however, tested for only one year were also found effective in reducing disease severity. Mustard cake reduced clubroot severity by 45.08%, Suthochu by 45.7%, Kwain Thong by 45% and Fosfilombrico-Star by 60%. Fosfilombrico-Star has been reported to be effective against mildews and *Pythium* Aminolom against a number of fungi such as *Botrytis*, *Rhizoctonia*, *Sclerotinia*, *Colletotrichum* (AlfredoInesta 2006). SoilSheath (*Paecilomyces*) was also found effective against clubroot severity. *Paecilomyces liliaceus* in combination with lime was reported to be effective in reducing clubroot disease (Villanueva and Binaliw 1989) supporting present results.

The chemical fungicides Fluazinam, and Dhanucop were as effective as Nebijin in reducing both the incidence and severity of clubroot. Fluazinam was found comparatively better than Nebijin and Dhanucop, however, all three were statistically similar in their effects on clubroot severity and incidence.

Table 2. Effects of different treatments on clubroot disease of cauliflower under screen house conditions during 2009/10

Treatments	Dose/rate	Clubroot severity index (1-6)		Clubroot incidence %	
		2009	2010	2009	2010
Aminolom calcio-boro	1.5 ml/l	2.6 abc	3.53 ab	73.8 a	73.9 abc
Fluazinam	2 g/l	1.0 c	1.00 c	5.5 b	0.0 d
Nebijin	2 g/l	1.25 bc	1.22 cde	26.1 b	16.7 cd
Garlic clove extract	50 g/l	2.00 abc	2.84 bc	36.4 ab	66.7 abc
Aminolom protector	1 ml/l	2.5 abc	2.77 bc	14.7 b	64.9 abc
Fosfilombrico Star	1 ml/l	1.2 bc	-	17.9 b	-
Mustard cake	20 g/l	1.2 bc	2.83 bc	12.27 b	58.9 abc
Dhanucop	2 g/l	1.3 bc	1.76 bc	18.0 b	28.9 bcd
Suthochu (EM5)	10 ml/l	1.25 bc	2.66 bc	9.64 b	62.8 abc
Soil Sheath	5 g/l	-	2.25 bcd	-	61.3 abc
Kwain Thong	1g/kg soil	1.25 bc	2.77 bc	8.03 b	64.3 abc
Untreated control	-	3.0 a	4.33 a	75.0 a	100.0 a
CV, %		38.1	29.07	63.32	41.59
P-value		0.04	0.0004	0.017	0.0067

Means with the same letter are not significantly different at P= 0.05 by Duncan Multiple Range Test (DMRT)

On-farm verification of Fluazinam

The fungicide, Fluazinam from Ishihara Sangyo Kaisha (ISK), Ltd., Japan was found highly effective as Nebijin, both under screen house and field conditions (Table 2 and 3) in reducing clubroot severity and incidence thereby increasing biomass and the yield significantly. Under field conditions, it reduced clubroot severity and incidence by 51% and 55% respectively and increased yield by 182% over control (Table 3).

Band application of Fluazinam was found effective by Cheah et al (1998). It is one of the registered fungicides for the control of clubroot disease in Western Australia (Lancaster, 2006). Field control of clubroot using Fluazinam has been reported in Australia and other countries as seedling dip (Donald and Porter 2009). Donald et al (2009) reported that band application of Fluazinam was more effective than seedling treatment. But in the present study, application was planting hole spray, that is, spot application which was as effective as Nebijin. The result is supported by the report of Lancaster (2006) who mentioned the effectiveness of Fluazinam when targeted at the root zone during transplanting. However, the cost analysis of Fluazinam is yet to be done, but seems to be more

effective and profitable from its wide spectrum characteristics. It has been reported to be effective against late blight of potato and Phytophthora blight of pepper and other groups of fungal pathogens.

Table 3. Effect of Fluazinam on clubroot disease of cauliflower in infested field at Bhaktapur 2010/11

Treatment	Severity index (1-6)		Incidence (%)		Bio-mass kg/plot		Marketable curd weight (kg/plot)	
	2010	2011	2010	2011	2010	2011	2010	2011
Fluazinam	1.7*	1.28 ns	55.75*	14.56*	35.09	50.78*	21.89*	33.83*
Untreated control	4.45	2.25	99.66	59.43	10.34	22.26	6.59	13.16
t-value	6.8275	2.646	2.1643	7.9828	4.3731	6.999	3.6366	6.9994
P-value	0.0208	0.1181	0.0005	0.0153	0.0119	0.0198	0.0220	0.0229

*, significant at P=0.05 level of significance; ns, not significant

In brief, eco-friendly treatments, such as mustard meal, Fosfilombrico star, Suthochu and Kwain Thong could be the effective components for integrated management of clubroot disease, however, there is need of verification under field conditions. Fluazinam could be alternative chemical fungicide to Nebijin, but needs to be analyzed its cost. Efforts should be given by concerned agencies or traders to make available it in the market. Similarly, the effect of copper-oxchloride needs to be verified under field conditions, which could be organically acceptable and cost effective treatment for the management of clubroot disease.

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Efficacy of Commercially Available Safe Pesticides for the Management of Cabbage Aphids, *Brevicoryne brassicae* (L.)

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ABSTRACT

Efficacy of commercially available safe pesticides: Derusom, Agri-Servo, Margosom, Ramban (biopesticide), OSHIN; chemical pesticide: Thiodan, and locally available products: Cattle urine and Geeti-Mal (fermented cocktail mixture of botanicals with cattle urine) were tested against cabbage aphids in cauliflower crops at Khumaltar, Lalitpur in the year 2009 and 2010. The study revealed that OSHIN 20% WP @ 0.4 g/liter water was found as effective as the Thiodan 35% EC @ 1.5 ml/liter against cabbage aphid (*Brevicoryne brassicae* L.). Application of Derusom, Agri-Servo, Margosom and cattle urine was not found effective to suppress aphid population in the cole crops, however, application of Geeti-Mal, AgriServo, Ramban were found better than control (water spray). Application of Geeti-Mal caused yellow patches on the leaf surface.

INTRODUCTION

Of the various vegetable crops, cole crops such as cauliflower, cabbage, broccoli, radish, mustard are economically important in Nepal in term of market value, productivity and area coverage. The productivity and quality of vegetables are greatly depended upon the level of insect pest attack, especially cabbage aphid, *Brevicoryne brassicae* (Linnaeus), Aphididae, Homoptera. Application of hazardous chemical insecticides frequently in higher dose than recommended has been practiced these days. Such application is unsafe to human health and environment as a whole. The problem of insect resistance to insecticides, outbreak of secondary insect pests and toxic residues on edible produce has become major concerns of plant protection. Recently, the use of various locally available materials and resources, local and exotic organic products and bio-control agents are claimed to be effective against aphids but scientific data of these agents against aphid in our diversified farming system is lacking.

Mineral oil with the trade name Agri-Servo, is a water soluble mineral oil. It is reported as non-poisonous and non-toxic to human and plants, bio-degradable and environment friendly. It is said to be effective against insect pests with cell sap sucking mouth parts, such as, aphids, whitefly, mites, thrips, jassids, scales and wooly apple aphids. Similarly, there are some Nepalese farmers who claimed fermented cocktail mixture of botanicals as effective to control over several insect pests and plant diseases. The cocktail mixture is prepared by mixing chopped pieces of different plant parts and cattle urine with water, and the mixture left for fermentation for several days (1-4 weeks). The mixture is then filtered, diluted with water, and then sprayed on plant foliage. However, authentic data regarding degree of effectiveness against pests are lacking. Bio-pesticides like, MargoSom, Derusom and Ramban are commercially available in Nepalese market with different trademarks. Animal urine (mostly cattle urine) diluted with water is being used by farmers to manage various insect pest populations like aphids, mealy bugs, and leaf feeding beetles. With this background, an experiment was carried out to evaluate the efficacy of commercially available safe pesticides for the management of cabbage aphids, *Brevicoryne brassicae* of cauliflower under field conditions at Khumaltar, Lalitpur (mid hill), Nepal.

MATERIALS AND METHODS

Field experiment

Experiment was carried out during November to July, 2009/10 and 2010/11 at Khumaltar, Lalitpur. Cauliflower variety Kathmandu-local was grown as test plants. About 35 days old seedlings were transplanted during 1st week of November. The plant spacing was maintained at 45 cm plant to plant and 60 cm row to row. Sixteen seedlings were maintained in each plot of 4.8 m² area. The experiment was laid in randomized complete block design (RCBD) with 3 replications of treatments. The cultural practices like irrigation, weeding, earthing-up were followed as per requirement in normal practice. Farm yard manure (FYM) was applied @ 4 ton/ha. The chemical fertilizers were applied @ 120:120:110 kg NPK/ha. Treatment application was initiated right from an initial infestation of aphid noticed in the plants. The following treatments were included in the experiment;

1. Agri-Servo @ 10 ml per litre water
2. Cattle Urine @ 1: 4 ratio with water
3. Margosom @ 5 ml per litre water
4. Geeti-Mal @ 1:1 ratio with water
5. Ramban @ 1ml per litre water
6. Derosom @ 3 ml per litre water*
7. Aqueous extract of Chinaberry fruits*
8. Jeebatu @ 50 ml per litre water**
9. OSHIN @ 0.4 g per litre water**
10. Thiodan 35% EC @ 1.5 ml per litre water
11. Water Spray (Control)

The treatments with one asteric were used in 2009/10 only, with two asterics in 2010/11 only, and without asteric in both years.

Criteria for selecting treatment

- Ramban is a biopesticide of *Pongamia pinnata* plant origin.
- Margosom is a biopesticide of *Azadirachta indica* plant origin.
- Derosom is a biopesticide of Derris plant origin.
- OSHIN (Dinotefuran 200 g/kg) is a low toxic insecticide having 1 -3 days of waiting period after application.
- Jeebatu, a Nepalese product, is a mixture of beneficial microorganisms being sold in the Nepalese market as biopesticide.
- Agri-Servo is mineral oil being sold in Nepalese market as a safe product.
- Geeti-Mal is a cocktail mixture locally produced by fermenting locally available succulent plant twigs, stems and leaves with cattle urine.
- Cattle urine is considered to be safe to apply on crops against several insect pests in a dilution form with water.

Observations

Monitoring of insect pests was carried out throughout the crop season before and after application of treatments. During this experiment cabbage aphids remained the destructive insect pest of cauliflower. The magnitude of aphid was recorded by counting number of aphids at top, middle and bottom leaves of each and every plant, and then calculated the mean number of aphids per plant. Based on the number aphids per plant, a qualitative score 0, 1, 2, 3, 4, 5 was given to the number of aphids, such as 0 = no aphids, 1 = 1-100 aphids/plant, 2 = 101-200 aphids/plant, 3 = 201-400 aphids/plant, 4 = 401-800 aphids/plant, 5 = >800 aphids/plant. The qualitative scale for each score was produced as core 0 = None, 1 = Very low, 2 = Low, 3 = Medium, 4 = High, 5 = Very high.

RESULTS AND DISCUSSION

During the whole season, only cabbage aphid appeared to be the serious insect pest of cauliflower. The insect preferred youngest leaves and flowering parts of cauliflower, and underneath cap leaves of curds. The aphids first noticed on 2nd week of November in 2009 and the first treatment was applied on 19th of November just after monitoring the aphids. During 1st week of December, aphid population reached at higher peak in the water-sprayed control treatment as compared to other treated plants. Aphid population was very low in the plants treated with Agri-servo, cocktail mixture and chemical insecticides. Aphid population was low in the plants treated with Ramban and Derosom. Second treatment was given in 4th December, 2009 and aphid was monitored in 23rd December. The aphid population was very low in the plants treated with chemical insecticides; low in the plants treated with Agri-servo and Ramban, and medium in the plants treated with Derosom and chinaberry extract, while very high population was recorded on water-sprayed control treatment. Third treatment was given on 23 December, 2009 and aphid population was monitored on 11th January, 2010. In 11th January, 2010, aphid population was very low in the plants treated with chemical insecticide, medium in the plants treated with Agri-servo as compared to very high in the plants treated with water, chinaberry fruit extracts, Derosom, Cocktail mixture, Margosom and Cattle urine. Treatment application was repeated on 11 and 25 January but aphid population was found very high in the plants treated with all treatments except chemical insecticides. The results showed that only the use of chemical insecticide Thiodan 35% EC @ 1.5 ml per litre was effective to manage aphids while the dose and frequency of application of other treatments were not found effective to manage aphids. The detail results are presented in Table 1.

Table 1. Mean score of cabbage aphids in different treatment plots at different time interval during 2009/10, Khumaltar

Treatment	Mean score of cabbage aphids (0-5 scale)					
	19 Nov '09*	04 Dec '09	23 Dec '09	11 Jan '10	25 Jan '10	5 Feb '10
Agri-Servo	3.3	2.0	2.3	3.0	3.3	4
Cattle urine	3.0	4.0	5.0	5.0	5.0	5
Margosom	2.0	3.0	3.7	4.7	4.7	5
Geeti-Mal	2.0	1.7	4.0	4.7	4.7	5
Ramban	3.0	2.3	2.3	5.0	5.0	5
Derosom	3.0	2.3	4.0	4.0	4.7	4
Extract of chinaberry fruits	2.7	1.7	3.0	4.7	4.3	5
Thiodan	2.7	1.3	1.0	1.0	1.0	1
Control	2.3	4.3	4.7	4.7	5.0	5

*Before treatment application

The Table 2 shows the mean score of cabbage aphids produced under different treatment conditions. The treatments were applied 7 times and aphid population was monitored 8 times. The low level of aphid population was observed during first monitoring of aphids at 1st week of January, 2011 before application of treatment. After application of treatment, the aphid population was very low in the plants treated with cocktail mixture (Geeti-Mal), OSHIN 20% WP and Thiodan 35% EC as compared to other treatments.

Table 2. Mean score of cabbage aphids in different treatment plots at different time interval during 2010/11, Khumaltar

Treatment	Mean score of cabbage aphids (0-5 scale) (n=3)							
	5 Jan'11*	12 Jan'11	20 Jan '11	27 Jan '11	3 Feb '11	10 Feb'11	18 Feb'11	28 Feb '11
Agri-Servo	3.0	3.3	3.7	4.0	2.3	2.3	2.3	3
Cattle urine	3.3	3.3	3.3	3.7	4.7	4.3	3.0	4
Margosom	2.3	2.3	2.7	2.7	4.0	4.0	5.0	5
Geeti-Mal	2.0	1.7	1.7	4.7	5.0	5.0	4.0	5
Ramban	2.0	2.3	2.3	3.3	4.3	4.7	3.3	4
Jeevatu	4.3	3.7	3.7	4.0	5.0	5.0	4.0	5
OSHIN	2.7	1.3	1.0	0.7	0.7	0.3	1.0	0.3
Thiodan	3.0	0.3	0.0	0.0	0.7	0.0	0.0	0.3
Water Spray	2.7	2.3	4.3	3.7	4.7	5.0	5.0	6

*Before treatment application

OSHIN 20% WP @ 0.4 g/liter water was found very effective as chemical insecticide Thiodan 35% EC @ 1.5 ml/liter against cabbage aphid. Sole application of Derusom, Agri-servo, Margosom and Cattle urine at 10-12 days interval was not effective to suppress aphid population in the cole crops. Application of Geeti-Mal, Agri-Servo, Ramban was much better than water spray in managing aphid. Application of Geeti-Mal affected plant vigor causing yellow patches on the leaf surfaces.

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Field Loss Assessment of Potato Leaf Miner Fly (PLMF), *Liriomyza huidobrensis* (Blanchard) (Diptera:Agromyzidae)

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ABSTRACT

With the aim to evaluate actual foliage loss due to potato leaf miner fly (PLMF), *Liriomyza huidobrensis* (Blanchard), survey sites were recognized from commercial potato pockets of Lalitpur, Kathmandu, Bhaktapur, Kavrepalanchok, Sindhupalchok and Makwanpur districts of Mid-Nepal in 2009. In total, 199 farmer's fields from 27 commercial potato pockets were visited and taken damage scores. The survey revealed that potato pockets of Lalitpur were the most prone area (89.3% foliage damage) to this pest followed by Kathmandu (82.6%), Bhaktapur (70%) and Kavrepalanchok (46.5%). But damage level was comparatively lower in Sindhupalchok (12.1%) and Makwanpur (27.9%). Damage level was found more in lower altitudes (790-1568 masl) than in higher altitudes (1560-2610 masl). Similarly, lower leaves were more damaged than the upper ones. So, altitude and plant age were two factors influencing damage by test insect. Since the pest is becoming severe and can withstand chemical sprays, it would be better to develop suitable IPM technique against this pest. Similarly, strict quarantine and awareness campaign against this insect pest are crucial to check its migration to virgin potato pockets.

INTRODUCTION

Potato is second staple food crop after rice in Nepal (FAO 2008, Giri et al 2008). It is grown throughout the country and contributes to national food security (Giri et al 2008). Area under potato cultivation is about 156,737 hectares with an average estimated productivity of 13,110 kilogram per hectare and total national annual production of about 20 million tons (MOAC 2007/08). Average productivity of potato crop is less in Nepal as compared to world's productivity (15.7 mt/ha) (FAO 2008). Agricultural Perspective Plan (APP 1995) of Nepal has identified potato as the priority crop. The per capita consumption of potato in Nepal (30 kg/year) is slightly more than the world average (28 kg/year) (Hidalgo et al 1999), and the trend of consumption is in increasing trend (51 kg/year) (Giri et al 2008) almost doubled since 1990 (FAO 2008). Potato crop loss due to pests and diseases during crop stand and storage is 32% in developing countries (World Potato Congress, 2006). Though Nepal produces potato, its productivity is low as compared to other countries. One of the major constraints of low productivity is the insect pest. It has been reported that more than 40 insect species have been associated with potato crops in Nepal.

According to Berry et al (2008), the major tuber feeding pests of potato are wire worm, flea beetle larvae, white grubs, leatherjacket, western spotted cucumber beetle, variegated cutworm, red backed cutworm, garden symphylan, and the slugs. Sucking insects like green peach aphids, potato aphids, two spotted spider mite, potato leaf hopper, lygus bugs, western flower thrips, and white flies are the major sucking insects of the potato. Among the foliage feeding pests of potato, Colorado potato beetle, variegated cut worms, western yellow striped army worm, red backed cut worm, alfalfa loopers, grass hoppers, blister beetles, flea beetle adults, and slugs are major ones. Blanchard in 1926 first reported the agromyzid fly *Liriomyza huidobrensis* from Argentina and now has attained its

potentiality (Valladares et al 1999) harbouring in many field crops including potato. Among the economically important *Liriomyza* species, *L. sativae*, *L. trifolii*, and *L. huidobrensis* have the most cosmopolitan distributions (Weintraub 2001). The Agromyzid fly *Liriomyza huidobrensis* was first reported from Argentina by Blanchard in 1926 and has attained a height of maximum infestation (Salvo and Valladares 1995, Valladares et al 1996a, 1999b). Its colonization has developed rapidly in Europe and Asia since 1980s (Liping et al 2002). It can be now considered as a cosmopolitan species (Spencer 1973, Shepard et al 1998). According to Scheffer (2002) and Dumont (1988), *Liriomyza huidobrensis* is a major pest of flowers and vegetables in many parts of the world, sometimes causing complete crop loss (Spencer 1973, Shepard et al 1998). Spencer (1990) reported 14 families of host plants harboring by *Liriomyza huidobrensis*, where as Zhang et al in 1999 reported the host plants from 31 families of vegetables, flowers, and weed plants. According to Salvo and Valladares (1995), the pest diffused from central Argentina to new areas of the region. It diffused then to Americas (Sanabria de Arevalo, 1994), then to Europe (Cabello et al 1993), Hawaii (Schreiner 1993) and recently to Israel which is resistant to chemical (Weintraub and Horowitz 1995), and even it is continuing to spread to new areas of the atlas (Weintraub 2001). Leaf miner fly (*Liriomyza* spp.) is the most important harmful insect pest of vegetable crops and flowers. *Liriomyza huidobrensis* and *Liriomyza trifolii* pose a real threat to vegetable crops (Spencer 1973, Martinez, 1993). According to C.R. Olivera and D. Bordat (1996), main cause of the increasing infestation of these pests is the inappropriate use of chemical control methods.

An agriculture newsletter of Nepal (Krishi Patrika 2008) describes it is the 10 years span of time farmers of Nepal are also facing the problem of the same pest, *Liriomyza huidobrensis*. As the pest is migratory in nature and digests the insecticides easily, it is better to develop IPM technique to control the pest reaching the economic damage level and to migrate to the new areas of the country. This study considers field survey from the commercial potato growing areas to assess the foliar damage level due to leaf miner fly specially focussed to assess the foliage damage level of potato due to this insect pest in different agro-ecological zones of Mid-Nepal, and to evaluate the extent of existence in these locations.

MATERIALS AND METHODS

Site selection

Firstly, information regarding the potential potato pockets of mid-Nepal covering 6 districts was collected from the respective District Agriculture Development Offices. The districts surveyed included Kathmandu, Bhaktapur, Lalitpur, Kavrepalanchowk, Sindhupalchowk and Makwanpur. A total of 199 farmers' fields from 27 potato pocket areas from 6 districts were surveyed for scoring of foliage losses caused by leaf miner fly. The name of potato pockets under six districts are given in Table 1.

Rating field damage

From each farmer's field 10 plants were sampled randomly and pinched out the 3 leaves from each plant from bottom, middle and the top portion. While calculating percentage loss, damaged leaflets per total leaflets in a compound leaf was calculated. Average of 3 leaves and 10 plants gives the damage percentage of one farmer's field. Average of the farmers' gives locality damage and averages of locality finally provides the district damage level.

Data collection and analysis

Data regarding the altitude, latitude, longitude, crop history, pesticide use pattern, land orientation, irrigation facility, location, age of the crop and the farmers' preferred varieties were recorded. Recorded data were percent calculated to overlook average field damage district-wise and tested

statistically the factor more responsible for increasing PLMF proportion in the population. Statistics used was Unbalanced Frequency Distribution ANOVA as of Ott and Longnecker (2001). General statistical model was used to see the independent effects of land aspect, irrigation condition, land type, altitude, pesticides application frequency, farmers' preferred varieties and their interactions on the lower, middle and upper leaf damage due to PLMF.

Table 1. Number of farmers fields surveyed under different potato pockets of six districts

District	Potato pockets areas	Farmers' fields selected (Number)	Total farmers' fields (Number)
Kathmandu	Dharmasthali	5	25
	Kavresthali	5	
	Mulpani	5	
	Shankhu	5	
	Sundarijal	5	
Bhaktapur	Duwakot	10	35
	Chhap	5	
	Gundu	10	
	Kharipati	10	
Lalitpur	Khokana	5	21
	Luvu	6	
	Tikathali	5	
	Chhampi	5	
Kavrepalanchwok	Nala	10	79
	Balthali	10	
	Panouti	10	
	Baluwa	10	
	Khanalthok	10	
	Panchkhal	9	
	Patlekheth	10	
	Kuntabesi	10	
	Mudhe	10	
Sindhupalchwok	Thumpakhar	4	24
	Kharidhunga	10	
	Chitlang	5	
Makwanpur	Palung	5	15
	Aghor	5	
		5	
Total	27 (Locations)	199	199

Models used

Model for independent factors

ANOVA model of multiple regressions of land aspect, irrigation condition, land type, altitude, pesticide use frequency and variety on lower leaf, middle leaf and upper leaf damage was:

$$Y = I + K_1X_1 + K_2X_2 + K_3X_3 + K_4X_4 + K_5X_5 + K_6X_6 + M$$

where, Y denotes lower leaf or middle leaf or upper leaf damage, I=over all mean, K₁=Regression coefficient of land aspect, X₁=land aspect, K₂=regression coefficient of irrigation condition, X₂=irrigation condition, K₃=regression coefficient of land type, X₃=land type, K₄=regression coefficient of altitude (location), X₄=location (altitude), K₅=regression coefficient of application frequency of the pesticides, X₅=application frequency of the pesticides, K₆=regression coefficient of the variety, X₆=variety, and M=residuals.

Model for factor interaction

$$Y = I + K_1X_1 + K_2X_2 + K_3X_3 + K_4X_4 + K_5X_5 + K_6X_6 + K_7X_1X_2X_3X_4X_5X_6 + M$$

where, Y denotes lower or middle or upper leaf damage, $\bar{Y}$ =over all mean, K_1 =regression coefficient of land aspect, X_1 =land aspect, K_2 =regression coefficient of irrigation condition, X_2 =irrigation condition, K_3 =regression coefficient of land type, X_3 =land type, K_4 =regression coefficient of altitude (location), X_4 =location(altitude), K_5 =regression coefficient of application frequency of the pesticides, X_5 =application frequency of the pesticides, K_6 =regression coefficient of the variety, X_6 =variety, and M=residuals. Similarly, coefficient of determination was calculated for the altitude and plant age effect on the lower, middle and upper leaf damage by PLMF. This was done because there were not significant effects of other factors except these in increasing population proportion of pest.

$$Y = \bar{Y} + K_1X_1 + K_2X_2 + K_3X_1X_2 + M$$

Where, Y denotes lower leaf damage, $\bar{Y}$ =over all mean, K_1 =regression coefficient of location, K_2 =regression coefficient of plant age, K_3 =regression coefficient of interaction between location and plant age, X_1 =location (altitude), X_2 =age of the plant, and M=residuals.

Coefficient of determination was calculated by the formula again as given by Ott and Longnecker (2001)

$$(R^2) = \{(SS \text{ (Total)} - SS \text{ (Residual)}) / SS \text{ (Total)}\}, \text{ where}$$

SS (Total) denotes Some of Squares of Total row of the ANOVA, and SS (Residual) - Sum of Squares of the Residuals.

RESULTS AND DISCUSSION

PLMF damage level according to the surveyed districts

Among the surveyed six districts for the abundance of *L. huidobrensis* and to score the damage level, Lalitpur district leads all the others in terms of damage level (almost 89.3±1.57%) followed by Kathmandu (81.8±3.5%), Bhaktapur (71.1±3.54%), Kavrepalanchowk (49.1±4.8%), Makwanpur (27.9 ± 5.3%) and the least affected district Sindhupalchowk (12.1±5.3%), respectively. No districts among the surveyed found free from this insect.

The general tendency of the survey result is that the level of damage of the pest is less in case of high altitudes as compared to the low altitudinal locations (Figure 2). This average pattern of the damage due to the test insect reveals that the infestation level is maximum at the lower altitudes and the damage level is quite low at higher altitudes. This percent foliage damage according to districts (which are located at different altitude) are supported by the following ANOVA of Unbalanced Frequency Distribution table which entails that the damage is mainly influenced by altitude and plant age and their subsequent interaction.

In an average the field loss was 53.5% from all these six districts. So, the pest is becoming severe and distributing countrywide in Nepal. This study confirmed that the damage level of this pest was more in lower altitudes (806-1568 masl) than in the higher altitudes (above 1560-2600 masl). So, the infestation level was much less in the commercial potato growing areas of Sindhupalchowk and Makwanpur district. Similar finding was reported by Setiawati and Uhan (1997) who indicated that *Liriomyza* sp. spread out of 1,000 meters to 2,200 meters above sea level with different infestation levels depending on location and plant age leading into early senescence and mortality as confirmed by Chandler and Gilstrap (1987). According to Setiawati and Uhan (1997), the plants of age below 25 days also incur some degree of damage. In case of lower altitudes of surveyed locations, there was little degree of damage of *L. huidobrensis*, which was increased as the plant age was increasing.

Table 2. ANOVA of multiple regression of location, plant age and their interaction

Leaf position	Source of variance	DF	SS	MSS	VR	FPr	R ² Value
Lower	Altitude	26	201875.3	7764.4	41.83	<0.001	0.87
	Plant age	5	38005.5	7601.1	40.95	<0.001	
	Altitude x Plant age	60	48027.8	800.5	4.31	<0.001	
	Residual	224	42286.8	185.6			
	Total	355	333195.3	944.6			
Middle	Altitude	26	196619.2	7562.3	30.25	<0.001	0.84
	Plant age	5	61547	12309.4	49.23	<0.001	
	Altitude x Plant age	60	64538.1	1075.6	4.3	<0.001	
	Residual	244	61005.2	250			
	Total	355	383709.5	1145.4			
Upper	Altitude	26	78529.9	3020.4	14.28	<0.001	0.78
	Plant age	5	49424.5	9884.9	46.74	<0.001	
	Altitude x Plant age	60	55368	922.8	4.36	<0.001	
	Residual	244	51601.2	211.5			
	Total	335	234923.7	701.3			

In brief, the pest under investigation was found in all districts surveyed. It may reach new potato pockets since the farmers are not familiar with this insect and the insect itself is migratory in nature. Unique biological nature of the pest is also influential in increasing its proportion in the natural population that is except adults, all the three stages can escape the pesticides. Since the pest is migratory in nature, strict local, regional and zonal quarantine are essential to check its migration to the virgin areas. As the pest is becoming the pest of global proportion today, it would be better to search the management options against this pest with no time wastage for which governmental, nongovernmental and community approach is at most. The present results of investigation may not represent the whole country, so intensive work in this line is essential and at most to check this devastating pest to migrate to the new areas. It is necessary to assess the existence and level of damage of this pest in each potato pockets throughout the country. The damage caused by PLMF at different days after planting of potato is shown below.

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Exploration of Appropriate Combination of Plant Nutrients on Onion Seed Production in Mid Hill of Nepal

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ABSTRACT

Plant nutrient management study was conducted on onion seed production through off-season bulbs in two consecutive years 2008 and 2009 in Deurali, Palpa (mid hill) of Nepal. The aim of experiment was to identify the best combination of plant nutrients to obtain optimum seed yield. Randomized complete block design was employed with three replications consisting seven different combinations of organic and inorganic fertilizers coupled with micronutrients as treatments. The plot size was maintained at 5.04 m² with spacing of 40 cm x 30 cm accommodating 42 plants. Agri Found Dark Red variety of onion was used in the study. Observation was taken on number of harvested plants, days to bolting and flowering and seed yield. Highly significant difference was observed for year in all traits. Furthermore, differences due to treatment were highly significant but interaction effect was only significant for days to bolting and seed yield. Pooled mean across years showed that early bolting was observed in 40.17 days and early flowering observed in 77 days by application of 60 kg K₂O ha⁻¹ with FYM 20 t ha⁻¹, 60:60 kg N, P₂O₅ ha⁻¹ and delayed bolting and flowering was observed in 45 and 80.17 days respectively by application of FYM 20 t ha⁻¹. Similarly, pooled mean across the years revealed that highest seed yield of 813 kg ha⁻¹ was observed with application of 40 kg K₂O ha⁻¹, FYM 20 t ha⁻¹ and 60:60 kg N, P₂O₅ ha⁻¹ supplemented with two sprays of Multiplex. It suggested that application of combination of organic and inorganic fertilizers accompanied with micronutrient was essential for better seed yield hence could be recommended to the farmers as viable technology in the western hills.

INTRODUCTION

Onion (*Allium cepa* L.) is important vegetable and leading spice crop of *Allium* group. The area under onion cultivation is gradually increasing in the recent years. According to MoAC (2010), area, production and productivity of onion in Nepal are 18860 hectare, 246584 ton and 13t ha⁻¹, respectively. The fresh onion consumption in Nepal is 7.7 kg per person that is extremely below the standard recommendation of 18 kg per annum. It has been observed that import of dry onion bulbs in Nepal is tremendously rising among which India shares large part of it to fulfill the Nepalese demand (Gautam et al 2006). The domestic production of dry onion bulbs meets very small quantity of total national demand even during the peak production periods in the major market centers and cities. The immature bulbs and green tops used as vegetables and dry bulbs are generally consumed as spices. It has very less risk of post harvest loss during distant transportation even with rough handling. Another advantage is that onion can be stored at harvesting period and can be sold when market price is hiking thus avoids the increasing fear among the grower from the excess production (Rokaya et al 2004). The normal growing season for onion in the hills is during October-November and fresh bulbs harvested during April to May which are available in the market till end of August.

There is no existence of Nepalese onion bulbs after August due to excessive rotting, rooting and sprouting on account of aggravating humidity and temperatures at storage (Budathoki et al 2004; Gautam et al 2006). It has forced farmers to sell their produce at the time of harvesting season thus

unable to fetch reasonable price. In order to mitigate this situation, off-season onion production technology through sets was developed, however, the application of this technology in farmer's level was very limited not only due to two years production period, low yield but also due to high post harvest loss and tedious handling practices for sets (Gautam et al 2006).

Recently, off-season onion bulb production technology has been introduced using short duration cultivars requiring 12 hours photoperiod. Onion bulb production during rainy season (July-November) is being very popular among the commercial growers throughout Nepal ranging from Terai to mid hills. In this connection, seed production is possible through off-season bulbs within one year. However, onion seed is not readily available in the Nepalese market because of production in only limited quantity in few pockets. The most adapted and popular variety Agri-found dark red produced 42.95 kg/ropani seed in Deurali, Palpa (Annual Report 2008). There is not adequate information on recommended dose of plant nutrients for seed production. Therefore, this study was initiated to explore appropriate combination of plant nutrients for better seed yield.

MATERIALS AND METHODS

The plant nutrient management trial was conducted on onion seed production through off-season bulbs produced during August-December season in two consecutive years 2008 and 2009 in mid hill agro-climatic region, Deurali, Palpa. Randomized complete block design was employed with three replications with seven treatments comprising different combinations of organic and inorganic fertilizers as well as micronutrients. The FYM was applied at 20 t ha⁻¹, N and P₂O₅ was applied at 60 kg ha⁻¹ and were kept constant for all the treatments except for control. But K₂O dose was varied at 20, 40, 60 and 80 kg ha⁻¹. The micronutrient treatment was split into two, one at 45 days after and other at 70 days after planting (DAP). The plot size was maintained 5.04 m² with spacing of 40 cm x 30 cm adjusting 42 plants and popular variety Agri Found Dark Red was used in the study. Observations were recorded on days to bolting and flowering, number of harvested plants and seed yield. The statistical analysis was done by Genstat 12th edition software with General analysis of variance method.

Treatment details

- T₁. 20 kg K₂O ha⁻¹ (K₁) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₂. 40 kg K₂O ha⁻¹ (K₂) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₃. 60 kg K₂O ha⁻¹ (K₃) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₄. 80 kg K₂O ha⁻¹ (K₄) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₅. 40 kg K₂O ha⁻¹ + Multiplex once (K₂M₁) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₆. 40 kg K₂O ha⁻¹ + Multiplex twice (K₂M₂) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹
- T₇. FYM 20 t ha⁻¹ (Control)

RESULTS AND DISCUSSION

Days to bolting

The statistical analysis showed highly significant difference in days to bolting for treatment and year, however, their interaction was only significant at (p<.011) (Table 1). Earliest bolting was observed in 40.17 days after planting (DAP) from 60 kg K₂O ha⁻¹ (K₃) followed by 40.67 days from 20 kg K₂O ha⁻¹ (K₁). Ali et al (2007) reported earlier scaping at 38 days from 100 kg N ha⁻¹ and 120 kg K₂O ha⁻¹ which is extremely higher dose as was used in this study. Furthermore, they did not obtain significant variation among different potassium doses, which is consistent with the present results. It could be due to balanced combination and optimum level of N, P₂O₅, K₂O required for phenological growth.

However, delayed bolting was obtained in 45 days from FYM @ 20 t ha⁻¹ (control). Early bolting was found in 2009 which could be due to high temperature accelerated by prolonged drought conditions.

Days to flowering

The days to flowering was highly significant for year but was insignificant due to treatment and treatment by year interactions (Table 1). Earlier flowering was obtained in 77 days by application of 60 kg K₂O ha⁻¹ (K₃) followed by 78 days from 40 kg K₂O ha⁻¹. It could be because of proper dose of potassium to enhance and foster the reproductive phase. Variation in potassium levels had no significant effect in relation to flowering that was reflected clearly in Table 1. Longest time of 80.17 days was taken from control treatment which was similar to 80 kg K₂O ha⁻¹ (K₄) and 40 kg K₂O ha⁻¹ (K₂M₂) supplemented with one to two sprays of micronutrient multiplex (Table 1). Delayed flowering was observed with additional potassium level and multiplex, which might be caused by extended vegetative period.

Number of harvested plants

The result was highly significant in relation to harvested plants for year, however, treatment and treatment by year interaction was insignificant (Table 2). Maximum 38 plants were harvested from T₁ (20 kg K₂O ha⁻¹, K₁) and remaining treatments were at par with control (36.17 days) except T₅ (40 kg K₂O ha⁻¹ plus single dose Multiplex (K₂M₁)).

Seed yield

The seed yield was highly significant due to treatments, year and their interactions (Table 2). The results showed that highest seed yield of 813 kg ha⁻¹ was obtained from T₆ (40 kg K₂O ha⁻¹ + Multiplex twice (K₂M₂) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹) followed by 741 kg ha⁻¹ in T₃ (60 kg K₂O ha⁻¹ (K₃) + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹) (Table 2). Lowest seed yield of 476 kg ha⁻¹ was produced in control (FYM 20 t ha⁻¹) as reported by Ali et al (2007). However, the findings indicated that application of 40 kg K₂O ha⁻¹ supplemented with two sprays of Multiplex was found superior in terms of seed yield followed by application of 60 kg K₂O ha⁻¹ (T₃). The result obtained from this study contradicted with the findings of Ali et al (2007) where they observed increased seed yield of onion with higher doses of potash. Significantly higher grain yield with 60 K₂O kg ha⁻¹ fertilization in Okra reported by Shubhashree et al (2011) is consistent in onion seed production in this study.

Table 1. Effect of different plant nutrients on days to bolting and flowering in onion seed production

Treatments	Days to bolting			Days to flowering		
	2008	2009	Mean	2008	2009	Mean
T ₁	45.67	35.67	40.67	91	65	78
T ₂	48	36	42	92.33	65.67	79
T ₃	43.67	36.67	40.17	88.67	65.33	77
T ₄	48.67	37	42.83	92.67	66.33	79.5
T ₅	49.67	37.33	43.5	92.33	66	79.17
T ₆	50	38.33	44.17	92	67	79.5
T ₇	50	40	45	90.67	69.67	80.17
Grand mean	47.95	37.29	42.62	91.38	66.43	78.9
CV%	2.9			2.6		
	F-test	LSD _(0.05)		F-test	LSD _(0.05)	
Treatment	**	1.44		ns	2.39	
Year	**	0.77		**	1.28	
Treatment*year	*	2.04		ns	3.38	

ns, not significant; *, significant; **, highly significant

Days to bolting and flowering was observed earlier when 60 kg K₂O ha⁻¹ and FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹ were applied. However, the bolting and flowering behaviour of onion didn't exhibit distinct pattern with variation in potassium levels. Likewise, increase in seed yield was not consistent with increased potassium levels. Highest seed yield of 813 kg ha⁻¹ was obtained from the fertilizer application of 40 kg K₂O ha⁻¹ + double dose of Multiplex. It was obvious that application of micronutrients (Multiplex) is beneficial for better harvest of seed. Furthermore, the fertilizer dose of 60 kg K₂O ha⁻¹ + FYM 20 t ha⁻¹ + 60:60 kg N, P₂O₅ ha⁻¹ found most appropriate for all the agronomic traits thus should be practiced as recommended fertilizer dose in the subsequent seed production programs.

Table 2. Effect of different plant nutrients on number of harvested plants and seed yield in onion seed production

Treatments	Harvested plants			Seed yield kg ha ⁻¹		
	2008	2009	Mean	2008	2009	Mean
T ₁	34.0	42.0	38.0	522	516	519
T ₂	33.67	42.0	37.83	608	549	579
T ₃	33.67	41.33	37.5	913	569	741
T ₄	30.0	39.67	34.83	780	608	694
T ₅	29.67	38.67	34.17	767	635	701
T ₆	34.0	38.33	36.17	939	688	813
T ₇	34.0	38.33	36.17	463	489	476
Grand mean	32.7	40.05	36.38	713	579	646.0
CV%	10.4			13.8		
	F-test	LSD _(0.05)		F-test	LSD _(0.05)	
Treatment	ns	4.486		**	0.1056	
Year	**	2.4		**	0.0565	
Treatment*year	ns	6.34		*	0.15	

ns, not significant; *, significant; **, highly significant

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Effect of Plant Spacing on the Yield and Quality of Flower, Corm and Cormel of Gladiolus cv. Jester

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ABSTRACT

Gladiolus is the most important cut flower among the bulbous flower, being commercially grown in Nepal. Plant spacing is one of the most important agronomic factors that affect the vegetative growth, yield and quality of flower, corm and cormels. In order to find the optimum plant spacing of gladiolus cv. Jester for mid hills of Nepal, experiments were conducted for two consecutive years 2006 and 2007 at Agriculture Research Station, Pakhribas. There were eight plant spacing as treatment, 20x15, 20x20, 20x25, 20x30, 30x15, 30x20, 30x25 and 30x30 cm with three replications. The experiment was laid out in randomized complete block design. The results showed that earliest spike harvesting days (75.37 d in 2006 and 90.07 d in 2007) in spacing 30x30 cm. First pair of flower opening after spike emergence was found earliest (14.83) from 30x25 cm in 2006 while in 14.57 days in 2007 from 30x30 cm. Largest flower size (10.902 cm) was recorded from 30x30 cm spacing in 2006 and 10.083 cm from 20x30 cm in 2007. In 2006, greater number of florets per spike (18.83) was recorded from 20x30 cm and in 2007 it was insignificant. Similarly, longest spike (104.60 cm and 101.90 cm) was found from 30x30 cm spacing in both 2006 and 2007, respectively. In case of average weight of daughter corm 20x30 cm produced maximum in 2006 while in 2007 it was found from 30x30 cm. Same result obtained for corm size, 20x30 cm gave largest corm in 2006 and by 30x30 in 2007. Finally, higher daughter corm yield (29746 kg/ha in 2006 and 17179 kg/ha in 2007) were acquired from narrower spacing (20x15 cm). Considering all of these results, it can be concluded that spacing 30x30 cm and 20x30 cm are best for both flower quality and corm size of gladiolus cv. Jester for mid hills of Nepal.

INTRODUCTION

Gladiolus is the most popular cut flower in the world. It is the fourth important cut flower after rose, chrysanthemum and carnation in the world. In case of Nepal it is the number one cut flower. According to Devtech (1995) it is the largest grown cut flower in Nepal which occupies 70% of all cut flower sales. It's popularity and demand is increasing day by day. The total demand of gladiolus sticks per day is 3500-4500 and its production per annum is only 80000 sticks in Nepal (Gauchan et al 2009). It clearly showed that there is ample room for area expansion of gladiolus cut flower in Nepal.

Gladiolus is popular among the growers because it is easy to grow and doesn't need any protected structure. It also has dual benefit to growers, which produce spike as well as corms. Gladiolus flower comes with great variability in color, which is the major reason that consumers prefer it for cut flower. The unique nature of gladiolus is its spike which opens one by one in sequence even under room conditions. Furthermore, it is also an important cut flower for both domestic and international market. Yanai et al (2007) reported that gladiolus is the cut flower having export potential for Nepal.

Proper plant spacing is an important agronomic practice which provide space for sunlight, moisture availability and soil nutrients which are vital for successful crop production and its quality (Sanjib et al 2002). Closer spacing occupies more plants but it reduces the quality of the product, while more

spacing produce good quality but at the expense of crop numbers and profit (Ingels 2001). El-Shaikh (2010) also reported that the adjustment of plant density offers a promising mean of reducing the cost of cultivation by increasing the productivity per unit area. Growers always want to gain more profit from per unit area. In order to get both quality spike and high corm yield, suitable plant spacing is necessary. Thus, we started this project with the objective to identify the proper plant spacing to produce maximum quality flower, corm and cormels of gladiolus cv. Jester at Agriculture Research Station, Pakhribas.

MATERIALS AND METHODS

The experiments were conducted for two consecutive years 2006 and 2007 at Agriculture Research Station, Pakhribas. There were eight plant spacing 20x15, 20x20, 20x25, 20x30, 30x15, 30x20, 30x25 and 30x30 cm with three replications. The trials were laid out in randomized complete block design. The plot size was 2.7 m² and 5 kg FYM and 60:30:30 NPK gm/m² were applied. Half nitrogen incorporated as basal dose and half nitrogen as top dress one month after planting. In 2006, planting was done in March 21 while in 2007 it was completed in February 21. Observations were made on spike emergence date, flowering date, flower size, spike length, corm and cormel yield. Data were analyzed by Genstat Discovery edition 4.

RESULTS AND DISCUSSION

Flower parameters for year 2006

There were significant differences for spike emergence days, flowering days, flower size and number of florets, plant height and spike length for 2006. The table 1 showed that the earliest spike emergence was from 30x30 cm spacing followed by 20x30 cm. The delayed emergence was found from 30x15 cm spacing. The flowering day is the day of flower harvesting counted after spike emergence. The earliest flowering was recorded from spacing 30x25 cm² in 14.83 days followed by 30x15 cm and 30x30 cm. More time taken for flowering was from 20x20 cm spacing. Largest flower was found from 30x30 cm spacing followed by 20x30 (Table 1) and smallest flower was from 20x15 cm and 30x15 cm spacings. Similarly, greater number of florets were recorded from spacing 20x30 cm followed by 30x30 cm. The number of florets were at par with spacings 20x30 cm and 30x30 cm with 18.83 and 18.77, respectively. Similarly, spike length which is the major criterium for grading the gladiolus was found longest from spacing 30x30 cm (Table 1) followed by 30x25 cm.

Table 1. Flower parameters in 2006

Treatments (Spacing, cm)	Spike emergence days	Flowering days	Flower size (cm)	No. of florets	Spike length (cm)
20x15	81.70±2.44cd	16.20±0.23abc	9.817±0.53e	17.07±0.80bc	93.43±6.10e
20x20	79.42±0.16abc	17.54±1.57c	10.100±0.25cde	17.83±0.03abc	96.63±2.90de
20x25	78.50±0.76abc	15.90±0.07abc	10.500±0.15abcd	18.20±0.34ab	100.53±1.00bc
20x30	76.57±2.69ab	16.40±0.43abc	10.667±0.32ab	18.83±0.97a	101.60±2.06abc
30x15	84.47±5.21d	15.03±0.93ab	9.983±0.37de	16.80±1.06c	98.07±1.47cd
30x20	80.30±1.04bc	16.80±0.83bc	10.283±0.07bcde	17.37±0.50bc	99.07±0.47bcd
30x25	77.77±1.49abc	14.83±1.13a	10.550±0.20abc	18.03±0.17abc	102.37±2.83ab
30x30	75.37±3.89a	15.03±0.93ab	10.902±0.55a	18.77±0.90a	104.60±5.06a
CV	2.7	6.2	2.8	3.8	2.0

Flower parameters for year 2007

For the year 2007, flower size, plant height and spike length were significantly different with different plant spacings but flowering days and number of florets were insignificant. Corms planted in 30x30

cm spacing emerged the spike in 90.73 days while planted in 30x15 cm spacing emerged in 97.67 days. In same case earliest flowering was recorded from 30x30 cm followed by 30x20 cm. The largest flower was observed from the spacing 20x30 cm (Table 2). Wider spacing provided the longest spike length (101.90 cm).

Table 2. Flower parameters in 2007

Treatments (Spacing, cm)	Spike emergence (days)	Flowering (days)	Flower size (cm)	No. of florets	Spike length (cm)
20x15	95.10±1.51bcd	16.50	9.473±0.28b	17.97	91.10±5.30b
20x20	93.33±0.25abc	19.40	9.660±0.09ab	17.17	98.23±1.83a
20x25	91.10±2.49ab	16.07	9.760±0.10ab	18.63	99.03±2.63a
20x30	91.83±1.75ab	17.87	10.083±0.33a	19.57	100.80±4.40a
30x15	97.67±4.08d	15.97	9.340±0.41b	18.60	89.33±7.07b
30x20	96.17±2.58cd	14.90	9.640±0.11ab	18.37	92.73±3.67b
30x25	92.77±0.82abc	15.13	10.000±9.25a	19.20	98.10±1.70a
30x30	90.73±2.85a	14.57	10.050±0.30a	19.53	101.90±5.50a
CV	2.4	14.5	2.8	2.1	2.9

Flower and its parameters are important for gladiolus for economic point of view. There are earlier spike emergence from 30x30 cm spacing in both years. In 2006, flower size was maximum by 30x30 cm spacing while in 2007 by 20x30 cm. As compared to year 2006, there were late spike emergence in 2007. This was due to early planting in 2007 (in February) and low soil moisture. Similarly, flowering in 2006 was earliest by 30x25 cm. Zubair and Wagir found earlier spike emergence in 20x60 cm spacing, while Ahmed et al (2010) reported the earlier spike emergence in 15x30 cm spacing. According to Bijimol and Singh (2001) spacing 25x30 produced the early emergence of gladiolus flower cv. Red Beauty. There are reports of earlier emergence of gladiolus spike cv. White Prosperity (Bhat et al 2010) and cv. Single (Mane et al 2007) from wider spacing. All these reports clearly showed that there is wide variation in spike emergence days with spacing. These variation in days taken to spike emergence might be due to difference in genetic composition of different cultivars and environment.

In our results we found largest flower size by 30x30 cm in 2006 and 20x30 in 2007. Bhat et al (2010) reported the largest flower diameter by 20x20 cm spacing. Zuber and Wagir did not find any significant difference on the floret size due to different spacings. Greater number of florets per spike in 2007 from 20x30 cm was recorded. Spacing of 20x30 cm gave greater number florets per spike in 2006 in our experiment. Bijimol and Singh (2001) also reported that spacing 25x30 cm increased the number of florets per spike and early emergence of spike. Bhat et al (2010), Zuber and Wagir also found the maximum number of floret with wider spacing. Similarly, Ahmed et al (2010) found the maximum floret of Blad Jack with 15x30 cm, of Arabian Night with 30x30 cm and of Sabu with 15x30 cm spacing. Increasing floret number per spike with increasing spacing might be due to availability of more light and nutrients. According to Zuber and Wagir, wider spacing decrease the competition for nutrients and light and yield more number of florets per spike as the it depends upon the vigor and health of plants and amount of carbohydrates stored in the plants.

Ahmed et al (2010) also found that wider planting distance increase spike length of gladiolus. Longest spike length (80.3 cm) found from 20x30 cm spacing by Ahmed et al (2010). Similarly, Mane et al (2007) found the same result that wider the spacing produced longer the spike of tuberose.

Corm parameters for year 2006

All corm and cormel parameters were significantly different with plant spacings. Highest average weight of daughter corm was measured 149.60 gm from the spacing 20x30 cm followed by 30x30 cm spacing. Rest of the treatments were at par, not significantly different with each others. Maximum

average cormel weight per plant (10.83 gm) was found from 30x30 cm spacings followed by 20x30 cm (10.50 gm). Largest corm diameter (7.68 cm) was recorded from 20x30 cm and spacing 20x 30 cm, but not significantly different with 20x20 cm, 20x25 cm, and 30x30 cm. Utmost corm yield (29746 kg/ha) was observed from 20x15 cm spacing which was significantly highest as compared to rest of all spacings. Similarly, highest cormel yield (989 kg/ha) was produced from 20x15 cm spacing followed by 840 kg/ha from 30x15 cm and 789 kg/ha from 20x20 cm.

Table 3. Corm yield and its parameters for year 2006

Spacings (cm)	Average corm weight (gm)	Average cormel weight/plant (gm)	Corm diameter (cm)	Total corm yield (kg/ha)	Total cormel yield (kg/ha)
20x15	80.8±21.7c	4.29±2.61bc	6.517±0.461c	29746±9583a	989±347a
20x20	93.1±9.4b	5.03±1.87bc	7.028±0.050abc	22647±2484b	789±147abc
20x25	108.1±5.6b	7.70±0.80abc	7.403±0.425ab	22511±2348b	604±38bcd
20x30	149.6±47.1a	10.50±3.60a	7.680±0.702a	17998±2165cd	468±174bcd
30x15	86.0±16.6c	3.60±3.30c	6.463±0.515c	21442±1279b	840±198ab
30x20	87.7±14.9c	4.50±2.40c	6.870±0.108bc	19828±335bc	662±20bc
30x25	99.6±2.9c	8.73±1.83ab	6.843±0.135bc	16184±3979d	490±152cd
30x30	115.3±12.7b	10.83±3.93a	7.020±0.042abc	10948±9215e	293±349d
CV%	18.5	35.7	6.0	9.3	26.5

Corm yield and its parameters for year 2007

In 2007, the effect of spacings on average daughter corm weight, corm diameter and total corm yield and total cormel yield were found significantly different, but average cormel weight per plant was insignificant. Highest average corm weight was produced by 30x30 cm and this spacing was found superior over all other spacings. The results presented in table 4 showed that largest corm (7.27 cm) was found in 30x30 cm followed by 30x25 cm (6.995 cm), while total corm yield (1717 kg/ha) was obtained from 20x15 cm. Average weight of daughter corm and total corm yield were found lower in 2007 as compared to year 2006. This might be due to heavy rainfall in 2007 during the flowering and corm formation stage.

Table 4. Corm yield and its parameters for year 2006

Spacings (cm ²)	Average corm weight (gm)	Average cormel weight/plant (gm)	Corm diameter (cm)	Total corm yield (kg/ha)	Total cormel yield (kg/ha)
20x15	73.8±13.3c	20.7	6.257±0.486c	17179±4196a	1402±41bc
20x20	75.5±11.5bc	21.0	6.563±0.179c	13463±479abc	1438±77bc
20x25	80.2±6.8bc	24.5	6.591±0.151c	12298±686abc	1301±60bc
20x30	85.5±1.5bc	16.9	6.673±0.069c	13901±918abc	1070±291bc
30x15	83.8±3.2bc	17.5	6.737±0.006bc	15463±2479ab	2228±867a
30x20	89.0±1.9bc	23.7	6.853±0.111bc	12290±693abc	1609±247ab
30x25	95.1±8.1b	19.9	6.995±0.254ab	10394±2590bc	1119±242bc
30x30	113.5±26.4a	23.8	7.270±0.527a	8880±4103c	721±640c
Cv%	11.9	36.1	2.5	20.7	28.9

Dana and Lerner reported that spacing of bulbous plants depends upon the size and type of bulb, varying from 3 inches for small bulbs to 5-7 inches for large bulbs. Ahmed et al (2010) also found the increasing weight of gladiolus corms with increasing spacing, which is in agreement of our results. They found 30x30 cm produced maximum weight for Arabian Night and Blad Jack produced more weight with 30x30 cm and Sabu produced more weight by 20x30 cm spacings. Wider spacing produced maximum number of corms, cormels and weight of cormels (Bhat et al 2010).

Ahmed et al (2010) also reported that wider spacing 30x30 cm produced maximum size of cormels. Both years' results showed the closer spacing yielded highest corm yield (kg/ha) and it is due to more plant population in closer spacing.

The present results clearly showed that 30x30 cm spacing resulted best quality of spike and flowers. However, for the corm and cormel parameters both 30x30 cm and 20x30 cm spacings were the best. Thus, it can be concluded that plant spacing 30x30 cm can be recommended for quality flower spike and quality corm and cormels

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Public Private Partnership Model for Agricultural Research and Development in Nepal

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ABSTRACT

Among different strategies of development implementation, public private partnership (PPP) model is drawing attention of present policy makers and politicians in recent years. This concept is complicated in case of agricultural research and innovation in a country like ours where most of the farmers are small and marginal. Two cases were studied in 2010 in order to identify constraints and opportunities of PPP use in agriculture research, i) the Commercial Agriculture Development Project for the promotion of high value crops in the eastern region, and ii) trout fisheries research and promotion in Rasuwa and Nuwakot districts. Research respondents included respective research and development workers, farmers, officials from respective PPP partners. This study employed qualitative approach of analysis to gather information from key stakeholders through interview and review of reports, websites, and other publications. Constraints of PPP use were identified as lack of coordination among partners, less interest of private sectors in agricultural research, and inefficiency in attaining the objectives of social inclusion and employment generation. This paper also i) proposes a broad PPP modality of implementation of Nepalese agricultural research projects which can address the resource scarcity in public research institutions in order to attain the developmental goal of equity and efficiency; and ii) suggests appropriate policy measures accordingly.

INTRODUCTION

Wikipedia defines public-private partnership (PPP) as a contractual arrangement between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk in the project. It further defines the role of a government as the contributions in kind, notably the transfer of existing assets in the form of financial, and/or natural resources. In projects that are aimed at creating public goods like in the infrastructure sector, the government may provide a capital subsidy in the form of a one-time grant, so as to make it more attractive to the private investors. With the use of PPP approach a government manages to carry out an economic activity which cannot be done, in general, based on market mechanism of neo-liberal economics due to low return to investment or presence of high risk or lack of capacity of the government of developing countries. Recent studies has shown higher research return from investments in agricultural research and development in the country, and also the country has scarcity of required resources, the partnering between private and public sector for the growth of the economy seems a rational development strategy.

Public-private partnership model is drawing attention of present policy makers and politicians in recent years. This concept is simpler in delivery of scientific information to the recipients, however, it is equally complicated in case of agricultural research and innovation in a country like ours where most of the farmers are small and marginal. Planners and policy makers of the country are starting to rethink about the state role in conducting agricultural research. Public-private partnership has been started to take as an alternative model of development in different sectors. In this context, identifying issues for PPP modality in agricultural research and development was urgent. This analysis provides

important issues of PPP modality and its constraints and opportunities in agricultural research in the country. This study uses the concept as used by Ferroni and Castle (2011), who have used PPP as a bilateral collaboration between a government and a private sector as well as “Hybrid Value Chains” encompassing private companies, non-governmental organizations (NGO), university, and research institutes. Private companies include growers, processors, and traders in our context. Present study has identified constraints and opportunities for promoting PPP in agricultural research in Nepal. This study employed qualitative approach of analysis. Information was gathered from key stakeholders through semi-structured interview schedule and review of reports, websites, and other publications. Two cases were studied, i) a bilateral collaboration with Commercial Agricultural Alliance for (CAA) for the promotion of high value crops, and ii) “Hybrid Value Chains” for trout promotion. Thus, the research respondents included relevant research and development workers, farmers, officials from Department of Agriculture, CAA and Agriculture Enterprise Centre (AEC) of Federation of Nepalese Chamber of Commerce and Industries (FNCCI).

Existing policy framework

In order to promote PPP modality in agricultural research in the country, all the relevant laws and regulations of the government should be conducive. Policy review comes to the analysis that there is no specific PPP policy in Nepal. However, many policies in agriculture are directly related to this concept. Nepal Agricultural Policy, 2004 has spelt out promotion of participatory and competitive agricultural research and development system involving the private and the non-government sectors. Such participatory activities include agricultural production, collection, grading, storage and packaging of agricultural products. The policy also envisages development, expansion and dissemination of a market information system in partnership with the private and cooperative sectors and the local bodies. The policy further envisages providing support to the development and expansion of collection centers near potential production sites with the participation of private and cooperative sectors by sharing cost and management. The National Fertilizer Policy, 2002 supports agricultural production by ensuring supplies of quality fertilizer (production, import and distribution) in the country, one of the key features of which is to ensure and sustain the participation of the private sector in the importation and distribution of the fertilizers. Other policies like National Seeds Policy, 1999; National Tea Development Policy, 2000; National Coffee Development Policy, 2003; and Agricultural Biodiversity Policy, 2003 have recognized the role of the private sector and included several provisions to attract private sector investment in agribusiness and value chain development.

Case of Commercial Agricultural Alliance for promoting high value crops

Commercial Agricultural Alliance (CAA) is a not-for-profit sharing company established in 2006 for the implementation of commercial investment and management component of Commercial Agricultural Development Project (CADP) in high value crops through managing fund on cost sharing term. The alliance, with an elected board and a management team headed by a general manager, has branches in each of the 11 project districts headed by a branch manager. CAA has been established to manage the Commercial Agricultural Fund (CAF), and more importantly to facilitate sub-project linkages and the networking of agricultural stakeholders within the project area. The CAF finances (i) community-based market infrastructure investments, and (ii) non-infrastructure investments. Only the general members of the CAA and District Development Committees (DDCs) within the project area are eligible to receive financing. To receive CAF financing as a grant on a costs sharing basis, the proposed investment must (i) incorporate public good content, (ii) add value to agricultural products, (iii) benefit other agricultural stakeholders and the community as a whole, (iv) improve market-chain efficiency, and (v) provide a strong demonstration impact for the community.

Only the DDCs are eligible to apply for community-based market infrastructure investments. Farmer communities, through their Village Development Committee (VDC), identify needs in a participatory manner and the DDCs screens VDC requests before submitting the proposal to the CAA to ensure (i) no duplication with other development programs in the district, and (ii) adequate appraisal of the

technical and financial feasibility of the proposal. In this type of investment, the CAF finances a maximum of 75% of the investment cost, with the community providing a minimum of 10% of the investment cost in the form of labor and in-kind contributions. The DDC finances the remaining 15% of the investment cost in the form of technical services, field appraisal, and assessment. The range of community-based investments includes small collection centers, small markets, ropeways, small suspension bridges, farm-to-market road improvement including culverts and swing bridges, small-scale cool or cold storage, and small-scale marketing-related water supply. The VDCs and farmer communities assisted by the DDC district technical office are responsible for construction, management, and maintenance of the infrastructure.

The CAF provides financial assistance for non-infrastructure investments of farmer groups and cooperatives, traders, and processors, which are the general members of the CAA. For this type of investment, the CAF finances a maximum of 50% of the investment, with the remainder to be contributed by the direct beneficiaries. Among others, the investments could include (i) group promotion of improved cultivation practices for HVC and emerging crops, (ii) pest management including integrated pest management techniques, (iii) farm machinery and equipment, (iv) greenhouse equipment, (v) agro-processing equipment and machinery, (vi) laboratory equipment for product testing and quality control, and (vii) market-related research and technology development such as pickle making, fruit or vegetable drying or preservation, tomato pulp making, crop diversification into emergent HVCs, and farm-to-market packaging systems. The selected investments must have maximum demonstration impact on the community and other agriculture stakeholders. All farm level investment supports have been provided to farmer groups or cooperatives, not to individuals. Traders and processors must explicitly demonstrate how their proposed investments enhance the agriculture value chain by strengthening linkages between farmer groups and markets. Other non-infrastructure investments by CAA general members include launching promotional and representational activities such as (i) trade fairs and trade promotion, (ii) industry networking on issues requiring joint action for resolving cross-border issues and reducing local red tape, (iii) product labeling and certification arrangements, (iv) product identification, branding, and feasibility studies, (v) quality mark initiatives, (vi) brand and intellectual property right protection, and (vii) specialized skill development and employment strategy formulation. Rest of the components is implemented through farmers' group and local NGOs.

The project outcome is improved efficiency of production, marketing, and processing of HVCs such as vegetables, fruits, tea, and spices, within the project area. However, CAA could not upgrade small and marginal farmers to next ladder of value chain from primary production of fruits and vegetables. Also, the linkage and coordination between producers and processors were loose and weak. Investment in local infrastructure in the form of collection and storage centers, cool stores, access to market information and agribusiness and/or product improvement technology are being provided. Attention is also on traders and processors to improve the quality and regularity of supply of products purchased by them and to encourage their investment in the market chain through linkages to farmers, such as contract farming arrangements.

The Project has envisioned generating employment opportunities for subsistence and marginal farmers by promoting HVC production and marketing, transporting products from the field to storage and processing centers, and assisting small-scale community-based market infrastructure development. The assumption was that CAA fund addresses and reinforces social inclusion and assists subsistent stakeholders to raise their commercial status through developing community-based market infrastructure and implementing the whole range of CAA activities that promote backward and forward linkages. However, it was observed that:

- Processing capacity of the processors has been increased with new installments.
- Farmers are organized in groups and cooperatives (institution building).

- CAA supports to production, processing and marketing are not linked to value chain development, are rather isolated and independent. CAA lacks the mechanism where the financial support to processing promotes linkage among the value chain stakeholders. In the absence of contract law, violation of agreement between producer and processor has been common.
- The inclusion aspect was not attained. Landless people was not linked to skill-based training in areas such as packaging (weaving of baskets for transport of agricultural products), primary processing (product washing and drying), tool making, and servicing (repair of small equipment) as envisioned.

Case of One Village One Product (OVOP) Program of Rainbow Trout

First of all in 1979, "One Village One Product" (OVOP) program was initiated by Mr. Morihiko Hiramatsu – the then Governor of Oita prefecture, Japan. Inspired by successful story of OVOP program in Japan, Thailand and other countries, the OVOP program introduced in Nepal is totally based on the concept of PPP. The Federation of Nepalese Chambers of Commerce and Industry (FNCCI) had worked out a great deal of homework to introduce OVOP program in Nepal. Finally, FNCCI/Nepal has been successful in introducing OVOP in Nepal in partnership with Ministry of Agriculture and Cooperatives, the Government of Nepal. The Finance Minister of the Government of Nepal through his budget speech amidst House of Representatives has announced the launching of OVOP program in Nepal with effect from the very beginning of the fiscal year 2063/64 (Economic Survey, 2006/07).

The overall objective of this program in Nepal is to alleviate poverty in local community and develop their entrepreneurship and other specific objectives are: to develop local product and to add value in the product as per market demand through involvement of local people and their skills; to develop competitive product system identifying the export potential product through specialized product oriented process; to alleviate the local community poverty and to help enhancing economic development; to develop and to promote the branding of the product implementation aspects (FNCCI/AEC website). The overall program has been implemented under a special OVOP working procedure called as "Ek Gaon Ek Utpadan (One Village One Product) Karyakram Karyanoyen Karyabidhi, 2063" that was prepared jointly by the Ministry of Agriculture and Cooperatives and Agro Enterprise Centre (AEC) of FNCCI and then amended in the year 2065. A high level agribusiness promotion committee headed by Minister, MOAC with the secretaries from various ministries including the president of FNCCI/Nepal as member in the policy level committee guides the OVOP committees. There are two central level committees. One is the Implementing Committee that comprises of 20 members from different ministries and other related institutions. The coordinator of the committee is the president of FNCCI followed by two Vice-Coordinators. One is Joint secretary from Agribusiness Promotion and Statistics Division of Ministry of Agriculture and Cooperatives and another one is the Chairman of Agro Enterprise Centre/FNCCI.

As defined in the working procedure, Agro Enterprise Centre has been authorized to work as a Secretariat of OVOP program in Nepal where the Executive Director works as Member Secretary of the Implementing Committee. Another Committee in the central level formed is "Basket Fund" sub-committee. This committee comprises 5 members headed by Joint Secretary of Agri-Business Promotion and Statistics Division of Ministry of Agriculture and Cooperatives as a coordinator. Besides central level committees, there is a provision of district level committee. The number of committees varies as per number of district included in the program. At present, Bhaktapur, Lalitpur, Ramechhap, Sindhuli, Nuwakot, Rasuwa, Bardiya and Kaski are the districts where OVOP is being implemented. This committee would have maximum five members, where the coordinator is the Chairman of district chamber of commerce and industries and the vice coordinator is the District Agriculture Development Officer. Local Development Officer or his representative represent as a core member. This program has been launched as a pilot project. The products selected are: Junar (Sweet Orange) in Sindhuli and Ramechhap, Lapsi (Hog plum) in Bhaktapur, Rainbow Trout Fish in

Nuwakot and Rasuwa, Bael in Siraha, Bardiya and Banke, Orchid in Lalitpur and Agro-Tourism in Lekhnath of Kaski.

This paper describes here this approach with respect to promotion of rainbow trout fish in Nuwakot and Rasuwa districts of Nepal. Rainbow trout fish program has been launched in Nuwakot district from the very beginning of the launching of OVOP program in Nepal. Interventions were in construction of raceway, fingerlings production, technology development and market promotion, among the main activities. The program has helped private sector trout farmers to produce fingerlings in their own raceways. Technical support has been provided to farmers by both the Fisheries Development Directorate and the Fishery Research Division (NARC). District Agricultural Office and the Nuwakot Chamber of Commerce and Industry have been providing all other administrative support to the program under direct supervision of Ministry of Agriculture and Cooperatives and the OVOP Secretariat, AEC/FNCCI.

In Rasuwa, the program was launched in 2064/65. Likewise in Nuwakot, the district program implementing committee has been formed headed by the Chairman of Rasuwa Chamber of Commerce and Industry as a coordinator. The program has been supported by the District Agricultural Development Office, Local Development Office, Fishery Research Station, Chamber of Commerce and Industry in local level and the Ministry of Agriculture and Cooperatives and the line agencies like Department of Agriculture, Fisheries Development Directorate and the Fishery Research Division (NARC) in central level along with OVOP Secretariat – AEC/FNCCI.

Fisheries Research component of NARC has developed technologies on breeding, hatchery management and feed formulation for rainbow trout. Under OVOP program these technologies are being disseminated to trout farmers of Nuwakot and Rasuwa districts. As a result, some of the farmers of these districts have started producing trout feed and fingerlings for their own use as well for supplying to nearby areas. Gurung (2008a) has identified constraints associated with production of trout feed were variation in the quality of raw materials, inadequate knowledge among farmers on feed formulation and quality maintenance, lack of laboratory facility for quality testing of trout feed, storage problem and quality losses during storage, lack of extrusion technology, lack of qualified manpower in private sector, high price for protein supplementation, insufficient infrastructure to fulfill ever growing demand of trout feed and finally, weak feed supply system. After a decade of continuous efforts on research, a complete technology package of breeding, fry nursing, rearing and grow-out of rainbow trout with feed production technology has been developed by NARC. However, the existing fisheries extension activity is not enough to promote “One Village One Product” slogan in Rasuwa and Nuwakot District due to i) the lack of subject matter specialists (SMS) and junior technicians (cold water), ii) employment of participatory extension involving NGOs/INGOs/CBOs and other relevant stakeholders and lack of programme level integration with micro/macro hydro-projects (Gurung 2008b).

Constraints for using PPP model in agricultural research and development

With the lessons learned so far, constraints and opportunities for PPP in Nepal's agricultural research are as follows:

- Lack of coordination and definition of roles and responsibilities among the partners are not still clear.
- Stakeholders limited capacity in updated technical knowledge.
- Public sector organization are not supportive rather critical of private sector.
- Nepal agriculture policy 2004, agribusiness policy 2006, industrial policy 2009 and trade policy 2010 are providing basis for PPP model of development, but still lacks the umbrella policy framework.
- There are unexplored potentialities in agricultural research in the country and proper patenting of research findings triggers private sector investment in agricultural research in the country.

- Lack of clear articulation of the NARC position with regard to the PPP. NARC at the policy level is supportive of the PPP, but it lacks proper arrangement at the local level to attract private sector.
- Interest of the private sector was profit maximization, whereas the interest of public sectors was poverty reduction by the project.

SUGGESTIONS

- Framing proper patent right laws in accordance with World Intellectual Property Rights Organization will open venues for PPP in agricultural research in the country benefiting PPP partners for the public good characteristics of research output and the problem of free riders. In such case subsidy to private sectors is necessary to offset the sector loss by free riders of the technology developed by private entity.
- Contract law should be framed to avoid non-compliance of the role of producer, processor and traders. Lack of the law has been a hindrance to PPP (personal communication, Pradeep Maharjan of FNCCI/AEC, 2011).
- Farming umbrella policy to promote PPP in agricultural research in the country is necessary.
- Patenting facilities for technology developers with a careful regulatory measures so as to value social goals which the neo-liberal economics may undervalue; and to prevent monopoly of patent right, a proper regulatory measures and environmental regulations should be in place at the same time (Fuglie et al 200).
- PPP should involve entire value chain, and before taking decisions about entering into partnerships there should be well-defined modalities for royalty sharing (APCoAB 2007).
- The public sector scientists and other researchers should be provided adequate incentives to drive the partnership towards achieving the desired goals.
- A Senior Level Working Group comprising NARC/DOA/DLS/FNCCI/universities/ INGO/NGO should be formed to regularly review the technological developments in the public sector and identify the appropriate ones suitable for commercialization with PPP.
- Possible areas of collaboration at present can be identified as seed production, agricultural extension, fertilizer production, and agricultural research with IPR, quality testing and certification facility, adoption of agricultural technologies, marketing and export promotion.

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Response of Different Manure and Fertilizer Combinations on Nutrient Status of Soil and Fresh Pod Yield of Cowpea under Acidic Soil Conditions

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ABSTRACT

A four-year study was conducted at Malepatan, Kaski on different combinations of manure and fertilizers to improve the productivity of acidic soil. Nine treatments with three replications were given in the soil and cowpea was grown. Soil analysis was done each year (2064-2067) to know the status of soil pH, organic matter, nitrogen, phosphorus and potassium content in the soil. The data on fresh pod yield of cowpea was collected and analyzed. The mean value on soil pH observed the highest (5.19) when FYM applied alone @ 10 t ha⁻¹. The percent organic matter and nitrogen content of the soil observed the highest (3.56 and 0.177, respectively) due to the application of FYM @ 5 t ha⁻¹ + N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively. The available phosphorus content of the soil observed the highest (68.42 kg ha⁻¹) when poultry manure applied alone @ 2 t ha⁻¹ and followed (64.0 kg ha⁻¹) by the application of N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively + poultry manure @ 1 t ha⁻¹. The amount of potassium content of the soil observed the highest (130.58 t ha⁻¹) due to application of N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively. The fresh pod yield of cowpea was the highest (5197.6 kg ha⁻¹) due to the application of poultry manure @ 1 t ha⁻¹ + N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹, respectively. This study revealed that the application of higher dose of FYM helps to improve the soil pH. The application of higher dose of chemical fertilizer in addition to FYM helps to increase the percent organic matter and nitrogen content in the soil. The phosphorus status and fresh pod yield of cowpea can be improved through the use of poultry manure in combination with chemical fertilizer.

INTRODUCTION

The continuous soil mining through the use of high yielding varieties, intensive multiple cropping systems and inadequate and imbalance fertilization further contributes to decline of soil fertility and crop productivity (Panday et al 1995). As in cereal crops, soil acidity is a serious problem for horticultural crops also as the soil have low pH, low base saturation and high exchangeable H and Al, where rainfall is high (Palaniappan and Varalakshmi 1999). The desertification as physical, chemical and biological degradation of soil is serious problem of today's agriculture in the absence of proper soil ameliorative practices to counter the effect of soil degrading process (Kanwar 2002).

The optimum soil pH range for the majority of agricultural crops is 5.5 to 6.5 (Schreier et al 1995) and soil consisting pH value 5.5 or less is considered as problematic acid soil (Tripathi 2058). About 49 per cent of the total geographical area of Nepal consist acidic soil. The application of lime and manure is one possible solution to avoid further increase in soil acidity (Schreier et al 1995). It is very important to focus the research on ameliorative management of acid soils to encourage the farmers and agro-based industries for sustainable agricultural production. For sustaining agricultural production, research programs should also focus on long term effects of different systems of farming including crops, soil fertility, manurial and other aspects of agricultural practices (Mohsin et al 1995). There is a lack of enough study on management of problematic acid soils at crop growing areas of Nepal.

Keeping these points in view, this study was conducted since 2064 with the objectives of identifying suitable combination of manure and fertilizer to increase the productivity of acidic soil and evaluating the fertility status of the acidic soil after different treatments.

Site characterization

- Site: ARS (Hort.), Malepatan, Kaski
- Latitude: 28° 13' 6.18" North
- Longitude: 83° 58' 27.71" East
- Altitude: 848 M masl
- Slope: 3-5 % (Nearly plain)
- Aspect: South-West
- Climate : Sub-tropical

The meteorological records averaged for 15 years (1991-2005) indicated that mean maximum temperature ranged from 19.2°C to 30.5°C. Similarly, mean minimum temperature range is 6.6°C to 22.1°C. May, June, July and August (30.1°C to 30.5°C) are the hotter months, whereas the December and January (6.6°C to 7.8°C) are the cooler months in a year. The annual total precipitation (averaged for 15 years) is 4112 mm at the site. About 80% of the total rainfall appears during the four months (June to September) and the highest in July (1015 mm). The Station also receives hailstone damages during February to May and sometimes in September to October (Annual report, 2063/64).

MATERIALS AND METHODS

About 400 m² of land consisting acidic soil was selected within the ARS (Horticulture) Research Station during 2064. The different sources of plant nutrients were selected during the preparation of treatments. The lower dose of chemical fertilizer constituted N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹, respectively and higher dose constituted N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, based on recommended dose of fertilizer for leguminous crops. The single dose of FYM was taken @ 5.0 t ha⁻¹ and double dose as 10.0 t ha⁻¹. Similarly, the single dose of poultry manure taken @ 1.0 t ha⁻¹ whereas, that of double dose given as 2.0 t ha⁻¹. Therefore, lower and higher dose of chemical fertilizer, single and double doses of FYM and poultry manure were selected during the preparation of treatment combinations. Altogether nine treatments were given in the soil to identify the better treatment combination that helps to correct the soil acidity and enhance the crop productivity. The experimental plots was laid out by following random complete block design and replicated three times and cowpea (Malepatan-1) was selected as indicator crop. The size of individual treatment plot was 9 m² (3 m x 3 m). Altogether, there were 27 individual plots. About half kg of soil sample was taken from each plot before the start of the experiment and after the harvest of cowpea in each year (2064 to 2067). In total, 27 soil samples were taken in each year and analyzed them for soil pH, percent organic matter, percent nitrogen, available phosphorus and available potassium content in the soil at "Regional Soil Testing Laboratory", Pokhara by following standard procedures.

Two to three seeds of the cowpea planted in a hill and there were 10 plant hills per row. The plant to plant distance was 30 cm and row to row distance was maintained 60 cm. There were five rows in a plot and 50 plant hills of cowpea maintained in each plot. The data on fresh pod yield of cowpea was collected during each harvest in each year. The data relating to soil and fresh pod yield of cowpea were collected for four years (2064, 2065, 2066 and 2067). The data were analyzed with the help of STATISTIX and MSTAT-C, statistical computer software.

Treatments

- T₁: Control (without any manure and fertilizer)
- T₂: Poultry manure @ 2.0 t ha⁻¹ (double dose)
- T₃: Farm yard manure @ 10.0 t ha⁻¹ (double dose)
- T₄: N:P₂O₅:K₂O @40:20:40 kg ha⁻¹, respectively (lower dose)

- T₅: T₄ + Poultry manure @ 1.0 t ha⁻¹ (single dose)
 T₆: T₄ + FYM @ 5.0 t ha⁻¹ (single dose)
 T₇: N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹, respectively (higher dose)
 T₈: T₇ + Poultry manure @ 1.0 t ha⁻¹
 T₉: T₇ + FYM @ 5.0 t ha⁻¹

The OM used during the preparation of treatment combinations were analyzed in the soil laboratory (Soil Science Division, Khumaltar) for their nutrient content and given in table 1.

Table 1. Nutrient content in the soil

Source of organic manure	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Farm yard manure	1.51	0.85	2.0
Poultry manure	2.06	0.78	1.0

Source: Joshi (2064)

RESULTS AND DISCUSSION

The mean pH value for the four years varied from 4.75 to 5.19, which is strong acidic in reaction (rating) and presented in table 2. The mean pH value observed the maximum (5.19) due to application of double dose of FYM only (@ 10.0 t ha⁻¹) and followed (5.05) by the application of lower dose of chemical fertilizer in combination with single dose of FYM (N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹ and 5 t ha⁻¹, respectively).

Table 2. Response of different manure and fertilizer combinations with time on pH status of the experimental site

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure/fertilizer)	4.50	4.20	5.33	6.00	5.00 ^{ab}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	4.27	4.27	5.33	5.67	4.93 ^{ab}
T ₃	FYM (@ 10 t ha ⁻¹)	4.60	4.33	5.50	6.33	5.19 ^{a.1}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	4.30	4.33	5.20	5.97	4.95 ^{ab}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	4.47	4.50	5.43	5.43	4.96 ^{ab}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	4.57	4.23	5.37	6.03	5.05 ^{ab.2}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	4.37	4.07	5.07	5.53	4.75 ^{b.L}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	4.43	3.97	5.30	5.33	4.75^{b.L}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	4.20	4.10	5.50	5.80	4.90 ^{ab}
Mean		4.41 ^c	4.22 ^{c.L}	5.36 ^{b.2}	5.79 ^{a.1}	GM=4.94
		LSD (0.05)	F-test	C.V. (%)		
Year (A)		0.234	**	16.13		
Replication (B)		0.203	**			
Treatment (C)		0.352	ns			
A*B*C		-				
S. E.		0.177				

*, significant; **, highly significant; ns, not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

The minimum value (4.75) of soil pH was observed due to higher dose of chemical fertilizer and/or in combination with single dose of poultry manure (N:P₂O₅:K₂O @ 60:40:60 kg ha⁻¹ and 1.0 t ha⁻¹, respectively). The overall pH scale seemed increasing due to different treatment imposed. However, the effect of treatment observed to be insignificant. In the year-wise comparison, the mean pH value observed the maximum (5.79) in 2067 and followed (5.36) by 2066. The lowest value on mean soil pH (4.22) was observed in 2065. The difference of means observed highly significant with time. The range of increment increase in soil pH varied from 0.38 to 0.59 units due to treatment and up to 1.57

units with time (year). The reaction of the soil of the experimental site changed from very strongly acidic to strong acidic in reaction before and after the experiment in that acidic soil.

These results indicated that application of different combination of manures and fertilizer showed positive response to increase the pH of the acidic soil. The mean values on percent organic matter content of the soil of the experimental site varied from 2.83% to 3.56% and are presented in table 3. This range of percent organic matter falls under medium in rating. The mean value on percent organic matter content of the soil observed the highest (3.56%) due to application of higher dose of chemical fertilizer in addition to single dose of farm yard manure and followed (3.42%) by control (without any manure and fertilizer application).

The percent organic matter content of the soil was the lowest (2.83%) due to application of poultry manure alone (@ 2.0 t ha⁻¹). However, the effect of treatment observed to be insignificant. The increment change in percent organic matter content of the soil found inconsistent. In the year-wise comparison of means, the highest amount of percent organic matter content (3.56%) was in the year 2067 and followed (3.09%) in the year 2065. The difference of means with time observed to be significant. The increment increase in percent organic matter with time is found to be 0.52%. The trend of percent organic matter content of the soil with time is increasing.

Table 3. The status of percent organic matter content in the soil of the experimental site due to different manure and fertilizer combinations with time

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure / fertilizer)	3.70	3.03	3.17	3.80	3.42 ^{ab.2}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	2.19	3.10	2.70	3.33	2.83 ^{c.L}
T ₃	FYM (@ 10 t ha ⁻¹)	3.53	3.17	2.90	3.50	3.27 ^{abc}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	1.99	3.10	2.93	3.33	2.84 ^c
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	2.26	3.17	3.10	3.30	2.96 ^{bc}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	2.71	3.33	3.13	3.57	3.19 ^{abc}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	3.86	2.87	2.90	3.63	3.31 ^{abc}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	2.84	3.17	3.17	3.80	3.24 ^{abc}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	4.26	2.87	3.33	3.73	3.56 ^{a.1}
Mean		3.04 ^{b.L}	3.09 ^{b.2}	3.04 ^{b.L}	3.56 ^{a.1}	GM=3.18
LSD (0.05)		F-test		C.V. (%)		
Year (A)		0.368	*	22.54		
Replication (B)		0.319	ns			
Treatment (C)		0.552	ns			
A*B*C		-				
S.E.		0.278				

*, significant, ns: not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

These results indicated that percent organic matter content of the soil can be increased through the adoption of higher dose of fertilizer with combination of organic manure. The four-year mean values on percent nitrogen content of the soil are presented in table 4. These values varied from 0.141% to 0.177% and medium in rating. The maximum amount of percent nitrogen content (0.177%) of the soil was observed due to application of higher dose of chemical fertilizer in addition to single dose farm yard manure and followed (0.173%) due to control (without any manure and fertilizer application). The minimum amount of percent nitrogen content (0.141%) observed due to application of poultry manure (@ 2.0 t ha⁻¹). However, the differences of means due to treatment observed to be insignificant.

The distribution of mean values on percent nitrogen content of the soil observed inconsistent and the trend is similar to percent organic matter content of the soil. In the year-wise comparison of means, the maximum amount of percent nitrogen content (0.177%) observed in the year 2067 and followed (0.154%) in the year 2065. But the value was lowest (0.152%) in the year 2066. The increment increase in percent nitrogen content of the soil over time is 0.024%. The difference of means with time observed to be significant.

These results indicated that the overall trend of percent nitrogen content of the soil over time is increasing due to addition of more amounts of farm yard manure as compared to first soil data (2064).

Table 4. Status of percent nitrogen content in the soil of the experimental site with time due to different combinations of manures and fertilizer

Treatment	Year				Mean ^K
	2064	2065	2066	2067	
T ₁ Control (w/o manure/fertilizer)	0.187	0.153	0.160	0.190	0.173 ^{ab,2}
T ₂ Poultry manure (@ 2 t ha ⁻¹)	0.107	0.153	0.137	0.167	0.141 ^{c,L}
T ₃ FYM (@ 10 t ha ⁻¹)	0.177	0.157	0.147	0.177	0.164 ^{abc}
T ₄ N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	0.100	0.157	0.143	0.167	0.142 ^c
T ₅ T ₄ + Poultry manure (@ 1 t ha ⁻¹)	0.113	0.157	0.153	0.167	0.147 ^{bc}
T ₆ T ₄ + FYM (@ 5 t ha ⁻¹)	0.137	0.170	0.157	0.177	0.160 ^{abc}
T ₇ N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	0.197	0.143	0.147	0.180	0.167 ^{abc}
T ₈ T ₇ + Poultry manure (@ 1 t ha ⁻¹)	0.143	0.157	0.157	0.190	0.162 ^{abc}
T ₉ T ₇ + FYM (@ 5 t ha ⁻¹)	0.213	0.143	0.167	0.183	0.177 ^{a,1}
Mean	0.153 ^b	0.154 ^{b,2}	0.152 ^b	0.177 ^{a,1}	GM=0.159
	LSD(0.05 F-test C.V. (%))				
Year (A)	0.018	*	22.61		
Replication (B)	0.016	ns			
Treatment (C)	0.0277	ns			
A*B*C	-				
S.E.	0.014				

*, significant; ns, not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

The four-year mean values on available phosphorus varied from 33.92 kg ha⁻¹ to 68.42 kg ha⁻¹ and presented in table 5. This range of availability of available phosphorus varied from medium to high in its rating. The mean value observed the highest (68.42 kg ha⁻¹) due to the application of double dose of poultry manure (@ 2.0 t ha⁻¹) and followed (64.50 kg ha⁻¹) by the application of higher dose of chemical fertilizer in combination with single dose of poultry manure. The minimum amount of available phosphorus (33.92 kg ha⁻¹) was observed due to application of lower dose of chemical fertilizer with combination of single dose of FYM. The effect due to treatment observed to be highly significant. In acidic soil, phosphate binds with Fe and Al and it forms iron and aluminum phosphate, which is unavailable to plant.

In the year-wise comparison of means, the maximum amount of available phosphorus (72.96 kg ha⁻¹) observed in the beginning (2064) and followed (60.70 kg ha⁻¹) in the year 2065. The difference of means with time observed to be highly significant. These results indicated that the application of poultry manure either double or single (@ 2.0 t ha⁻¹ or 1.0 t ha⁻¹) is efficient in combination with chemical fertilizer to increase the availability of available phosphorus. The overall trend of availability of phosphorus is decreasing with time.

Table 5. Status of available phosphorus content (kg ha⁻¹) in the soil of the experimental site with time due to different combinations of manures and fertilizer

Treatment		Year				Mean ^K
		2064	2065	2066	2067	
T ₁	Control (w/o manure/fertilizer)	80.30	60.67	12.33	26.67	45.00 ^{bcd}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	104.33	79.67	11.00	78.67	68.42 ^{a.1}
T ₃	FYM (@ 10 t ha ⁻¹)	53.00	51.33	4.00	38.33	36.67 ^{bcd}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	66.67	35.67	11.00	65.33	44.67 ^{bcd}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	64.00	54.33	3.67	56.00	44.50 ^{bcd}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	42.67	51.33	4.67	37.00	33.92 ^{bcd.L}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	64.00	57.67	7.33	38.67	41.92 ^{bcd}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	77.33	89.00	21.67	70.00	64.50 ^{ab.2}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	104.33	66.67	5.33	62.00	59.58 ^{abc}
Mean		72.96 ^{a.1}	60.70 ^{ab.2}	9.00 ^L	52.52 ^b	GM=48.79
		LSD(0.05)	F-test	C.V. (%)		
Year (A)		13.43	**	73.24		
Replication (B)		11.63	ns			
Treatment (C)		20.15	**			
A*B*C		-				
S. E.		10.15				

**, highly significant; ns, not significant; P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

The data relating to mean values on available potassium varied from 86.67 kg ha⁻¹ to 130.58 kg ha⁻¹ and presented in table 6. The observed range of available potassium falls under low to medium in its rating. The highest amount of available potassium (130.58 kg ha⁻¹) was observed due to application of higher dose of chemical fertilizer and followed (129.25 kg ha⁻¹) by the combined application of higher dose of chemical fertilizer and single dose of FYM.

The lowest amount of available potassium content of the soil (86.67 kg h⁻¹) was observed in controlled plot (i.e., without application of lime, fertilizer and manure). The difference of means due to treatment observed to be significant. The year-wise comparison of means showed that the maximum amount of available potassium (242.41 kg ha⁻¹) was observed in the year 2064 and followed (1186.15 kg ha⁻¹) in 2067. The lowest amount of available potassium (17.30 kg ha⁻¹) was observed in 2066. The difference of means with time was highly significant.

These results indicated that the availability of available potassium can be increased with the application of higher dose of chemical fertilizer.

The data relating to mean values on fresh pod yield of cowpea for the four years is presented in table 7. Mean values varied from 3032.90 kg ha⁻¹ to 5197.60 kg ha⁻¹. The highest pod yield (5197.60 kg ha⁻¹) of the cowpea was observed due to application of lower dose of chemical fertilizer with combination of single dose of poultry manure (N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹ and 1.0 t ha⁻¹, respectively). The yield was followed (4925.90 kg ha⁻¹) by double dose of poultry manure (@ 2.0 t ha⁻¹). The lowest pod yield (3032.90 kg ha⁻¹) of the cowpea was observed due to control treatment (without application of any manure and fertilizer). All the mean values on fresh pod yield of cowpea due to treatment observed the higher than that of controlled treatment.

The effect due to treatment observed highly significant. In the year-wise comparison of means, the maximum pod yield (6976.30 kg ha⁻¹) observed in the year 2064 and followed (4820.30 kg ha⁻¹) in 2065. The lowest yield (2322.76 kg ha⁻¹) observed in 2066. The difference of means with time

observed to be highly significant. However, the trend of the fresh pod yield of cowpea is decreasing with time.

Table 6. Response of different manure and fertilizer combinations on status of available potassium (kg ha⁻¹) with time in the soil of the experimental site

		Year				
Treatment		2064	2065	2066	2067	Mean ^K
T ₁	Control (w/o manure/fertilizer)	223.00	65.00	10.67	48.00	86.67 ^{bc.L}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	211.00	105.67	16.33	119.33	113.0 ^{abc}
T ₃	FYM (@ 10 t ha ⁻¹)	239.67	62.00	13.67	72.00	96.83 ^{bc}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	252.33	72.33	15.33	136.00	119.0 ^{ab}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	270.67	71.33	16.33	136.00	123.58 ^{ab}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	201.33	70.67	17.33	96.00	96.33 ^{bc}
T ₇	N:P ₂ O ₅ :K ₂ O (@ 60:40:60 kg ha ⁻¹ res.)	281.33	75.33	13.67	152.00	130.58 ^{a.1}
T ₈	T ₇ + Poultry manure (@ 1 t ha ⁻¹)	245.00	72.67	23.33	160.00	125.25 ^{ab}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	257.33	86.67	29.00	144.00	129.25 ^{a.2}
Mean		242.41 ^{a.1}	75.74 ^c	17.30 ^{d.L}	118.15 ^{b.2}	GM=113.4
		LSD (0.05)	F-test	C.V. (%)		
Year (A)		19.53	**	80.57		
Replication (B)		16.91	ns			
Treatment (C)		29.29	*			
A*B*C		-				
S. E.		14.75				

*, significant; **, highly significant; ns, not significant; ^{K, m} means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); ^{a, b, c} means in the row (year mean) with similar letters are not significantly different by LSD (0.05)

This study revealed that the application of lower dose of chemical fertilizer (i.e. N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹) in addition to poultry manure (1-2 t ha⁻¹) is the most suitable combination to grasp the higher yield of fresh pod yield of cowpea.

Table 7. Response of different manure and fertilizer combinations on fresh pod yield (kg ha⁻¹) of cowpea in the experimental site

		Year				
Treatment		2064	2065	2066	2067	Mean ^K
T ₁	Control (w/o manure / fertilizer)	4749.73	2866.30	3437.87	1077.78	3032.9 ^{cd.L}
T ₂	Poultry manure (@ 2 t ha ⁻¹)	7125.40	5926.29	3055.53	3596.29	4925.9 ^{ab.2}
T ₃	FYM (@ 10 t ha ⁻¹)	6892.27	4690.18	3195.53	2511.11	4322.3 ^{abc}
T ₄	N:P ₂ O ₅ :K ₂ O (@ 40:20:40 kg ha ⁻¹)	6212.33	4653.70	2046.47	2814.81	3931.8 ^{bc}
T ₅	T ₄ + Poultry manure (@ 1 t ha ⁻¹)	8454.40	5094.81	2191.13	5048.14	5197.6 ^{a.1}
T ₆	T ₄ + FYM (@ 5 t ha ⁻¹)	7112.60	5209.62	1996.73	3592.59	4477.9 ^{abc}
T ₇	N:P ₂ O ₅ :K ₂ O(@ 60:40:60 kg ha ⁻¹ re	6745.73	5129.25	2890.93	3192.59	4489.6 ^{abc}
T ₈	T ₇ + + Poultry manure (@ 1 t ha ⁻¹)	7806.80	5281.47	1733.47	4107.40	4732.3 ^{abc}
T ₉	T ₇ + FYM (@ 5 t ha ⁻¹)	7687.40	4531.11	357.13	4125.92	4175.4 ^{bc}
Mean		6976.30 ^{a.1}	4820.3 ^{b.2}	2322.76 ^{d.L}	3340.74 ^c	GM=4365.1
		LSD (0.05)	F-test	C.V. (%)		
Year (A)		661.60	**	50.03		
Replication (B)		572.96	ns			
Treatment (C)		992.40	**			
A*B*C		-				
S. E.		499.82				

*, significant; **, highly significant; ns, not significant; ^P, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); ^{a, b, c} means in the row (year mean) with similar letters are not significantly different by LSD (0.05).

The application of different combination of manures and fertilizer showed positive response to increase the pH of the acidic soil. The overall trend of percent organic matter and nitrogen content of the soil over time is increasing due to addition of more amounts of farm yard manure as compared to first soil data (2064). The application of poultry manure (@ 1.0 to 2.0 t ha⁻¹) in addition to chemical fertilizer is efficient to increase the availability of available phosphorus. The overall trend of availability of phosphorus is decreasing with time. The availability of available potassium can be increased with the application of higher dose of chemical fertilizer. The fresh pod yield of cowpea can be increased through the use of poultry manure (@ 1.0 to 2.0 t ha⁻¹) in combination with lower dose of chemical fertilizer (N:P₂O₅:K₂O @ 40:20:40 kg ha⁻¹, respectively).

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Market Assessment Survey of Apple Grown in JUMLA

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ABSTRACT

A survey was carried out during June 2011 to provide a concise picture of entire value chain of apple in order to identify the constraints and opportunities. Primary data were collected by individual interviews, PRA and focus group discussion whereas secondary data were collected from various publications. The results revealed that 11,332 households were involved in apple farming in the district. Six agrovet, 33 nursery owners and Agriculture Research Station (Horticulture), Jumla were major input suppliers. Tatopani, Chandannath and Shinjha were major pockets covering 1574 ha of land producing 3500 mt apple fruits/annum with an productivity of 6.6 mt/ha. Out of total production, 43%, 11% and 15% have been used for local consumption, processing and export, respectively whereas 31% fruits were lost due to decay. Altogether 10 collection centres and 8 cellar stores were operating. Karnali Fruit Company, District Cooperative Federation, local collectors, vendors at the airport and R. K. Apple Processing and Horticulture Distillery are the major collectors in the district whereas B. H. Enterprise, Kathmandu was major contractor for trading organic-certified apples. The price of organic-certified apple fixed by District Cooperative Federation at Jumla airport ranged from NRs 15 to 35 per kg whereas for non-organic apples depending on grade ranged from NRs 15 to 30/kg. Transportation cost via aeroplane was NRs 25 per kg whereas via truck was NRs 4/kg. Bhatbhateni supermarket, fruit stalls, vendors were major retailers of Jumla apple. R. K. Apple Processing and Horticulture Distillery supplies organic brandy, organic juice, jam and dried apple slice to Jumla Kosheli Ghar, Jumla Organic Multipurpose Cooperative and Anurag Trade Concern at Kalanki in Kathmandu. The results revealed that despite of high potentiality, apple growers were not able to obtain optimum benefit due to low productivity of existing varieties (6.6 mt/ha), poor orchard and nursery management practices, infestation of apple orchards by various insect pests, high losses in quality and quantity during post harvest handling period.

INTRODUCTION

At present, production of deciduous fruits in Nepal is limited compared with tropical fruit thus substantial quantities are imported to meet domestic demand. Among deciduous fruits, apple is the most important crop in terms of area, production and household economy in remote mountain districts. Apple cultivation in Karnali region has been a major source of income enhancing the livelihood of poor farmers. Considering this fact, Agriculture Perspective Plan (APP) and Three Years Interim Development Plan have given number one priority to apple as high value cash generating commodity for high-hill farmers of Nepal. A total of 54 districts grow apple, however, only 12 major apple producing districts mainly from high mountain regions. Of them, Karnali zone is the major apple producing area and Jumla ranked first among the apple producing districts of Nepal in terms of area (1574 ha) and production (3500 mt). Although this is a considerable amount, production is very scattered and mostly consumed locally

Despite of high potentiality of apple cultivation, apple growers particularly in Jumla have not been able to obtain optimum benefit from this crop due to low productivity of existing varieties, poor orchard management practices, infestation of apple orchards by various insect pests resulting less

attractive fruit colour, high losses in quality and quantity during post harvest handling period. Due to lack of storage, transportation and proper marketing facilities, Indian and Chinese apple fruits arrive in Nepalese market after November. Nepal produce 41755 mt apple/annum, however, most of them are being consumed locally whereas Nepal imports 37400 mt apple, out of which 92% of apple demand in urban markets is being met from imports i.e., China (65%), India (22%) and other countries (5%). Nepal has potentiality and comparative advantage of exporting apple fruits to Bangladesh market due to high quality fruits. Thus, the main objectives of this investigation was to draw a concise picture of entire value chain of apple in order to identify constraints and opportunities that can be exploited for promoting income and employment for rural pro-poor.

MATERIALS AND METHODS

Study is based both on secondary and primary information. Primary data were collected from various groups viz producers, LARPs, input suppliers, local traders, processors, etc. by individual semi-structured questionnaire fills up (Annex 1), PRA, focus group discussion at cluster level and interaction and sharing from concerned stakeholders whereas secondary data collected from documents and publications of various government and non-government organizations. Technicians of Agriculture Research Station (Horticulture), Jumla, District Agriculture Development Office, business communities, processors, traders and exporters were interviewed to come up with more realistic data on production as well as value additions and value chains (N=87).

RESULTS AND DISCUSSION

Value chain map

Figure 1 illustrates the value chain map of various actors involved in the Jumla apple value chain, from input suppliers and producers at the bottom all the up to the final consumers. On the left side, various functions are shown of these primary value chain actors, while on the right side various service providers or support organisations can be seen. Especially the government support organisations have a strong role in determining the enabling environment through policies, subsidies, etc.

Nursery management and input supply

There are a total of 33 registered apple nurseries which were organised in a “Fruit Nursery Association” since February 2008. However, more than 100 apple nurseries were not registered and many of them supported by NGOs and INGOs. In 2010/2011, a total of 300 thousand apple saplings @ NRs 2 were distributed by DADO with subsidy of NRs 23 per sapling. Similarly, eight agrovets are currently selling agricultural inputs such as organic pesticides, bio fertilizers, sprinklers and other inputs. These agrovets need to be trained in delivery of organic services.

Major challenges for the nurseries were related to improving the quality of their saplings:

- 1) Most nursery owners were not aware which varieties and some of them do not have mother plants
- 2) No access to supply new and improved varieties
- 3) Transmission of graft transmissible insects and pests
- 4) *Edimail* and *surkilo* are used as apple rootstock however, seed is too expensive (10,000-15,000 per kg)

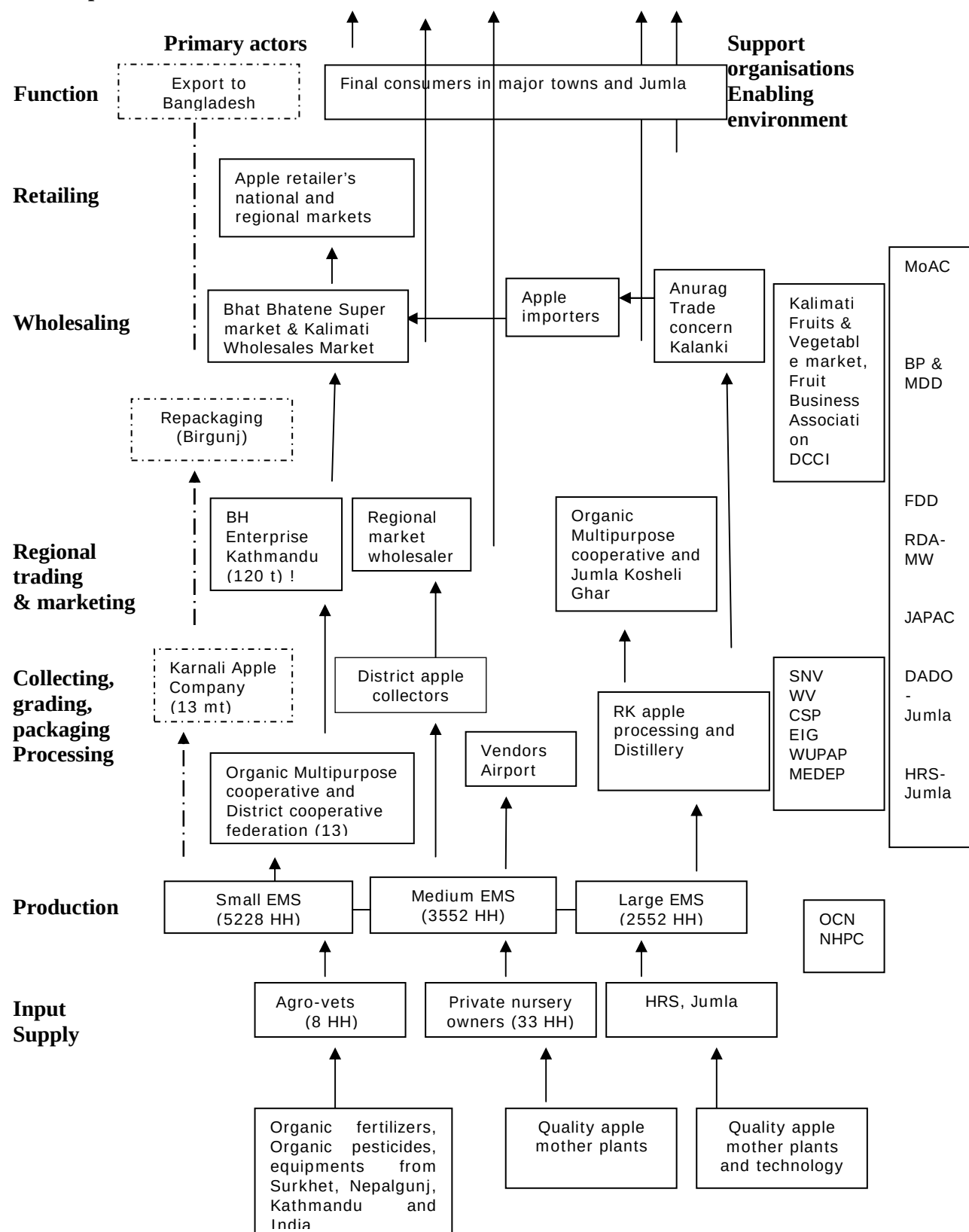
Consumption**Figure 1. Value chain map for Jumla apples**

Table 1. List of registered private nurseries in Jumla

Name of the nurseries	Name of nursery owner	Address
Shivapuri Fruit nursery	Purinath Neupane	Kartikswami 2
Priyabari Fruit nursery	Govinda Rawat	Chumchaur 2
Uccha Himali fruit nursery	Toyanath Yogi	Mahat 2
Navadip fruit nursery	Navraj Rawal	Talium 4
Basantapani fruit nursery	Gopal Acharya	Depalgaun 7
Uccha Himali fruit nursery	Suka Nepali	Dillichaur 8
Dolkati fruit nursery	Lachiman Bohora	Dillichaur 6
Mahadev fruit nursery	Khadka Bahadur Buda	Patmara 7
Mahesh fruit nursery	Mahesh Bahadur Bhandari	Depalgaun 8
Sundari fruit nursery	Sankhu Khatri	Kartikswami 4
Malika fruit nursery	Man Bahadur Buda	Kanakasundari 7
Hasta fruit nursery	Hasta Bahadur Buda	Kanakasundari 7
Dipak fruit nursery	Birkha sarki	Depalgaun 7
Himali fruit nursery	Hira Bahadur Shahi	Chandannath 5
Chandannath temperate fruit nursery	Hari Bahadur Rokaya	Talium 9
Satra Khamba fruit nursery	Ambar Bahadur Rawal	Talium 2
Kalika fruit nursery	Ratan Bahadur Rawat	Talium 2
Ghumkhola fruit nursery	Khadka Bahadur Buda	Talium 7
Chimara fruit nursery	Purna Bahadur Bohora	Dillichaur 6
Devdhara fruit nursery	Laxmi Buda	Dillichaur 3
Tularam fruit nursery	Tularam Buda	Garjankot 2
Mahadev fruit nursery	Khadka Bahadur Buda	Chandannath 2
Mahadev fruit nursery	Hira Bahadur buda	Dillichaur 7
Ganesh fruit nursery	Durga Prasad Pandey	Hanku 5
Jalpa fruit nursery	Devidatta Pandey	Hanku 7
Chulisanghu fruit nursery	Man Bahadur Rawal	Talium 7
Krushu fruit nursery	Sattal Singh Thami	Dillichaur 7
Rahedeu fruit nursery group	Tek Bahadur Buda	Dillichaur 8
Lache fruit nursery	Lache Bahadur Buda	Dillichaur 4
Doldhunga fruit nursery	Dhan Bahadur Rawat	Chumchaur 2
Him fruit nursery	Bishnumaya Mahat	Mahat 6
Lekali fruit nursery	Lilu Shahi	
Dolkati fruit nursery	Laxmiman Bohora	Dillichaur 3

Table 2. List of agro-vets and input suppliers in Jumla

Agro-vet	Address	Owner	Input Suppliers
Malavid Agro-vet	Chandannath 6	Dhananjaya Khatri	Sagarmatha agrovet-
Dhital Agro-vet	Chandannath 6	Purna Dhital	Kalimati, Annapurna
Dhital Agro-vet	Sanigaun 1		agrovet-Nepalgunj,
Alamdevi Agro-vet	Narakot	Alamdevi	Manakammana agrovet-
Chandannath Agro-vet	Chandannath 6	Kuldev Khatri	Narayangarh, Lucknow,
Kanakasundari Agro-vet	Kanakasundari 8		HRS-Jumla
Purna Agrovet centre	Chandannath 6	JAPAC	
Prem agrovet centre	Badki	Prem B. Shahi	

Apple production

Ten varieties of apple are being cultivated in Jumla: Red, Royal and Golden Delicious constitute approximately 70% of total production. The rest includes Jonathan, Torikulu, sweet Ambri and Macintosh, etc. Area under apple cultivation has almost doubled in 2063 compared to 2057. Altogether 11,332 household have been cultivating apple in Jumla among which 2552 have more than 50 apple trees. Similarly 3552 and 5228 households have 26-50 and less than 25 apples trees, respectively.

Table 3. Pocket area, production and area coverage of apple enterprise in Jumla district

Pocket area	FY 064/065		FY 065/66		FY 066/67	
	Area (ha)	Prod. (mt)	Area (ha)	Prod. (mt)	Area (ha)	Prod. (mt)
Tatopani pocket (Taliun, Lamra, Haku, Tatopani, Kudari, Malikathata, Ghodemahadev)	297	801	345	931	395	1050
Chandanath pocket (Patmara, Chandanath, Depalgaun, Garjyankot, Mahat, Kartikswami)	710	1775	789	1972.2	943	2100
Sinja pocket (Mahabaipatarkhola, Kalikakhetu, Badki, Shannigaun, Narakot, Dhapa, Birat, Pandavgufa, Kanakasundari, Botamalika)	198	297	210	310.5	236	350
Total	1205	2873	1344	3213.7	1574	3500

Cultivation practices

While some apple trees are grown on fertile and irrigated low-lands, most have been planted on the slopes with low soil fertility and little irrigation. Apple is mostly inter-cropped with beans, potato and wheat. The present apple orchard management is very poor. One of the reasons is that farmers do not have adequate knowledge on when or how to efficiently irrigate, fertilise, and prune their apple trees.

Diseases and insect pests

The common diseases reported are: stem black, powdery mildew, scab, Nectria twig blight, Alternaria twig blight, papery bark/pink disease. Similarly, some of the common pests reported are: woolly aphids, San Jose scale, stem borer, root borer, bark borer, twig eating beetle, etc.

Organic apple production and certification

Important factor which has limited quality production is that declaration of Jumla as an organic district was not sufficiently combined with awareness and knowledge of apple growers and agrovets. Pine litter is the main constituent of farm yard manure, which increases acidity and decreases nutrient availability. SNV Nepal, World Vision and DADO-Jumla agreed to support organic certification in 2009. In 2010/2011, Organic Certification Nepal (OCN) trained three organic apple producer groups formed in Mahat, Kartikswami and Patmara VDCs; inspected their orchards; and certified "Organic in Conversion". Thus, there is an opportunity for the Jumla organic apple to be directly sold to supermarkets in Kathmandu with a premium price. Nevertheless, the market for organic products is still very scattered. Organic Village has various organic outlets.

Organization of producers

Apple producers in Jumla are hardly organised and are selling apple independently, therefore, they do not have the bargaining power for better prices. They do not have direct contact with major apple wholesalers in urban markets and depend on apple sales to local traders. Due to the organic apple certification initiative, where organisation is necessary to receive group certification, three organic apple producer groups were initiated in 2009: Kartikswami Organic Group, Malika Organic Agriculture Production Group and Janachetana Organic Group. For the marketing in 2010, these 3 groups organised an apple management committee which signed a contract with CCI-Jumla. However, the entire certified apples were marketed by District Cooperative Federation, Jumla in 2011.

Harvesting and post harvest management

Despite of high potentiality of apple cultivation, the apple growers particularly in the Karnali region especially in Jumla district have not been able to obtain optimum benefit from this crop due to high

losses during the post harvest handling period. Reduction of post harvest losses is a complementary means for increasing production. The cost of preventing losses after harvest in general is less than the cost of producing a similar additional amount of apple fruits of same quantity.

Harvesting, sorting, grading, packaging and storage

Apple producers do not have much knowledge on the appropriate techniques for proper picking, grading and packing. Apples are harvested in a most haphazard manner – including shaking the tree and picking from the ground. Without grading they are transported to Jumla airport in *dokos*, especially by women. Grading is done by the traders – usually three grades depending on size alone for export to Surkhet, Nepalgunj and Kathmandu. The district headquarter traders would use the worst apples for processing or for the local market. Traders have till 2008 also not properly prepared themselves by bringing packaging material before the monsoon starts. A lot of losses occur due to improper packaging; old boxes are used without any wrapping or separation material and a considerable amount gets damaged. Farmers store apples underground inside the house, a pit in the ground filled with barely straw and covered with a stone or wooden slab.

Table 4. List of Cellar stores in Jumla

Ownership	Address	Capacity (mt)	Established year	Existing condition	Supporting institution
Navayuba farmer's group	Chandannath 3	10	2051	Good	SEBED
Raj Bahadur Bhakri	Chandannath 3	5		Good	Farmer group
Sidda Bhawani farmers group	Talium 7	5	3063	Fair	DADO
Agriculture production group	Talium 8	5	2062	Good	DADO
Depak Shahi	Kartik Swami 6	10	2059	Good	Farmer group
Krishna Bahadur Shahi	Kartik Swami 6	5	2059	Good	Farmer group
Purinath Neupane	Kartik Swami 1	6	2064	Good	Private
NA	Depalgaun 4	5	2064	Fair	RDGP

Marketing

The local traders collect apples in major collection and market centres and supply them out district market centres like Surkhet, Nepalgunj and Kathmandu.

Table 5. List of Major market centres in Jumla

Major market centres	Covered VDCs
Talium Bazaar	Talium and Lamra
Tatopani Bazaar	Tatopani and Lamra
Kudari Bazaar	Kudari, Tamti and Raralihi
Nagma Bazaar	Ghodemahadev and Kalikakhetu VDC
Narakot Bazaar	Narakot, Dhapa, Shannigaun and Kanakasundari
Haatsinjha Bazaar	
Urthu Chautara	Patmara and Dillichaur
Dillichaur Bazaar	Dillichaur, Chumchaur and Pataransi
Manisangu Bazaar	Gothichaur
Airpot/Chandanath	Chandanath, Kartikswami, Mahat, Garjangkot and Depalguan

Chart 1: Production and distribution of Jumla apple (mt) during 2010

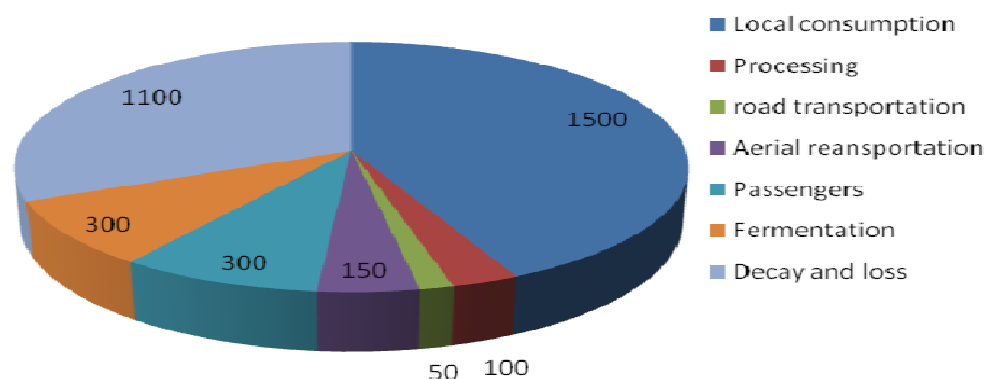


Table 6. List of collection centres at Jumla

Name	Address	Command VDCs	Capacity (mt)
Hanuman mandir hat bazaar	Chandannath 6	Chandannath, Depalgaun, Garjankot, Mahat, Tallium, Patmara, Kartikswami	NA
Apple collection centre and selling centre, airport	Chandannath 1	Chandannath, Mahat, Patmara, Kartikswami	125
Organic apple Collection centre, Airport	Chandannath 1	Chandannath, Mahat, Patmara, Kartikswami	150
Chandannath collection centre and selling centre	Chandannath 1	Chandannath, Depalgaun, Garjankot, Mahat, Tallium, Patmara, Kartikswami	NA
Urthu-Chauthara Collection centre	Patmara 3	Patmara	10
Fruit and vegetable collection and selling centre	Chandannath 6, 7	Chandannath, Mahat, Patmara, Kartikswami	140
Fruit and vegetable collection and selling centre	Tatopani 1,2	Tatopani, Kudari, Hanku	NA
Fruit and vegetable collection and selling centre	Narakot 4	Narakot, Dhapa, Sanigaun	45

Trade from Jumla

Track of Karnali Highway from Surkhet to Jumla (232 km) was opened in 2007. This has greatly increased the perceived future perspectives for the Jumla apple sector. World Bank is supporting the blacktopping of 132 km - it still will take few years for the road to be all weather proof all the way to Jumla. Most apple transport takes places by air, not just a very costly business but also quite unreliable as flights depend on weather conditions.

Table 7. Price of apple determined by District Cooperative Federation during 2011

Description	Grade	Price (NRs/kg)
Organic certified	A	35
Organic certified	B	30
Organic certified	C	20
Non-organic	A	30
Non-organic	B	25
Non-organic	C	15

Table 8. Transport costs

Route	Mode of transport	Transport cost per kg (NRs.)
Jumla-Nepalgunj/Surkhet	Air	25.00 (traders with access to DADO subsidies can reclaim 7.00 after the apples have reached Surkhet).
Jumla-Surkhet	Truck/tractor	4.00
Nepalgunj/Surkhet- Jumla	Air	95.00 (excess luggage) 75.00 (cargo separate) 42.00 (charter)
Surkhet-Jumla	Truck/tractor	10.00 depending on the volume

Those 10% apples which do reach the market outside Jumla mostly serve the cheaper market segment in the terai: poor management, all the way from orchard management to packaging and transport, make these relatively small and often bruised apples less attractive. Nevertheless, in comparison to Chinese and Indian apples, Jumla apples are widely recognised as tasty and crispy apples in Nepal, but size, colour and general condition have a big influence on consumers' liking.

Various marketing or trade modalities are currently in operation in Jumla:

- 1) District Cooperative Federation collects organic certified apples at Jumla airport and send to contractor (BH enterprise, Kathmandu)
- 2) Large apple producers who bring their produce to Surkhet and Nepalgunj themselves.
- 3) Growers, especially in Jumla's Sinja belt - who collect from other farmers as well and the produce to the terai.
- 4) District headquarter traders with a storage at the Jumla airport who either a) 'rent' orchards and organise the harvest themselves, or b) buy at the airport from farmers.

Regional apple traders

There are fruit traders in Nepalgunj, Surkhet, Narangarh (Chitwan) who are all interested to trade with Jumla apples. These traders have market networks to major urban cities/towns across the country, including Kathmandu. In the past, local traders and even some local apple producers delivered Jumla apples to regional traders.

Apple wholesalers

Wholesale traders at Nepalgunj and Surkhet buy and put their apple fruits mainly on night buses to various destinations, where they sell to retailers. There are many wholesale traders in Kathmandu and other market hubs of Kathmandu, who trade mainly Indian and Chinese apples. Recently B.H. Enterprise, Kathmandu has become the main contractor of Jumla organic certified apples who trade apples to Kalimati Fruits and Vegetable Market, BhatBhateni Super Market as well as to the retailers in Kathmandu.

Table 9. Number of wholesalers in major towns of Nepal

Towns	Number of wholesale dealers	Towns	Number of wholesales dealers
Bhairhawa	2	Itari	4
Biratnagar	5	Janakpur	8
Birgunj	3	Kakarbitta	3
Butwal	6	Lahan	3
Dhangadi	4	Nepalgunj	4
Dhankuta	3	Pokhara	10
Dharan	3	Narayangarh	4

In the past, some local apple producers delivered Jumla apples to wholesalers in Kathmandu. The wholesalers in Kathmandu found Jumla apples very tasty and juicy, but complained about their poor

appearance and colour. Presently, they are mainly importing apples from China and India to meet urban demand of apples. In case of the organic certified apples of Jumla, Organic World & Fair Future, a distributor specialised in organic products, delivered to various supermarkets. The Naryangarh Fruit Cooperative also took up wholesale of certified apples.

Retailer

Very high quality apples from overseas are directly imported and sold by supermarkets such as Bhatbateni and Salesway. Similarly, there are several fruit stalls at different towns that trade Jumla apples. Likewise, there are more than 30 fruit vendors at Jumla airport, and other towns involving trading of Jumla apples seasonally.

Processing

One of the largest enterprise established in 2011 at Mahat-1, Jumla called R.K. Apple Processing and Horticultural Distillery Pvt. Ltd., have started production and trading of brandy, dried slice, juice and jam on commercial scale to Anurag Trade Concern at Kalanki. Likewise, Organic Multipurpose Cooperative Ltd., Jumla has also contracted with Saugat Griha of Tripureshwor for marketing of apple processed products. However, there are more than hundred unregistered apple processing enterprises involved in production of *rakshi* (alcohol), dried slice, juice and jam. The collection and marketing is mainly being carried out by Jumla Kosheli Ghar and Organic Multipurpose Cooperative Ltd.

Table 10. Demand of diversified apple products and their price at R.K. Apple Processing and Horticultural Distillery Pvt. Ltd., Jumla

Apple products	Annual demand		Annual supply	Whole sell price (NRs)
	Local level	National level		
Organic Brandy (42.5%)*	2400 litre	1,00,000 litre	7000 litre	400 per 750 ml
Cider	-	-	-	-
Jam	-	100 kg	100 kg	225 per kg
Jelly	-	-	-	-
Dried apple slices	1000 kg	5000 kg	1500 kg	800 per kg
Organic juice	5000 litre	45000 litre	10,000 litre	150 Per litre

*Chiraito is used for fermentation instead of commercial yeast

Supporting agencies

Agriculture Research Station (Horticulture), Rajikot, Jumla amongst others have been providing technical and other supports in apple value chain in Jumla. The agencies with their role are given in Table 11.

Table 11. Organizations promoting and supporting apple sub-sector in Jumla

Lead organizations	Role
Agriculture Research Station (Horticulture), NARC, Rajikot	Provide primary mother stocks of apple, technologies and various trainings on nursery and orchard management
SNV-Nepal	Trainings related to nursery and orchard management, organic certification, facilitation of Jumla Apple Development Plan
World Vision	Supporting with organic certification promotion and training of LARPs
Community Support Program (CSP)	Supporting the promotion of LARP
Education for Income Generation and Conflict Mitigation (EIG-CM)	Implemented a consortium led by WINROCK is providing support for apple packaging
Western Upland Poverty Alleviation Project (WUPAP)	Supporting mainly on promotion of apple production in leaseholds forestry
Micro Enterprise Development Programme (MEDEP)	Promoting the production of bio-pesticides, marketing and resource survey on apple
Nepal Horticulture Promotion Centre (NHPC)	National level NGO is providing nursery, orchard management and harvest/post-harvest management trainings through SNV
Organic Certification Nepal (OCN)	Providing organic certification for the apple growers in 6 VDCs of Jumla
Chamber of Commerce and Industry (CCI)	CCI is running <i>Khoseli Ghar</i> viz souvenir shop, which sells various local produced food stuffs like dried apple slice, apple juice, etc
Fruit Development Directorate (FDD)	Carry out various activities aimed at developing the fruit sector in the country
Agribusiness Promotion and Marketing Development Directorate (ABP & MDD)	Agribusiness promotion and marketing of various agricultural commodities like vegetables, fruits, species, cash crops and other agricultural products
Agribusiness Promotion and Statistics Division	Planning, monitoring, evaluation, policy formulation for agribusiness and trade
District Development Committee	Policy formation such as “Every household one apple orchard”, “Employment through Apple and Tourism, Declaration of organic district
Jumla Apple Processing Centre (JAPC)	Training and input packages for processing of apple and necessary materials and equipments
District Agriculture Development Office (DADO)	Key role in promoting apple sub-sector

Market trends and competitiveness

Area under apple cultivation is drastically increasing every year. Although there is demand for apples, the competitiveness of the Jumla value chain with other supply chains of apple to the major markets will in the end determine whether the Jumla farmers will be able to sell their produce. Taste of Jumla apples is considered best in terms of its juiciness, crunchiness and sweetness compared to Chinese and Indian apples. Jumla apples can fetch NRs 20 to 25 higher price per kg than Chinese and Indian apples provided they can be improved in terms of size, appearance and colour. Traders' suggestions are to train apple growers in proper picking, handling, sorting, grading, storing and improved orchard and nursery management practices by which quality of Jumla apple can be improved to a greater extent.

Domestic production

There are 11 major apple producing districts in Nepal producing 41755 mt of fresh apple during 2066/2067; most of them are being consumed locally. Nepal imports 37400 mt of apple, out of which 92% of the apple demand in the urban markets is being met from imports i.e. 65% is from China, 22% from India (22%) and 5% from developed countries. Mustang apples are mostly sold in

Baglung, Myagdi and Pokhara and Kathmandu during apple harvesting season. Jumla organic apples are mostly sold in Kathmandu whereas non-organic apples are mostly sold in Surkhet and Nepalgunj.

Imported apples

About 20-25 Chinese apple wholesale dealers based in Kathmandu import apples from China covering a distance of 2200 to 3000 km and supply to Kathmandu wholesalers who get a 3-4% commission. Transport costs are NRs 200/crate containing 7 to 10 kg. Indian apples are cheaper during harvesting season, so traders prefer to deal with Indian apples from Himachal Pradesh and Kashmir from a distance of 1200 to 1500 km. Transport cost is NRs 4/kg, tax and other duties are NRs 25,000/truck. Wholesale price for Indian apples range from NRs 50 to 80/kg depending upon the variety, quality and grade of apple where as retailers sell at a price ranging from NRs 60 to 120/kg. During the peak season Indian apples becomes cheaper than Chinese apples. High quality apples from imported from other countries (Australia, New Zealand and US) are being sold in big supermarkets. Wholesalers have stopped importing apples from countries other than China and India because of high cost in recent years.

Observation visit to apple growing areas of Himanchal Pradesh and China must be arranged for all the stakeholders. Private nursery owners need to improve their orchard management practices and capacity enhancement of agrovets through training is needed. Apple growers should improve their orchard management practices to produce quality apples as per market demand and big campaign is needed to disseminate improved technologies. On the spot trainings are required for production of home-brewed organic pesticides. Production of quality compost and intercropping of grain legumes in apple orchards are required. Technologies for water conservation and utilization, harvesting, handling, sorting, grading, waxing, packaging, storage and transportation should be developed. Supply of packaging material should be well organised. District traders should work towards reliable market channels with sufficient flexibility to adapt to price changes of apple in the major markets. Apple cooperatives need to be formed which could take over tasks from district traders and deal directly with wholesalers. Stable marketing channel for organic certified apples should be developed to reach niche markets where apples can fetch premium prices.

Performance of Organic Orthodox Tea (*Camellia sinensis*) Genotypes in Nepal

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ABSTRACT

A total of 12 existing tea genotypes were evaluated at Agriculture Research Station, Pakhribas, Dhankuta in 2010 and 2011. On the basis of two years' data, the highest production of green tea leaves (1701 kg/ha) and made tea (405 kg/ha) was found in the genotype Tinali, and the lowest production green leaf tea (363 kg/ha) and made tea (13.4 kg/ha) was found in Banokbarna-157. Average productivity of tea genotypes were found 1526 kg/ha for green leaf tea and 401.5 kg/ha for made tea. Percentage of dry tea from green tea was 26.3% where as highest 30.4% was found in Tagda-135. Highest caffeine (4.17%) was observed in Ghumti selection and highest crude fiber (12.30%) was observed in Tagda-135. The results showed that the highest tea was produced by Tinali and the highest percentage of made tea was produced by Tagda-135 genotype.

INTRODUCTION

Tea (*Camellia sinensis* L.) is an important industrial crop. It is grown in wide altitudinal range from 150 to 2200 meter above sea level (masl) in the eastern region of Nepal. It belongs to the family Theaceae. Tea is grown in more than 100 countries of the world but major tea producing countries are China, India, Sri Lanka, Indonesia, Malaysia, Singapore and Japan (San 1999). About 200 different tea species are reported to be cultivated around the world (Shrestha 1999). It is one of the important crops to improve the national economy of the African countries such as Cameroon, Senegal (Alawi and Tanania 1998 and Ireland 1995). Tea is one of the popular consumed beverages in the world and it is estimated that about one billion cups of tea are being drunk in a day (Shrestha 1999). The probable reason for its popular consumption is that it has medicinal value and used against some diseases such as cancer, stroke, osteoporosis and heart attack as well as tooth decay (Shrestha 2000). Over 2.5 million tons of tea is produced around the world, most of them in Asian countries. Now a day, the scope of the tea industries is of worldwide economic importance.

Tea plant is evergreen nature. It has thick leaves, dark green in color and strong stem. The tea flowers bloom in white or pink and have a delicate fragrance. The total area under tea cultivation in Nepal is 11,210 ha and production is 112,000 kg and it accounts 0.3% of world production (Shrestha 2004). It provides direct employment opportunity to 10 thousand people. There are 10 registered Tea estates and 10 Tea processing factories in private sectors in Nepal which contribute 85% of the national production volume. The production potentiality of tea is about 5000 kg/ha/year but in Nepal productivity of tea is 750-1477 kg/ha (Anonymous 2009) where as in Darjeeling and Assam, it is 1300-2000 kg/ha. Low production of tea in Nepal is due to limitation of high yielding clone and narrow genetic base of the existing plant materials (Sharma 1999). On the other hand, tea is grown in marginal land where the multiple cropping is not possible. However, profitability of tea is four times greater than maize and millet in the hills of Nepal.

epal has wide range of climate from terai to higher hills which is suitable for the production of Orthodox tea in hill range and Terai. Favorable climatic conditions mainly rainfall, temperature and soil pH are critical determining factors for the success of tea cultivation (Filani and Okelana 1980). The soil that is acidic, deep and well drained, with high organic matter content and average annual rainfall with low average daily temperature is favorable for tea cultivation (Moss 1957). Two distinct tea species: the small leaves are "China bush" (*Camellia sinensis*) and large leaved are "Assam bush" (*Camellia assamica*). Chinese bush are grown in hilly areas and Assam bush are grown in terai. Generally Assam bush yields higher than China bush.

The research work on selection, breeding and location specific genotype study could not be carried out in the past in Nepal (Gupta 1985). Introduction and evaluation of high yielding clone of tea is required to improve the production, productivity and quality of tea in Nepal. Farmers are demanding high yielding variety and low cost production technology of tea for commercialization. In this study, quality and yield performance of existing genotypes was studied for the selection of elite genotypes.

MATERIALS AND METHODS

An experiment was carried out in Agriculture Research Station Pakhribas, Dhankuta at 1600 to 1750 masl during 2010-2011. Twelve existing genotypes were selected for evaluation and replicated 3 times in randomized complete block design. Total of 21 plants (7 plants per treatment) were included in each treatment (genotype). Two kg of well rotted compost with one kg vermin compost were applied in each plant per year. Age of the plant was 8 years and plucking was started from March to October. Generally, 4-5 plucking was done per month. After plucking the green leaves were processed manually. The following steps were followed for the preparation of orthodox tea.

Weathering

In this process, 2-3 true leaves of tea picked-up and collected in the basket, then they were sun-dried till about 50-60% moisture be removed.

Rolling

Leaves were rolled by hands for releasing the liquids from the leaf in order to allow the fermentation and oxidization.

Fermentation

In this step, the enzymes within the leaves are bound with oxygen as a result the leaves turned into brown colour and created typical flavor of the tea. This stage takes about 3 hours.

Drying

After stopping the oxidization process, the tea is sun dried till around 12% moisture is maintained. At the end of this process a long-lasting, stable product is produced.

Parameters

Plucking time, green tea weight, made tea weight and percentage of made tea were recorded and analyzed using simple statistical procedures. About 200 g of end product of tea sample was sent to the Food Research Unit of NARC at Khumaltar, Lalitpur for chemical analysis of crude fiber on moisture basis.

RESULTS AND DISCUSSION

Production of green leaf tea

The plucking of first flush was started from March. The first tea crops of every year are called "new tea" and it is rich in flavor and aroma (FAO 2011). The two years yield data revealed that the highest production of green leaves (533 g) (21 plants) was recorded in March from the genotype Tinali and the lowest (53 g) production was from Tagda-78. The highest production of green leaf tea was observed (1701 kg/ha) from Tinali and the lowest (363 kg/ha) from Banokbarna-157 (Table 1). High variation of green leaf production was observed and that could be due to the variation of soil fertility and plant number. Normally, production of tea started from March to September and it gradually decreased from October. That might be due to the decrease in temperature.

Table 1. Total production of green leaf orthodox tea from different genotypes at ARS Pakhribas in 2011

Month	Quantity of green leaf (g)											
	Tagda -78	Phoob shring- 312	Am- bari- 135	Tagda -135	Tara- pur	Happy Valley	Tagda -383	Tinali	Phoob shring- 1404	Banok Barna- 157	Bala- san	Ghumti selec- tion
March	53	173	69	178	342	390	335	533	238	71	115	245
April	160	42	81	16	183	145	158	236	128	8	53	223
May	149	98	90	24	113	191	192	205	126	17	90	204
June	349	224	135	79	145	233	390	499	238	45	149	290
July	155	181	164	143	220	252	111	170	161	163	63	312
August	245	100	73	90	207	308	264	151	96	49	50	91
Sept.	141	109	135	41	291	245	268	258	155	72	158	160
October	91	71	88	48	107	159	151	84	110	37	59	212
Total (g)	1820	998	835	619	1608	1923	1869	2136	1252	462	737	1274
Total (kg/ha)	1430	784	655	486	1265	1511	1468	1701	984	363	579	1001
Average (kg/ha)	179	98	82	61	158	182	184	213	123	45	72	125

Production and percentage of made tea

Production of made tea started from March with plucking of new green leaves. The two years' yield data revealed that highest production of made tea (141 g) from 21 plants was recorded in March from the genotype Tinali and the lowest (2 g) production was recorded from Banokbarna-157 in April. The highest productivity of made tea was observed in Tinali and lowest in Banokbarna-157 genotypes (Table 2). The highest percent of made tea (30.4%) was in Tagda-135 and lowest (22.8%) in Happy Valley genotypes (Table 2). The highest amount of made tea was produced in March and lowest production month is October in a year.

Table 2. Production of orthodox (made) tea from twelve genotypes at ARS Pakhribas in 2011

Month	Tagda -78	Phhoob Shring -312	Am- bari-2	Tagda -135	Tara- pur	Happy Valley	Tagda -383	Tinali	Phoob Shring -1404	Banok Barna -157	Bala- san	Ghumti Selec- tion	Total
March	123	48	22	47	85	107	90	141	69	21	32	63	848
April	44	14	24	4	50	41	43	61	36	2	16	64	399
May	49	25	23	7	31	59	68	47	35	3	22	66	435
June	94	61	48	25	61	61	97	109	62	15	43	81	757
July	40	50	56	44	81	14	27	37	41	48	18	87	543
August	47	23	16	20	46	53	51	29	24	13	11	22	355
Sept.	37	27	32	13	71	61	58	67	43	20	38	35	502
October	27	17	25	11	32	43	51	24	32	13	17	46	338
Total (g)	461	265	246	188	457	439	485	515	342	135	197	361	4091
Total (kg/ha)	327	208	193	148	359	345	381	405	269	106	155	284	3214
Average (kg/ha)	45.5	25.9	24.4	18.9	44.8	43.2	47.9	50.3	33.8	13.4	19.6	35.4	401.5
% of mac tea	25.3	26.6	29.3	30.4	28.4	22.8	25.9	24.1	27.3	29.2	26.7	28.3	26.3

Chemical composition of tea genotypes

Chemical composition of orthodox tea depends on the genotypes, maturity of leaves, growing conditions, harvesting period and processing techniques. Caffeine and polyphenols (flavanols, flavonoids and phenolic acids) are natural substances found in tea plants. Catechins, a group of flavonoid, is a powerful antioxidant that is easily oxidized and have health benefits. The average amount of caffeine from brewed tea leaves depends on the type of tea (generally black tea contains more caffeine than green tea), the brewing duration, and the water temperature (the higher the temperature greater the amount of caffeine drained from the leaves). In the present study, the average amount of caffeine found in 12 genotypes was 3.74% where as the highest caffeine 4.17% was found in Ghumti selection and lowest 2.93% in Phoobsering-312. Similarly, amount of crude fiber was 12.30% in Tagda and lowest 9.92% in Happy Valley. A healthy individual can consume up to about 350 mg of caffeine per day without any concern. Including the yield parameter we also evaluated the colour and perfume of made tea. The colour of made tea was observed pale green in Tinali and Ghumti selection where as dark black colour was observed in Banokbarna and Happy Valley.

Table 3. Chemical composition (%) of 12 genotypes of tea

Variety	Total ash	Alkalinity of soluble acid	Water soluble ash	Acid insoluble ash	Caffeine	Crude fiber
Phoobsering-312	5.61	1.62	3.77	0.07	2.93	12.03
Phoobsering-1404	5.29	1.41	3.41	0.03	4.06	11.56
Tukdah-383	5.25	1.40	3.31	0.07	4.02	10.37
Tukdah-78	5.45	1.42	3.43	0.08	3.53	10.92
Tukdah-135	5.21	1.37	3.28	0.07	3.63	12.30
Tinali	5.24	1.48	3.26	0.13	4.07	11.37
Happy valley	5.32	1.52	3.70	0.02	3.64	9.92
Tarapur	5.18	1.49	3.57	0.04	3.90	11.16
Banockburn-157	4.86	1.30	3.09	0.06	3.39	10.13
Balasun	6.28	1.61	3.18	0.06	3.50	11.44
Ghumti selection	5.42	1.53	3.59	0.09	4.17	11.25
Ambari-2	4.85	1.23	3.25	0.03	4.07	11.44
Total	63.97	17.37	40.85	0.73	44.91	133.89
Mean	5.33	1.45	3.40	0.06	3.74	11.16

On the basis of two years' evaluation data the highest production of green leaf tea (1701 kg/ha) and made tea (405 kg/ha) was found in the genotype Tinali and the lowest green leaf tea (363 kg/ha) and made tea (13.4 kg/ha) was found in Banokbarna-157 at ARS Pakhribas, Dhankuta. Average percentage of dry tea from green tea was 26.3% where as highest (30.4%) was found in Tagda-135 genotype. Highest caffeine and crude fiber was observed in Ghumti selection and Tagda

genotypes. In this study, production of green and made tea was found higher in Tinali genotype but percentage of made tea was higher in Tagda-135 genotype and caffeine percent in Ghumti selection genotype. Evaluation should continue for confirmation of these results.

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Effect of Lime Application on Major Plant Nutrient Dynamism in Acidic Soils

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ABSTRACT

Acidic soil in cultivating farmland is considered to be a major problem in Nepal. A four-year experiment was conducted in acidic soil at Malepatan, Pokhara to identify the ways to solve the problem since 2007. Four doses of lime (0, 2, 4 and 6 t ha⁻¹), farmyard manure and with or without application of recommended dose of fertilizers were used in the experiment. Altogether, nine treatments were included in randomized complete block design with three replications. Cauliflower (Kathmandu Local) and Cowpea (Malepatan-1) were grown in the plots. The soil samples were collected after the harvest of cauliflower crop each year to study the plant nutrient dynamics in the soil. The pH of the soil increased from 5.17 to 5.61 (0.44 units up). The available phosphorus and potassium observed the highest (137.34 kg ha⁻¹ and 221.46 kg ha⁻¹, respectively), when agricultural lime applied @ 6 t ha⁻¹. However, the trend of phosphorus content of the soil observed decreased with time whereas, that of potassium increased. The percent organic matter and the nitrogen content of the soil observed the highest (3.87% and 0.174%, respectively) when farmyard manure alone applied @ 25 t ha⁻¹ in the soil.

INTRODUCTION

Soil is a vital natural resource for sustainable agriculture. Desertification as physical, chemical and biological degradation of soil is a serious problem of today's agriculture in the absence of proper soil ameliorative practices to counter the effect of soil degrading process (Kanwar 2002). There are number of reasons, why soils are acidic in the middle mountains. The geology of Nepalese mountains consists of granite, schist, quartzite, gneisses, phyllite and limestone. Soil formed from these parent materials except limestone is acidic in nature (Tripathi 2058, Schreier et al 1995). Use of acid forming fertilizers (ammonium sulphate and urea), pine leaves as a source of organic manure and leaching of bases at high rainfall areas are other reasons of soil acidification. Therefore, soils of hills and mountains are generally slightly acidic to acidic in reaction (Panday et al 1995). Inadequate supply of organic manure and cultivation practices without application of lime in acid soil tends to increase in acidity (Schreier et al 1995) and decline in potentials of production. Increase in soil acidity is the major factor of declining production in Nepal (Turton et al 1996). Therefore, problematic acid soil of Nepal needs amelioration to boost up the agricultural production. The major constraints to agricultural production in acid soils are toxicity of Al, Fe, Mn and H and deficiency of Ca (Jackson 1967). When soil is more acidic than 6.0, the availability of plant nutrients such as N, P, K, Ca, Mg, S, and Mo may be low for satisfactory plant growth.

Most of the microbial processes, such as beneficial activities of *Azotobacter* and nodule forming bacteria of legumes are adversely affected as the soil acidity increases (Mohsin et al 1995). The optimum soil pH range for the majority of agricultural crops is 5.5 to 6.5 (Schreier et al 1995) and soil consisting pH value 5.5 or less is considered as problematic acid soil (Tripathi 2058). The application of lime and manure is one possible solution to avoid further increase in soil acidity (Schreier et al 1995). There is no standard

pH for liming acid soil. It varies from soil to soil and with crop species. Liming not only increases the yields of crop but also enhances the efficiency of fertilizers used. The leaching of bases, Ca and Mg, building of toxicity by H and Al, deficiencies of B and Mo and low cation exchange capacity (CEC) are major factors affecting the productivity (Palaniappan and Varalakshmi 1999).

Farmers at different parts of Nepal are suffering from low agricultural production due to problematic acid soils. There is very limited study on recommendation of lime amount and other amending materials to different crops grown under acidic soil conditions of Nepal. There is no consistency on amount of lime application to amend the acid soils in Nepal. So, amount of amending materials based on soil and its acidity (pH) is needed to quantify in the Nepalese context. Keeping these points in view, a study was carried out to identify suitable dose of lime to increase the productivity of the soil, and to identify the effect of lime application on plant nutrient dynamics of the soil. The on-station study site, Agriculture Research Station (Horticulture) Malepatan of Kaski, lies at the altitude of 848 m above sea level with 28° 13' 6.18" North (latitude) and 83° 58' 27.71" East (longitude); slope of 3-5% (nearly plain); and south-west aspect. The meteorological records averaged for 15 years (1991-2005) showed that mean maximum temperature ranged from 19.2°C to 30.5°C; mean minimum temperature ranged from 6.6°C to 22.1°C. May, June, July and August (30.1°C-30.5°C) are the hotter months, whereas the December and January (6.6°C-7.8°C) are the cooler months. The annual total precipitation is 4112 mm at the site. About 80% of the total rainfall occurs during the four months (June to September) with the highest in July (1015 mm). The station also receives hailstone damages during February-May and sometimes in September-October (Annual Report 2063/64).

MATERIALS AND METHODS

A general survey of soil pH was carried out in farmers' fields and within the Station. About 510 m² of land having the soil pH 5.5 or less was selected at the station in 2064 BS. Soil sampling and analysis was done for its texture, pH, organic matter (OM), nitrogen, phosphorus and potassium content before the application of treatments. The texture of the soil varied from silt loam to sandy loam. Based on the available soil pH data (Soil Test Report 2064), the range on amount of agricultural lime requirement for the study was 3.0 t ha⁻¹ to 7.0 t ha⁻¹. Nine treatments comprising different level of lime (0, 2, 4 and 6 t ha⁻¹) along with recommended dose of chemical fertilizer (N: P₂O₅: K₂O @ 200:120:80 kg ha⁻¹ for cauliflower) and farmyard manure (25 t ha⁻¹) were included in the experiment. Lime was applied twice, the first in the beginning of 2064 and the second in 2066. The agricultural lime used had 80% calcium. The experimental plots were laid out in randomized complete block design and replicated three times. The size of individual treatment plot was 10.5 m² (3.5 m x 3.0 m). Altogether, there were 27 individual plots. Cauliflower (cv. Kathmandu Local) was grown in the plots. Twenty-five cauliflower seedlings per plot were planted during Aswin in each year. Soil sampling was done before the experiment start and after the harvest of cauliflower each year (2064, 2065, 2066 and 2067). All the soil samples were analyzed for pH, organic matter, nitrogen, phosphorus and potassium content in the soil. The data were analyzed using STATISTIX and MSTAT-C as appropriate.

The details of the treatments are as follows:

Treatment	L : R : F	Treatment	L : R : F	Treatment	L : R : F	Treatment	L : R : F
T ₁	0 : 0 : 25	T ₃	2 : 0 : 25	T ₅	4 : 0 : 25	T ₇	6 : 0 : 25
T ₂	0 : R : 25	T ₄	2 : R : 25	T ₆	4 : R : 25	T ₈	6 : R : 25

- L: Lime application @ 0, 2, 4, 6 t ha⁻¹ (Ca content 80 %).
- R: Recommended dose of chemical fertilizer (N:P₂O₅:K₂O 200:120:80 kg ha⁻¹, respectively)
- F: Farmyard manure @ 25 t ha⁻¹ (It is common to all treatment except control /T₉)
- Treatment (T₉) – L:R:F 0:0:0

RESULTS AND DISCUSSION

Change in soil pH

The mean pH values for four years are presented in table 1. The highest mean pH value (5.61) was found in the plots applied with lime @ 6 t ha⁻¹ and farmyard manure followed by the plots applied with lime @ 6 t ha⁻¹ with chemical fertilizer and FYM (5.40). The lowest pH value (5.04) was found in the plots without lime. The pH increased from 5.17 to 5.61 (0.44 unit) when agricultural lime applied @ 6 t ha⁻¹. Bhattarai (2006) observed that the pH of soil increased from 4.7 to 5.8 (1.1 unit up) when lime applied @ 225 kg per ropani at Chambas area. Significant difference in mean pH value was not found between the application of lime @ 4 and 6 t ha⁻¹. In the year-wise comparison, the mean soil pH increased from 5.0 in 2064 to 6.15 in 2067. The difference of means with time was highly significant. These results showed that application of lime @ 4 to 6 t ha⁻¹ is sufficient to raise the pH of acidic soil.

Table 1. Change in soil pH status of the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	5.17	4.43	5.33	6.07	5.25 ^{bc}
0 : R : 25	4.80	4.37	5.20	5.80	5.04 ^{c, L}
2 : 0 : 25	5.13	4.77	5.37	5.73	5.25 ^{bc}
2 : R : 25	5.10	4.43	5.37	5.77	5.11 ^{bc}
4 : 0 : 25	4.87	4.93	5.40	6.30	5.37 ^{abc}
4 : R : 25	5.00	4.83	5.40	6.23	5.36 ^{ab}
6 : 0 : 25	5.17	5.0	5.53	6.73	5.61 ^{a, 1}
6 : R : 25	4.93	4.87	5.47	6.33	5.40 ^{ab, 2}
0 : 0 : 0	4.83	4.33	5.37	6.40	5.23 ^{bc}
Mean	5.0 ^c	4.66 ^{d, L}	5.38 ^{b, 2}	6.15 ^{a, 1}	GM=5.29
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	0.165	**	12.26		
Replication (B)	0.143	*			
Treatment (C)	0.247	*			
A*B*C	-				
S. E.	0.124				

*, difference of means is significant at 5% level; **, difference of means is significant at 1% level; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Change in organic matter content

The mean values on percent organic matter content of the soil of the experimental site are presented in table 2. The highest mean organic matter content (3.87%) was found in the plots applied with farmyard manure alone @ 25 t ha⁻¹, but there was no significant difference between the treatments, even with no application of farmyard manure. However, there was significant increase of organic matter content in the following years compared with the base year (2067). The results indicated that percent organic matter content of the soil can be increased through the use of higher doses of organic manure that enhances the fertility of soil.

Change in nitrogen content

The four year's mean values on percent nitrogen content of the soil are presented in table 3. The highest mean nitrogen content (0.174%) of the soil was found in the plots applied with farmyard manure alone @ 25 t ha⁻¹ and followed by the plots applied with lime @ 6 t ha⁻¹ without the use of chemical fertilizer (0.169 %). The percent nitrogen content of the soil correlates directly to percent organic matter content of the soil. However, there was no significant difference between the

treatments. In the year-wise comparison, the mean nitrogen content significantly increased from 0.156 in 2064 to 0.189 in 2066, and decreased significantly in 2067.

Table 2. Change in the status of organic matter in the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	2.57	5.16	3.71	4.05	3.87 ^{a. 1}
0 : R : 25	2.16	4.61	3.79	3.75	3.58 ^{ab}
2 : 0 : 25	2.51	4.00	3.71	3.88	3.52 ^{ab}
2 : R : 25	2.13	3.92	3.36	3.71	3.28 ^{b. L}
4 : 0 : 25	2.25	3.79	3.88	3.53	3.36 ^b
4 : R : 25	2.35	4.31	3.88	4.27	3.70 ^{ab. 2}
6 : 0 : 25	2.37	4.65	4.05	3.71	3.69 ^{ab}
6 : R : 25	2.31	4.26	3.97	2.67	3.30 ^b
0 : 0 : 0	2.99	4.30	3.79	3.02	3.52 ^{ab}
Mean	2.40 ^{c. L}	4.33 ^{a. 1}	3.79 ^{b. 2}	3.62 ^b	GM=3.54
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	0.331	**	27.29		
Replication (B)	0.287	**			
Treatment (C)	0.498	ns			
A*B*C	-				
S. E.	0.250				

*, difference of means is significant at 5% level; **, difference of means is significant at 1% level; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Table 3. Change in percent nitrogen content in the soil of the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	0.168	0.189	0.185	0.156	0.174 ^{a. 1}
0 : R : 25	0.143	0.173	0.189	0.146	0.163 ^{ab}
2 : 0 : 25	0.164	0.155	0.185	0.151	0.164 ^{ab}
2 : R : 25	0.140	0.153	0.168	0.146	0.152 ^{b. L}
4 : 0 : 25	0.148	0.149	0.193	0.141	0.158 ^{ab}
4 : R : 25	0.154	0.164	0.193	0.162	0.168 ^{ab}
6 : 0 : 25	0.155	0.174	0.202	0.146	0.169 ^{ab. 2}
6 : R : 25	0.152	0.162	0.198	0.116	0.157 ^{ab}
0 : 0 : 0	0.181	0.164	0.189	0.132	0.166 ^{ab}
Mean	0.156 ^{bc}	0.165 ^{b. 2}	0.189 ^{a. 1}	0.144 ^{c. L}	GM=0.163
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	0.013	**	18.53		
Replication (B)	0.011	**			
Treatment (C)	0.019	ns			
A*B*C	-				
S. E.	0.009				

*, difference of means is significant at 5% level; **, difference of means is significant at 1% level; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Change in available phosphorus content

The four year's mean values on available phosphorus content are presented in table 4. The highest mean available phosphorus content (137.34 kg ha⁻¹) was found in the plots applied with lime @ 6 t ha⁻¹ along with chemical fertilizer and FYM. There was no significant difference between the treatments.

In general, the plots applied with chemical fertilizer had higher content of available phosphorus. In the year wise comparison of the means, the maximum amount of available phosphorus (178.04 kg ha⁻¹) was found observed in the first year (2064) and reduced significantly in the following two years and increased significantly (135.18 kg ha⁻¹) in 2067. These results showed positive correlation between higher pH and availability of available phosphorus (Table 1). In acidic soil, phosphate binds with Fe and Al and forms iron and aluminum phosphate, which is unavailable to plant.

Table 4. Change in status of available phosphorus (kg ha⁻¹) in the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	205.00	85.00	55.50	109.37	113.72 ^{ab}
0 : R : 25	199.87	95.67	58.10	167.47	130.28 ^{ab.2}
2 : 0 : 25	187.90	94.00	55.87	133.19	117.74 ^{ab}
2 : R : 25	172.57	92.00	57.23	133.30	113.77 ^{ab}
4 : 0 : 25	142.87	93.67	53.80	123.07	103.35 ^{b.L}
4 : R : 25	239.27	100.33	60.52	129.70	119.79 ^{ab}
6 : 0 : 25	174.27	96.33	53.68	95.73	105.00 ^b
6 : R : 25	169.10	96.33	55.04	228.90	137.34 ^{a.1}
0 : 0 : 0	162.23	111.67	51.27	95.90	105.27 ^b
Mean	178.04 ^{a.1}	96.11 ^c	55.67 ^{d.L}	135.18 ^{b.2}	GM=116.25
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	19.79	**	51.31		
Replication (B)	17.14	*			
Treatment (C)	29.69	ns			
A*B*C	-				
S. E.	14.95				

*, significant; **, highly significant; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K: Lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Table 5. Change in status of available potassium (kg ha⁻¹) in the experimental site

Treatment ^K	Year				Mean ^L
Lime : RDCF : FYM	2007	2008	2009	2010	
0 : 0 : 25	173.50	145.60	93.88	100.94	139.16 ^{bc}
0 : R : 25	178.13	172.00	122.70	190.23	203.96 ^{ab}
2 : 0 : 25	195.50	149.33	140.27	151.76	175.36 ^{abc}
2 : R : 25	130.47	214.67	144.73	213.24	216.05 ^{a.2}
4 : 0 : 25	105.70	169.67	97.67	112.58	135.34 ^{bc}
4 : R : 25	75.57	248.33	143.30	208.90	207.80 ^a
6 : 0 : 25	169.90	143.00	120.00	136.00	158.31 ^{bc}
6 : R : 25	96.70	279.67	123.47	207.48	221.46 ^{a.1}
0 : 0 : 0	101.30	152.00	112.73	98.37	118.76 ^{bc.L}
Mean	136.31 ^c	186.03 ^{b.2}	122.08 ^{c.L}	257.72 ^{a.1}	GM=175.13
	LSD (0.05)	F-test	C.V. (%)		
Year (A)	38.29	**	53.25		
Replication (B)	33.16	ns			
Treatment (C)	57.43	*			
A*B*C	-				
S. E.	28.93				

*, significant; **, highly significant; ns, not significant; Q, means in the column (treatment mean) with similar letters are not significantly different by LSD (0.05); , means in the row (year mean) with similar letters are not significantly different by LSD (0.05); ^K, lime (t ha⁻¹): Recommended dose of chemical fertilizer (N:P₂O₅: K₂O ha⁻¹): FYM (t ha⁻¹)

Change in available potassium content

The four years' mean values on available potassium are presented in table 5. The highest amount of available potassium ($221.46 \text{ kg ha}^{-1}$) was found in the plots applied with lime @ 6 t ha^{-1} along with chemical fertilizer and FYM. The lowest amount of available potassium content ($118.76 \text{ kg ha}^{-1}$) was found in controlled plots (without application of lime, fertilizer and manure). The plots applied with chemical fertilizer had significantly higher content of available potash. The year-wise comparison of means showed that the available potash content significantly increased from the base year 2064 ($136.31 \text{ kg ha}^{-1}$) to 2065 ($186.03 \text{ kg ha}^{-1}$) reached maximum ($257.72 \text{ kg ha}^{-1}$) in 2067. These results indicated that available potassium can be increased by balance application of lime, chemical fertilizer and farmyard manure.

CONCLUSION

- The pH of the soil increased from 5.17 to 5.61 (0.44 units up), when lime applied @ 6 t ha^{-1} in acidic soil of Malepatan. The application of lime @ $4\text{-}6 \text{ t ha}^{-1}$ is sufficient to raise the pH of acidic soil.
- The available phosphorus and potassium found the highest ($137.34 \text{ kg ha}^{-1}$ and $221.46 \text{ kg ha}^{-1}$, respectively), when agricultural lime applied @ 6 t ha^{-1} . However, the trend of phosphorus content of the soil found to be decreasing with time whereas, that of potassium was increasing.
- The percent organic matter and the nitrogen content of the soil found the highest (3.87% and 0.174%, respectively), when farmyard manure alone applied @ 25 t ha^{-1} in the soil. The percent organic matter content of the soil can be increased through the use of higher dose of organic manure that also enhances the fertility of soil.

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Response of Different Organic Manures on Fresh Cherry Yield of Coffee

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ABSTRACT

A three year (2008-2010) collaborative study was conducted on response of organic manures on fresh cherry yield of coffee at Agriculture Research Station (Horticulture), Malepatan, Pokhara. Farm yard manure (FYM), pig litter, mustard oil cake and poultry manure were evaluated on four coffee varieties (Pacamara, Pacas, Tekisic and Chhetradeep). Poultry manure @ 5 t ha⁻¹ gave the highest fresh cherry yield (1805.85 kg ha⁻¹) followed by mustard oil cake @ 2.5 t ha⁻¹ (1731.83 kg ha⁻¹), pig litter @ 10 t ha⁻¹ (1538.24 kg ha⁻¹) and FYM @ 10 t ha⁻¹ (1458.77 kg ha⁻¹). However, the differences were not significant. The highest mean yield of fresh cherry (2290.14 kg ha⁻¹) was found in 'Tekisic' variety followed by Chhetradeep (1683.76 kg ha⁻¹), Pacas (1520.12 kg ha⁻¹) and Pacamara (1040.66 kg ha⁻¹). The 'Tekisic' variety and 'Chhetradeep' (locally grown coffee) recorded as promising coffee varieties for the fresh cherry production under Malepatan conditions.

INTRODUCTION

Coffee, a evergreen and perennial shrub, which is a new cash crop cultivating since 1995 B.S. (Devkota 2061) in the hilly districts of western and central region of Nepal. The province 'Kaffa' in Ethiopia is considered to be the original habitat of Arabica coffee. In high value plantation commodities like coffee, there is a very good scope for organic farming. It has high potential to get higher returns from unit quantity exported, when produced by organic means (CCRI 2000). More than 270 mt of coffee was exported during last fiscal year (2010/2011) from Nepal to abroad on the understanding of organic-based production.

The productivity of green bean coffee in Nepal is 300 kg ha⁻¹, which is very low as compared to other countries (Dhakal 2061). The area under coffee cultivation is increasing each year and more than 25000 farmers are involved in the coffee farming. The total area and production (parchment) during the F.Y. 2066/067 were 1630 ha and 417 mt, respectively (NTCDB 2068). The production of coffee is not enough to run the existing coffee-based industries smoothly. Shrestha (2004) expressed that lack of research, unavailability of high quality sapling of coffee of known origin have become major constraints to increase the productivity and quality of coffee. Among different species of coffee, only the Arabica coffee is performing well under Nepalese conditions.

Coffee is grown on hilly ranges coming under high rainfall regions (CCRI 2000). Arabica coffee prefers a deep, well drained, slightly acidic loamy soil, rich in humus and exchangeable bases, particularly potassium. The total amount of phosphorus seems to be of less importance (Wrigley 1988). Therefore, there is suitable climate and soil existed for the better organic coffee farming in Nepal. In addition to soil and climate, it is necessary to identify the efficacy of type and amount of organic manures for better coffee production. Thapa et al (2009) reported that the most efficient combination of organic manure and chemical fertilizers for proper plant growth and development of

coffee was the application of FYM @ 10 t ha⁻¹ + N:P₂O₅:K₂O :: 100:30:60 kg ha⁻¹, respectively. Keeping these points in view, Agriculture Research Station (ARS), Horticulture at Malepatan, Pokhara in collaboration with National Tea and Coffee Development Board (NTCDB) conducted a study on "Response of different organic manures and varieties on fresh cherry yield of coffee" at Malepatan conditions during the years 2065-2067 BS with the objectives to identify effective organic manure for increases fresh cherry production of coffee and to identify the high yielding varieties of coffee.

MATERIALS AND METHODS

The characteristics of research site are as follows – site: ARS (Hort.) Malepatan, Pokhara, Kaski; altitude: 848 masl, aspect: south-west, plain; latitude: 28° 13' 6.18'' N; longitude: 83° 58' 27.72'' E; maximum temperature (2066 BS) : 32.0°C (June); minimum temperature: 7.6°C (January); Annual precipitation: 3323.8 mm (highest in August i.e., 1026.2 mm). About 80 percent rainfall occurs within four months (June to September) of rainy season. The site sometimes receives hailstone damages from February to May.

The experimental plots were laid out in factorial randomized complete block design in four replications covering 2500 m² of land under shade (Litchi plantations) during Mangsir, 2062. The size of each pits prepared was 0.45 m x 0.45 m at the distance of 2.0 m and 256 pits prepared in total. These pits were filled with four types of organic manures (farmyard manure, pig litter, mustard oil cake and poultry manure) as treatments given below. Manure was applied on the basis of 2000 plants per hectare. Seedlings of four varieties of coffee were planted during Chaitra, 2062. The preliminary cherry bearing was observed for the first time in the year 2064. Data of fresh cherry yield was collected for three years (2065-2067) and analyzed with the help of STATISTIX and MSTAT-C.

Varieties

V₁ – Pacamara
V₂ - Pacas
V₃ - Tekisic
V₄ - Chhetradeep

Treatments

T₁ - FYM @ 5.00kg/plant (10.00 t ha⁻¹) as control
T₂ - Pig litter @ 5.00 kg/plant (10.0 t ha⁻¹)
T₃ - Mustard oilcake @ 1.25 kg/plant (2.5 t ha⁻¹)
T₄ - Poultry manure @ 2.50 kg/plant (5.0 t ha⁻¹)

RESULTS AND DISCUSSION

Effect of treatments on fresh cherry yield of coffee

The effect of different treatments was not significant (Table 1). However, the maximum yield of fresh cherry (1805.85 kg ha⁻¹) was found in the treatment with poultry manure @ 5.0 t ha⁻¹ followed by mustard oil cake @ 2.5 t ha⁻¹ (1731.83 kg ha⁻¹). The minimum cherry yield (1458.77 kg ha⁻¹) was in the control treatment (FYM @ 10.0 t ha⁻¹). The mean values on fresh cherry yield due to application of mustard oil cake and poultry manure observed the higher than grand mean (i.e., 1633.67 kg ha⁻¹). The results, though not statistically significant, indicates that application of mustard oil cake and poultry manure could be better in fresh coffee production compared with farmyard manure and pig litter.

Effect of varieties on fresh cherry yield of coffee

The mean values on fresh cherry yield of coffee of different varieties for three years are presented in table 1. Mean yield varied from 1040.66 kg ha⁻¹ to 2290.14 kg ha⁻¹. Varietal response to fresh cherry yield was highly significant. The variety Tekisic gave the highest fresh cherry yield (2290.14 kg ha⁻¹) followed by the locally grown variety Chhetradeep (1683.76 kg ha⁻¹). The lowest yield (1040.66 kg

ha⁻¹) was found in Pacamara. Thus, coffee variety 'Tekisic' and local coffee 'Chhetradeep' were found promising for the fresh cherry production of coffee at Malepatan conditions.

Table 1. Fresh cherry yield⁺ of coffee varieties under different manuring

Variety/Treatment	Fresh cherry yield of coffee (kg ha ⁻¹)				Mean
	Pacamara	Pacas	Tekisic	Chhetradeep	
FYM @ 10 t ha ⁻¹ /Control	792.9	1534.7	1828.0	1682.5	1458.8
Pig litter @ 10 t ha ⁻¹	1204.2	1326.2	1930.9	1691.7	1538.2
Mustard oil cake @ 2.5 t ha ⁻¹	1163.9	1544.1	2583.3	1636.0	1731.8
Poultry manure @ 5.0 t ha ⁻¹	1001.7	1678.4	2818.5	1724.8	1805.9
Mean	1040.7c	1520.1b	2290.1a	1683.8b	
	LSD (0.05)	F-test	CV (%)		
			44.83		
Year (A)	371.7	**			
Replication (B) ⁰	429.2	ns			
Variety (C)	429.2	**			
Treatment (D)	429.16	ns			
S. E.	217.49				

+, Mean values for 3 years (2065, 2066 and 2067); **, Difference of means is significant at 1% level; ns, not significant; , Means in the row (variety mean) with similar letters are not significantly different by LSD (0.05); 0: Means due to replications are significantly different by LSD (0.10)

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Evaluation of Indigenous Buffalo for its Genetic Improvement by Participatory Approach

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ABSTRACT

Productive and reproductive performance evaluation of indigenous buffalo (Lime and Parkote) was carried out in Deupur of Parbat and Dhampus of Kaski district during 2009 to 2011. A total of 86 lactating animals were used for this study. Productive and reproductive parameters such as average daily milk yield, total lactation milk yield, age at first service, age at first calving, service after calving, calving interval were recorded and found to be 3.19 ± 0.105 lit, 975.5 ± 32 lit, 2.9 ± 0.63 years, 3.88 ± 0.64 years, 3.09 ± 3.57 months, 13.82 ± 3.98 months, respectively. The major calving season was August-September. The sex ratios of male and female calves were found 33.73% and 60.47%, respectively. Majority of the farmers were found to be keeping buffaloes from first to fourth parity for milk production in their households. The minimum and maximum milk yield per lactation (305 days) was recorded to be 399.5 to 2008 lit. The variation in productivity of indigenous buffalo can be best utilized by adopting selection procedure for its genetic improvements.

INTRODUCTION

Buffalo is an integral component of Nepalese agricultural system, having multipurpose uses providing milk, meat and draft power and significantly contributing in agriculture gross domestic product (AGDP). Apart from these, it has several other uses such as hides, bones and hairs. The skins are the major sources of income for leather and bone industries as well as foreign earnings of the nation (Neopane et al 2007). The domestic buffalo (*Bubalus bubalis*) belongs to the family *bovidae*, sub-family *bovinae*, genus *bubalis* and species *arni* or wild Indian buffalo is indicated by their species name. The water buffalo includes two subspecies named the river type (*Bubalus bubalis bubalis*; $2n=50$) and the swamp type (*Bubalus bubalis carabensis*; $2n=48$), which were domesticated approximately 5000 years ago (Rife 1962). It is one of the world's top producers of milk, more than half of the milk is produced on small farms by buffaloes. Such farms constitute a significant part of agriculture and 60-80% of the Asian population is affiliated with farming. As the human population increases the buffalo holds great promise and potential for meeting the required milk and meat production (Cockrill 1981).

Buffalo alone contributes about 52% of livestock share in National GDP (Shrestha et al 2003, APP1995), about 65% in meat production (Banstola et al 2006) and about 70% in milk production (Rasali and Crow 1999) which are equivalent to 987 thousand mt of milk and 157 thousand mt of meat (AICC 2010/11). It is the main source of animal protein (25%) rather than goat, sheep, pig and poultry (Bastola et al 2006; NDRI 1995). Demand of buffalo meat has been increasing throughout the

world due to its high content of lean meat and less amount of cholesterol (<46%) compared to chevon (58%) and mutton (68%) (Sinclair et al 1982, Bastola et al 2006). In spite of ever increasing demand,

production and supply of buffalo meat is very poor and inadequate.

Nepal has a population of 4.49 million heads of buffalo (AICC 2010/11), about 66% of these buffaloes are scattered over the mountains and hills, although most of them can be found in the middle mountains and hills of the Western region, they all are indigenous (non-descriptive type) breed (Rasali and Crow 1999). The indigenous buffaloes, which make up the majority of buffalo population in the western hills, are said to be true-to-breed types, namely Lime and Parkote. Previously, Lime was thought to be swamp type with 48 chromosomes. Study conducted at Agricultural Research Station, Lumle revealed that both of these types are of riverine buffaloes consisting of 50 chromosomes (2n=50) (Rasali and Patel 1998). Within these types, there is tremendous variation in milk production and other reproductive performance. This variation in productive and reproductive performance can be utilized by selective breeding scheme through participatory breeding approach for genetic improvement in buffalo.

MATERIALS AND METHODS

Altogether two indigenous buffalo raising sites were selected in consultation with respective District Livestock Service Office (DLSO) of Kaski and Parbat. Households having at least one buffalo (lactating and pregnant) were selected for recording. A total of 86 buffaloes comprising of 16 in Dhamphus of Kaski and 70 buffaloes in Deupur of Parbat district were included with their owners in two consecutive years for recording of productive and reproductive performance record. A semi-structural questionnaire format was developed and asked verbally to participatory farmers to know the information on productive and reproductive performance. A one and half day training was provided to all the participatory farmers on theoretical and practical aspects of registration, tagging, recording of productive and reproductive performance and participatory selection of superior buffalo. All the selected buffaloes were registered and tagged. Milk yield was recorded at monthly interval. Received information was analyzed through SPSS statistical package version 16.

RESULTS AND DISCUSSION

Productive performance

Breed: There are two types of indigenous buffalo breeds found in western hills (Fig. 1). Among them Lime are the predominant buffalo breed found in western hills where as population of Parkote breed are very low compared to Lime and intermediate crossbred between these two breeds.

Indigenous breed of buffalo

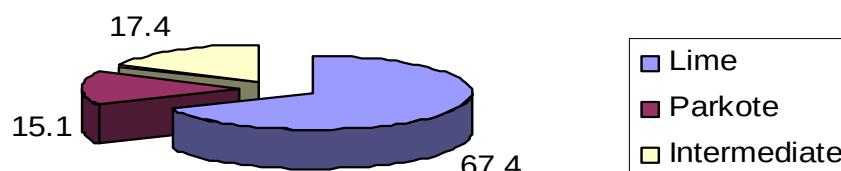


Figure 1. Ration of indigenous breed of buffalo.

Milk yield: Total milk yield of indigenous buffaloes was found to be ranged from 399.5 to 2008 litres per lactation of 305 days. The mean lactation yield was found to be 975.5 ± 32 litres with an average of 3.2 litres per day. Similar findings with significant variation in milk of indigenous buffalo were also reported by Rasali (1996), Amatya et al (2000) and Shrestha et al (2003). The significant variation in milk yield can be best utilized through selective breeding procedure which is one of the major tools for genetic improvement.

Table 1. Milk yield of indigenous buffalo

Milk yield	Quantity (litre)
Maximum	2008.1
Minimum	399.5
Mean	975.5 ± 32
Average daily milk yield	$3.2 \pm 0.1.5$

Reproductive performance

Calving month: The calving pattern of indigenous buffalo is given in Fig. 2. The calving season spans between Jeshtha to Magh with peak calving during Srawan to Ashoj. The frequencies of calving were found lower in other months. Although the calving has been occurred throughout the year, Falgun, Chaitra and Baishakh (mid February to mid April) months were not reported by the farmers. The calving of the indigenous buffaloes is found similar with the finding of Shrestha et al (2003) and Joshi et al (2001).

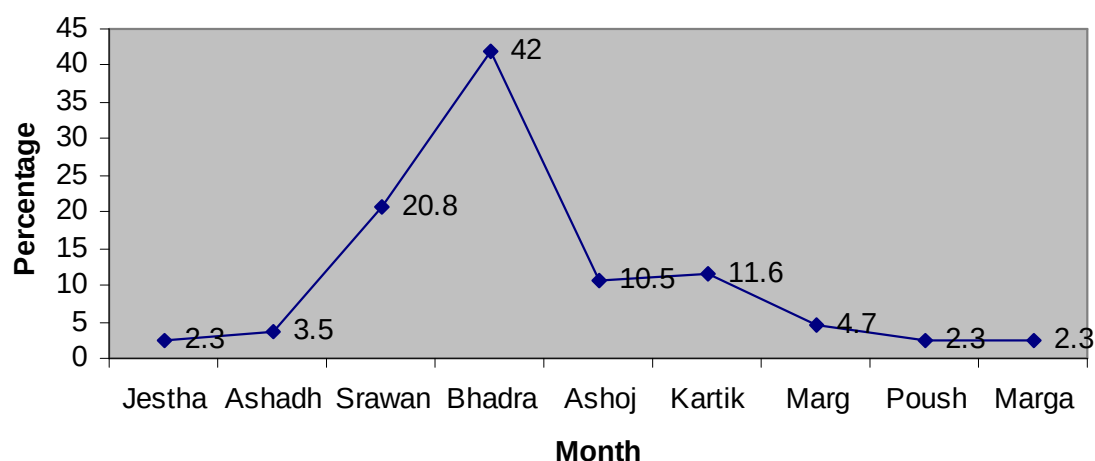


Figure 2. Calving pattern of indigenous buffaloes in western hills

Sex ratio of calf: An attempt was made to know the ratio of male and female calf born from indigenous buffaloes in sampled population. The number of female calf was found higher (60.47%) than male (33.73%) with 5.82% dead calves (Fig. 3).

Sex Ratio of Calf

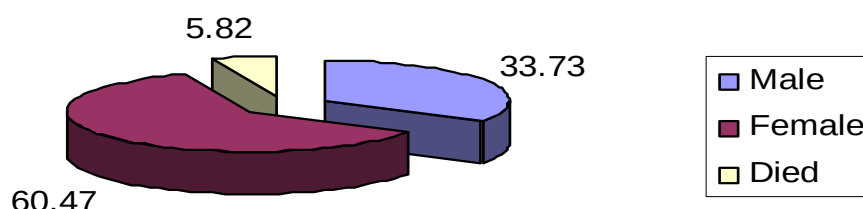


Figure 3. Sex ratio of buffalo calves

Parity: Parity is regarded as the most crucial factor for milk production. An attempt was made to know the parity of buffalo raised by the participatory farmers in sampled population. Majority of buffaloes were found between third to fourth parity, however, buffaloes were found with first to thirteenth parity in the sample population.

Other reproductive performance

Age of buffalo was found between the ranges of three to twenty years with first to thirteen parity in the sample population. A large variation in the age at first service was found and ranged between 1.5

to 4 years. The mean age at first service was found to be 2.90 ± 0.63 years. Similarly, the variation was also shown in age at first calving with the range from 2.50 to 5 years with mean age of 3.89 ± 0.64 years. Service after calving was found to vary between 0.66 to 12 months with an average of 3.1 ± 3.57 months. The first calving interval varied between 10 and 24 months. Longer calving intervals were found to be associated with higher lactation yield. Such association was expected since prolonged calving intervals were the results of long lactation period, probably due to late conception, which was directly influenced by feeding, management and heat detection practices. Hence, the reduction in calving interval can be achieved through better management, nutrition and feeding.

Table 2. Some reproductive parameters of indigenous buffaloes

Particulars	N	Minimum	Maximum	Mean	Std. Deviation
Age (year)	82	3.00	20.00	7.4268	2.85355
Age at 1 st service (year)	78	1.50	4.00	2.9000	0.63307
Age at 1 st calving (year)	79	2.50	5.00	3.8861	0.64026
Service after calving (months)	70	.66	12.00	3.0971	3.56902
Calving Interval (months)	70	10.00	24.00	13.8214	3.98188

In brief, there are three indigenous buffalo breeds that have been identified and characterized so far throughout the country. They are Gaddi, Lime and Parkote. Among these, Lime and Parkote breeds are found in western hills. The variability within the indigenous buffaloes in terms of milk production, age in first service, age at first calving and calving interval were found to be very high. There is clear indication that this variation can be best utilized by selective breeding for genetic improvement. In addition to this, implementation of artificial insemination is immense need to collect the superior bull's semen and providing it in best performer buffaloes for conservation and genetic improvement.

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Productive and Reproductive Performance of High Grade Jersey Cattle in RARS, Lumle Farm

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ABSTRACT

The productive and reproductive performances of high grade Jersey cattle were studied in livestock farm of Regional Agriculture Research Station, Lumle. The cattle had been maintained on-station with basal diet of commercial feed, locally available grass and a supplementary grazing for 3 hours per day. A total of 57 full lactation records from 20 cows spread over 11 years were used for this study. Productive and reproductive performance records of the animals - age at first mating, age at first calving, gestation periods, calving interval, lactation length, dry period, lactation yield and peak yield were recorded as per the standard format. The age at first mating, age at first calving, calving interval, gestation period and calf birth weight were found to be 684.4 ± 20.5 days, 989.7 ± 25 days, 399.5 ± 15.3 days, 278.65 ± 0.78 days and 22.114 ± 0.39 kg, respectively. The sex ratios of calves produced were 56% male and 44% female. The conception rate of artificial insemination (AI) was 70.18% in the first insemination. The major mating months were Asar (June-July) and Kartik (October-November) and calving months were Shrawan (July-August) and Chaitra (March-April) with 15.79, 15.79, 14.04 and 17.54% mating and calving on these months, respectively. The average lactation yield, average daily milk yield, peak milk yield, days to peak milk yield, lactation length and dry period were found to be 2386.7 ± 91.2 lit, 6.9 ± 0.23 lit, 12.06 ± 0.38 lit, 38.47 ± 5.02 days, 349.63 ± 9.42 days and 47.26 ± 8.21 days, respectively. The correlation between first lactation milk yield and second lactation was found to be 0.492 ($P < 0.074$) and second and third lactation 0.677 ($P < 0.065$).

INTRODUCTION

Nepal is an agricultural country where livestock farming has been developed as integral part of agriculture. About 65.6% of the total population depends on agriculture (ABPSD 2008/09). Agriculture is the mainstay of economy, providing a livelihood for three-fourths of the population and accounting for 38% of Gross Domestic product (GDP). Livestock, as a whole, constitutes an important sub-sector in the economy, contributing about 32% share to the total agricultural gross domestic product (AGDP) and milk alone contributes nearly half of the total livestock GDP and 6% to the total gross domestic product (Pradhan et al 2007/08).

Cattle are one of the most important components of livestock in Nepal. There are 7.17 million cattle in the country (ABPSD 2008/09), out of which, 12% is exotic (pure or crossbred) and rest 88% is indigenous (Neopane and Pokharel 2005). In the Nepalese context, cattle are used for multipurpose uses; production of milk for human consumption, manure for increasing and maintaining soil fertility, bio-fuel production and draft power for agricultural operation and pack. The cattle are also important for every cultural and social values of Hindu culture, mostly milk, ghee and urine are used. More than 75% of households in the country are keeping cattle for their multiple functions (Neopane and Pokharel 2005). Cattle are important livestock species which comes second next to buffalo in terms of contributing to the total livestock GDP.

Jersey cattle (*Bos taurus*) are one of the most valuable and popular European breeds of cattle and this breed has been widely used for upgrading of native stocks in Nepal. Historically, this breed were introduced in country with main objectives of improving genetic potentialities of indigenous cattle in 1917 Bikram Era in which the Rana regimes (Pradhan et al 2007/08). In Lumle farm also, Jersey cattle were initially introduced for improving genetic potentialities of indigenous cattle and thereafter for continuous grading up. Now, cattle maintained in Lumle have above 90% blood level of Jersey breed.

MATERIALS AND METHODS

In the initial period, the high grade Jersey cattle were produced through crossing of local cattle. Now in these cattle has above 90% blood level of Jersey. These cattle and their progenies maintained in the station have been used for this study. The cattle had been maintained on the station with basal diet of commercial feed, locally available grass and a supplementary grazing within 3 hours daily. Day to day on-station maintenance and management of these cattle their progenies have been performed with the routine works such as breeding, feeding, fodder collection, cleaning, weighing, milking, grooming etc. Productive and reproductive performance records of the animals i.e. age at first service, age at first calving, gestation periods, lactation length, dry period, lactation yield, peak yield etc. have been recorded as per standard format of 11 years data and analyzed in Minitab and MS Excel statistical package. Moreover, some required data regarding the study was taken as a secondary source of information from reliable books and journals.

RESULTS AND DISCUSSION

Reproductive performance

The performance record revealed that most of the animals were in first parity 35.09% and second to seventh parity animals were in continuous decline with 24.56, 15.79, 8.77, 7.02, 5.26 and 3.51%, respectively as depicted in Table 1.

Table 1. Number of animals in different parity

Parity number	Number of animal	Percent
1	20	35.09
2	14	24.56
3	9	15.79
4	5	8.77
5	4	7.02
6	3	5.26
7	2	3.51
Total	57	100

Breeding performance

Breeding performance is the most important aspect of cattle farming. When the breeding performances are superior that indicate the herd is more productive. The breeding performance of jersey cattle of Lumle farm is presented in table 2. The age at first mating, age at first calving, calving interval, gestation period and calf birth weight were found to be 684.4 ± 20.5 days, 989.7 ± 25 days, 399.5 ± 15.3 days, 278.65 ± 0.78 days and 22.114 ± 0.39 kg, respectively. The results are compared with the finding of ABD (2005) who reported that age at first mating 23 month, age of first of calving 32 month calving interval 15 months. Whereas, Acharya (2009) reported that age at first mating 18.08 months, age of the first calving 27.11 months and calving interval 11.97 months for jersey cattle, which is very close with the previous findings.

Table 2. Breeding performance

Parameter	Mean $\pm$ SE	Standard deviation	Minimum	Maximum
Age at first mating (days)	684.4 $\pm$ 20.5 (20)	91.9	493.0	810.0
Age at first calving (days)	989.7 $\pm$ 25 (20)	111.8	781.0	1162.0
Calving interval (days)	399.5 $\pm$ 15.3 (37)	92.9	310.0	854.0
Gestation period (days)	278.65 $\pm$ 0.78(57)	5.85	260	290
Calf birth weight (kg)	22.11 $\pm$ 0.39 (57)	2.961	14	30

Sex ratio of calves. The sex ratio of calves are presented in Figure 1. The proportion of male calves was more compared to the female.

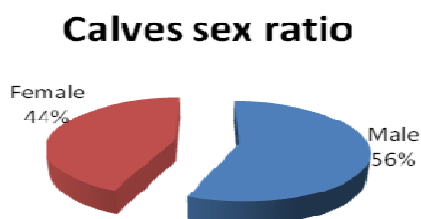


Figure 1. Calves sex ratio

Conception rate per parity through artificial insemination (AI)

In this farm, the conception rate of artificial insemination (AI) is 70.18% in the first insemination. This result was compared with the findings of Sah (2009) who reported only 54% conception rate in the first insemination, so this performance is better than national average.

Table 3. Conception rate per parity through artificial insemination (AI)

Time of frequency	Number of animal	Percent
1	40	70.18
2	12	21.05
3	4	7.02
4	1	1.75
Total	57	100

Mating season

The mating season of the Jersey cattle are presented in figure 2. Though the mating occurred whole

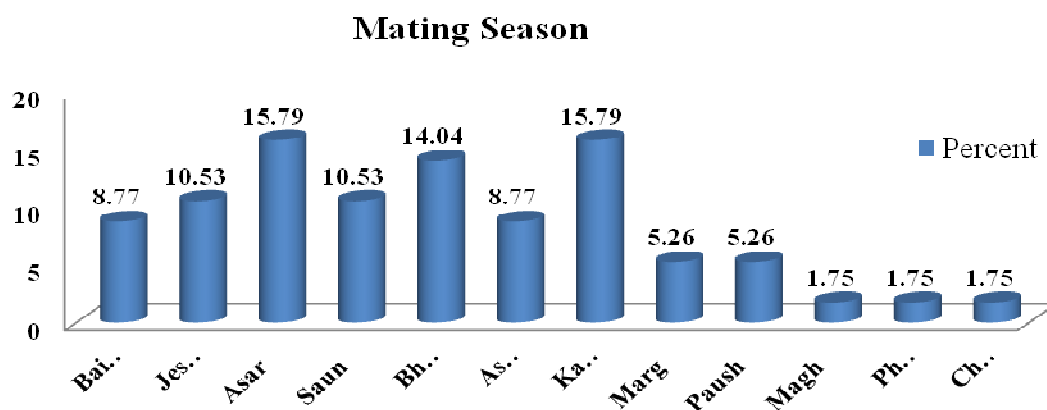


Figure 2. Mating season

the year the maximum number of the cattle did mate during the months from Baishakh to Kartik (March to October). In these months under the Lumle conditions temperature is higher as well as green fodder like white clover, Qui-qui, Setaria, Napier and different local grasses are available.

Calving season

The cattle are calving whole year round but Shrawan and Chaitra (July/Aug and March/April) had more number of animals calved with 14.04% and 17.54%, respectively (Figure 3).

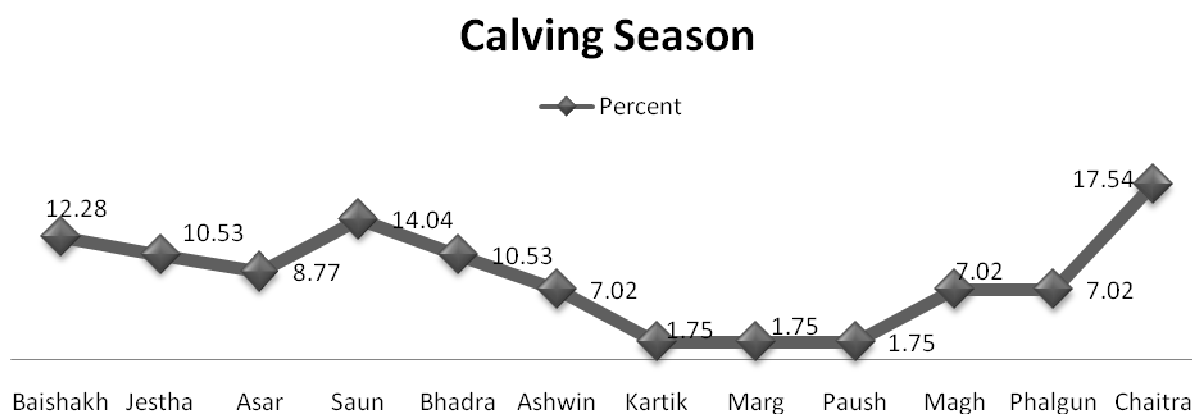


Figure 3. Calving season

Productive performance

The productive performance records found that (Table 4) the average lactation yield, average daily milk yield, peak milk yield, days to peak milk yield, lactation length and dry period were 2386.7 ± 91.2 lit, 6.9 ± 0.23 lit, 12.06 ± 0.38 lit, 349.63 ± 9.42 days and 38.47 ± 5.02 days, and 47.26 ± 8.21 days respectively. The correlation between first and second lactation milk yield was found to be 0.492 ($P < 0.074$) and it was 0.677 ($P < 0.065$) for second and third lactation. The results are comparable with the findings of Acharya (2009) who reported that peak milk yield per day was 17.35 ± 4.65 liter, average milk yield per day was 10.05 ± 3.28 liter and days of milking per lactation was 297.00 ± 33.97 days..

Table 4. Productive performance

Parameter	Mean $\pm$ SE	Standard deviation	Minimum	Maximum
Lactation yield (L.)	2386.7 $\pm$ 91.2 (57)	688.2	722.3	4299.3
Average daily milk yield (L.)	6.9 $\pm$ 0.23 (57)	1.737	2.01	10.26
Peak milk yield (L.)	12.065 $\pm$ 0.381 (57)	2.878	3.8	19.2
Days to peak milk yield (days)	38.47 $\pm$ 5.02 (57)	37.87	9	189
Lactation length (days)	349.63 $\pm$ 9.42 (57)	71.09	193	565
Dry period (days)	47.26 $\pm$ 8.21 (57)	59.76	0	453

In brief, the results obtained from this study indicated that Jersey breed has the promising potential to upgrade local cattle for genetic improvement and to increased productivity. If the animals are provided with required nutrition-green fodder and forage and concentrate, cattle can be bred whole year round. This breed also showed wide variation in productive and reproductive performance under Lumle farm conditions.

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Comparative Efficacy of Neem (*Azadirachta indica*) Leaves Extract and Ivermectin against Ectoparasites in Calves

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ABSTRACT

An experiment was carried out over a period of 6 months from June to November, 2006 to investigate the efficacy of Ivermectin (@ 200µg/kg body weight) injected subcutaneously and spray of 15% aqueous solution of Neem (*Azadirachta indica*) leaves against ticks in calves. A total of 15 calves, 5-6 months age, were examined for the presence of ticks by physical examination and were divided into three equal groups as, Group A (infected control group), Group B (treated with Neem) and Group C (treated with Ivermectin). Ticks infestation was examined physically on individual animal. The procedure of examination was to count the adult ticks of para-lumbar region with an area of 6×5 i.e. 30 square cm. All the calves were allowed to free pasture grazing for 2-3 hours daily. Water was also provided ad lib to all calves. The therapeutic efficacy of ivermectin and Neem was evaluated by counting the number of ticks dropped-off from the body of calves at definite intervals. Ivermectin treatment was 100% effective against ectoparasites in calves on day 7 and remained so on day 28 as well, whereas, spray of Neem leaves showed 68% efficacy at day 28. Effect of Ivermectin injection and Neem leaves spray was evaluated on certain blood parameters like hemoglobin (Hb), packed cell volume (PCV), total erythrocyte count (TEC) and erythrocyte sedimentation rate (ESR). The effects on TEC, Hb level was increased significantly at 7th, 14th, 21st and 28th day of treatment and PCV level was increased significantly on 28th day of treatment. All the calves after Ivermectin injection and Neem spray remained healthy with improvement on appetite, growth and hair coat color with no adverse effects.

INTRODUCTION

Ectoparasites in livestock are very common all over the world including Nepal and Bangladesh. The ectoparasites entirely live on blood and lymph of all kinds of vertebrate animal. The damages caused by ticks are irritation, inflammation, exudation of lymph which coagulates to form crusts. Ectoparasites, like ticks, play an important role as vector of deadly pathogens to animals and man. Mites cause dermatitis, alopecia and sometimes animals are infected secondarily by bacteria causing toxemia, septicemia and ultimately death of the animals.

Most of the farmers in Bangladesh cannot afford to buy modern medicine for the treatment of the livestock because of high price of the drug and poor economic condition of the farmers. Development of the traditional system of medicine in Bangladesh would be highly beneficial for the farmers and for the overall improvement of the livestock. Recently much interest in the field of medicinal plants has been grown throughout the world. Many countries have already realized that the medicinal plants have the vast therapeutic potential due to their availability and cost effectiveness. Various kinds of herbal extract showed larvicidal and acaricidal effects as reported by Chungsamarnyart and Jansawan (1991).

In developed countries the principles of controlling helminth parasites (Ecto) are based on pasture, barn management and protective treatments but in Bangladesh where animals are mainly maintained

in mixed farming system with virtually no pasture land for grazing, these methods have limitation to control parasites. So, protective treatments with routine dosing of anthelmintics and dipping with ectopesticides would be the choice of controlling the parasites in animals of Bangladesh. The present research is being conducted to study the efficacy of medicinal plant in veterinary practice. In Bangladesh, many drugs are being used for long time to combat parasitic infestation in livestock. A large number of anthelmintics are now available in the market. The indiscriminate use of anthelmintics made the parasites to be resistant against the drug, which have been reported by experts throughout the World including Bangladesh (Hannan et al 2001). So, we should have to back the traditional uses of medicines.

The Agro-ecological and geo-climatic condition of Bangladesh favors the survival, multiplication, spread and perpetuation of animal parasites. Moreover, animal management and managerial system play an important role in high degree of occurrence of parasitic disease in Bangladesh. There are several indigenous medicinal plants (Nath et al 1983, Mostofa 1983) have anthelmintic action and used against both ecto and endoparasites in Bangladesh (Mostofa 1983, Mannan et al 1997) India (Dutta and Hazarika 1976). There are various types of ivermectin which are imported from abroad and very costly, having side effects and they are not equally active on all stages of lifecycle of ectoparasites. Ivermectin stimulates the release of GABA from nerve ending and enhance binding of GABA to special receptors at nerve junctions.

Ivermectin subcutaneous injection preparation is easy to administration to the calf without any risk that is associated with any other routes of administration. Ivermectin was the safest and more effective for the treatment of endo and ectoparasites. The chemicals used against ectoparasites are hazardous for both man and animals.

Our poor farmers are illiterate; they can not apply insecticides on the animal body properly. In addition, there is no report on the toxic and residual effect of ivermectin injectable formulation. Therefore, the patent drug Ivomec® (Ivermectin) and locally available medicinal plant *Azadirachta indica* (Neem) was selected with the aim for comparative investigation of the efficacy of anthelmintic activity on ectoparasites and on some hematological parameters in calves. The present study also paid attention to study the adverse effect of the both treatment.

MATERIALS AND METHODS

The experiment was carried out for a period of 6 months from June to November, 2006 in the Department of Medicine and Department of Physiology of Bangladesh Agricultural University (BAU), Mymensingh. Fifteen calves of both sexes aged between 5 to 6 months were selected in this study. All the calves were examined for the presence of ectoparasites and the efficacy of Ivermectin and indigenous medicinal plant *Azadirachta indica* (Neem) were studied against these naturally infested ectoparasites. The calves were divided into 3 equal groups (Group A, B and C). Calves of group A was kept as infected control, rest into two groups i.e. B and C were treated with Neem spray and Ivermectin, respectively.

Neem leaves were collected from BAU campus and made 15% aqueous solution for spray in the selected animals. Saturated salt solution, normal saline (0.9%), anticoagulant sodium citrate (3.8%) Hayem's solution, (0.14%) Hydrochloric acid solutions were prepared following the standard procedures. The leaves were dried and powdered. Fifteen gm of leaf powder was mixed with 100 ml distilled water and stirred for 2 hours. It was kept overnight at 40°C and the supernatant was collected. This was used as the crude leaf extract to study. The ectoparasites (ticks) were detected by physical examination of the animals and the presence of ectoparasites was recorded. Ticks infestation was

examined physically on individual animal. The procedure of examination was to count the adult ticks of Para lumbur region with an area of 6×5 i.e. 30 square cm. The selected 30 square cm were marked with a permanent colour and ticks within this area were counted at pretreatment and post treatment days. Group A was considered as control group (no drugs given), group B and C were treated with Neem spray 15% and Ivermectin (Ivomec® 10%w/v, Merial, Bangladesh) @ 200µg/kg body weight S/C, respectively. After injection of Ivermectin and application of Neem, all calves (three groups) were closely observed for 28 days of post treatment and the considered parameters were (a) linical parameters (severity of infestation, feeding efficiency, conditions of hair coat and adverse effects). (b) Hematological parameters (TEC, Hb, PCV and ESR). All calves were allowed for free pasture grazing for 2-3 hours daily with *ad lib* water.

The severity of infestation of ectoparasites (ticks) was observed by counting the number of ectoparasites in a selected area of the individual calves. The ectoparasites were detected by visual examination of the calves and the number of parasites was recorded. The ticks within this area were counted at pre-treatment at day 0 and at 7th, 14th, 21st and 28th day treatment period. The adverse effects, if any on the treated calves were also examined before and after treatment. Hair coat of the treated calves as well as the untreated infested control group was physically examined by visual examination before and after treatment. Feeding efficiency of treated and untreated (infested control) groups was compared at pretreatment (0 day) and treatment (7th, 14th, 21st and 28th) period. Blood samples were collected from Jugular vein of the calves of treated and control group in vials containing anticoagulant (Sodium citrate 3.8%) at day 0, 7th, 14th, 21st and 28th of treatment period to determine the effects of ivermectin and Neem on the following hematological parameters such as total erythrocyte count (TEC), hemoglobin (Hb) content, packed cell volume (PCV) and erythrocyte sedimentation rate (ESR).

Total erythrocyte count (TEC)

Thomas red blood cell pipette was used for total erythrocyte count (TEC). The pipette was filled upto 0.5 marks with blood and diluting fluid (Hayem's solution) was then drawn till it reached the 101 mark. The contents were thoroughly mixed for 2 minutes. The dilution of the contents was 1:200. The counting chamber and cover slip were cleaned and dried properly. The cover slip was placed on the chamber in proper position. The content of the pipette was again shaken and 2 or 3 drops of the fluid were expelled. The chamber was then filled with the contents so that the fluid was flown under the cover slip by capillary action. The ruled area at the chamber was filled completely, taking care that excess did not run into the troughs and no air bubble appeared under the cover slip. The counting chamber was then placed under microscope and examined first with low power objectives (10X) to ensure that there was an even distribution of the cells. The cells were then counted with the aid of high power objectives (100X). The central squares of the counting chamber were counted in the far corner and one central square of the chamber. The counting and calculation of red blood cells were performed as per methods indicated by Coffin (1955). The number of RBC was calculated as follows: Number of RBC = No. of cell counted × 10,000 and the result was expressed in million/cu.mm.

Determination of hemoglobin (gm %)

The hemoglobin estimation was performed by the acid Haematin method with the Hellige Hemometer (Coffin, 1955). Hydrochloric acid (N/10) solution was taken in the special graduated tube upto its 20 mark. The special Sahli pipette was filled with well mixed oxalated blood upto 20 mark and blood on the side of the pipette was wiped out by cotton. The content of the Sahli pipette was expelled into the special graduated diluting tube and thoroughly mixed. The tube was then allowed to stand for 10 minutes for development of acid haematin. Distilled water was then added drop by drop and each time mixed with the help of stirring rod until the colour of the solution matched with the standard colour of the comparator. The result was read as per method described by Coffin (1955).

Packed cell volume (PCV)

The PCV was determined as per method described by Coffin (1955). The Wintrobe hematocrit tube was filled up with well-mixed blood by special loading pipette upto 10 marks. Then the tube was centrifuged at 3,000 rpm for half an hour and reading was taken.

Determination of erythrocyte sedimentation rate (ESR)

The collected blood sample was filled with the special loading pipette slightly above the '0' mm mark or '10' mark. The tip of the pipette was inserted to the bottom of the hematocrit tube and the blood was expelled by the pressure on the rubber bulb, withdrawn the pipette as the tube filled. Each tube was then placed in the special rack being certain that they were vertical. The tube was allowed to remain in the support without disturbance for an hour. The ESR value was determined as per the methods described by Coffin (1955).

Statistical analysis

Data obtained from the experiment were analyzed statistically using Student 't' test.

RESULTS AND DISCUSSION

A research work was conducted to evaluate the anthelmintic activity and certain blood parameters of *Azadirachta indica* (Neem) spray and Ivomec® Ivermectin in different treatment groups, including untreated control. In Group B, Neem at 15% spray was found to be 68% effective against tick infestation with the mean value of 12.20 ± 1.2806 . Ticks were decreased within the selected area on 7th, 14th, 21st and 28th day after the treatment on the other hand in control group A, the number of ticks increased gradually on 7th, 14th, 21st and 28th day of treatment. Group C were treated with Ivermectin at the dose rate of 200 µg/kg body weight subcutaneously showed 100% efficacy i.e. no ticks were found by physical examination on the 7th, 14th, 21st and 28th day of post treatment whereas, the rate of tick infestation was constant in the calves of group A. All the calves after Ivermectin injection and Neem spray remained healthy, no adverse effect was seen and calves appetite found increased.

The hair coat of the infested calves (group B and C) was rough with discolored wool on day 0. In group B and C, after treatment with Neem and Ivermectin, the hair coat started to become smooth and shiny gradually and on 28th day of treatment the hair coat of the treated calves were almost normal. The hair coat of the infested control group became more rough and discolored. In control group (A), TEC values was decreased upto 2.45% on 28th day of treatment. On the other hand, the TEC values were increased in Neem and ivermectin treated groups (B and C) to the extent of 5.20%-9.25% (Table 1). So TEC values were increased significantly in treated groups on 28th day of treatment.

Table 1. Effects of ivermectin and neem leaves on total erythrocyte count (TEC) (million/cu. mm) in calves

Group	Treatment	Pre-treatment '0' day	Post-treatment			
			7 th day	14 th day	21 st day	28 th day
A	Control	7.16±0.108	6.72±0.116 (6.55)	6.46±0.150 (4.02)	6.38±0.13 (1.25)	6.23±0.154 (2.45)b
B	Neem	6.47±0.156	7.476±0.074 (13.46)	8.91±0.213** (16.09)	10.068±0.078 (11.50)	10.62±0.186** (5.20)a
C	Ivermectin	6.8±0.084	8.32±0.128** (18.27)	9.046±0.072** (8.03)	10.364±0.162* (12.72)	11.42±0.169* (9.25)a

Values given above are mean ±SE of 5 calves; *, significantly increased (P<0.05); **, significantly increased (P<0.01); a, percent of increased a; b, percent of decreased b.

In control group (A), hemoglobin content was decreased upto 4.52% on 28th day of treatment. On the other hand, the hemoglobin contents were increased in treated groups B and C to the extent of 1.10-3.02%, respectively. So hemoglobin content was increased significantly in treated groups on 28th day of treatment (Table 2).

Table 2. Effects of ivermectin and Neem leaves on hemoglobin (Hb) content (gm %) in calves

Group	Treatment	Pre-treatment '0' day	Post-treatment			
			7 th day	14 th day	21 st day	28 th day
A	Control	6.58±0.420	7.082±0.197 (6.98)	6.62±0.180 (6.88)	6.88±0.193 (3.80)	6.59 ±0.168 (4.52)b
B	Neem	7.14±0.117	7.38±0.116** (3.25)	7.66±0.108** (3.66)	8.60±0.145** (10.97)	8.7±0.114** (1.10)a
C	Ivermectin	6.46±0.144	7.32±0.097** (11.75)	7.56±0.150** (3.17)	8.34±0.129* (9.35)	8.6 ± 0.195* (3.02)a

Values given above are mean ±SE of 5 calves; *, significantly increased (P<0.05); **, significantly increased (P<0.01); a, percent of increased a; b, percent of decreased b

In control group (A), PCV values was decreased upto 14.07% on 28th day of treatment. On the other hand, the PCV (%) values were increased in all treated groups (B and C) to the extent of 1.11-1.45% (Table 3).

Table 3. Effects of ivermectin and neem leaves on packed cell volume (PCV) (%) values in calves

Group	Treatment	Pre-treatment '0' day	Post-treatment			
			7 th day	14 th day	21 st day	28 th day
A	Control	28.99±0.909	29.63±0.259 (2.17)	29.2±0.251 (1.49)	26.44±0.267 (10.44)	23.18±0.295 (14.07)b
B	Neem	28.41±0.349	28.50±0.318** (0.34)	28.892±0.173** (1.33)	29.82±0.887 (3.11)	29.39±0.381 (1.45)a
C	Ivermectin	29.75±0.307	29.58±0.229** (0.57)	29.49±0.159** (0.31)	30.69±0.433** (3.93)	30.36±0.469** (1.11)a

Values given above are mean ±SE of 5 calves; **, significantly increased (P<0.01); a, percent of increased a; b, percent of decreased b

In control group (A), ESR (mm/1st hr) values was increased upto 5.19 on 28th day of treatment. On the other hand, the ESR (mm/1st hr) values were decreased in all treated groups of B and C significantly to the extent of 38.89-76.67 (Table 4).

Table 4. Effects of ivermectin and Neem leaves on erythrocyte sedimentation rate (ESR) (mm/1st hr)

Group	Treatment	Pre-treatment '0' day	Post-treatment			
			7 th day	14 th day	21 st day	28 th day
A	Control	0.944±0.019	1.034±0.012 (9.28)	1.404±0.017 (26.35)	1.828±0.026 (23.19)	1.928±0.033 (5.19)a
B	Neem	0.118±0.011	0.0854±0.014 (41.69)	0.060±0.004** (42.33)	0.050±0.007 (20.00)	0.036±0.011** (38.89)b
C	Ivermectin	0.146±0.010	0.11 ±0.009 (30.91)	0.0916±0.021** (20.09)	0.083±0.013* (10.36)	0.030±0.007** (76.67)b

Values given above are mean ±SE of 5 calves; *, significantly increased (P<0.05); **, significantly increased (P<0.01); a, percent of increased a; b, percent of decreased b

The present findings support the earlier observation of Ninkov and Savin (1986), Nettleton and Beckett (1976) and Sangwan et al (1995) who reported 90% to 100% efficacy of ivermectin against tick infestation in calves. It was seen that no ectoparasites were present on body of animal after 7th day to the end of experiment (28th day post treatment). The hematological changes in calves affected

with the ectoparasite were determined at pre and post treatment period dosed with Neem and Ivermectin. The mean value of haemoglobin was decreased in the ectoparasites affected calves (control group). The results are in agreement with the reports of Nettleton and Beckett (1976) and Anosa (1977). In the present study significant changes in Hb, gm% and PCV% were observed in the treated group of calves and this might be due to expulsion of blood sucking and other parasites and ectoparasites from the body. The significant reduction in the sedimentation rate of erythrocytes in successfully treated group was observed and this may be due to recovery from inflammation in ectoparasites, which was produced by ectoparasites. Anil and Joshi (1992) found increase on Hb gm% level in Ivermectin-treated calves.

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Growth and Reproductive Performance of Goat of Chitwan District

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ABSTRACT

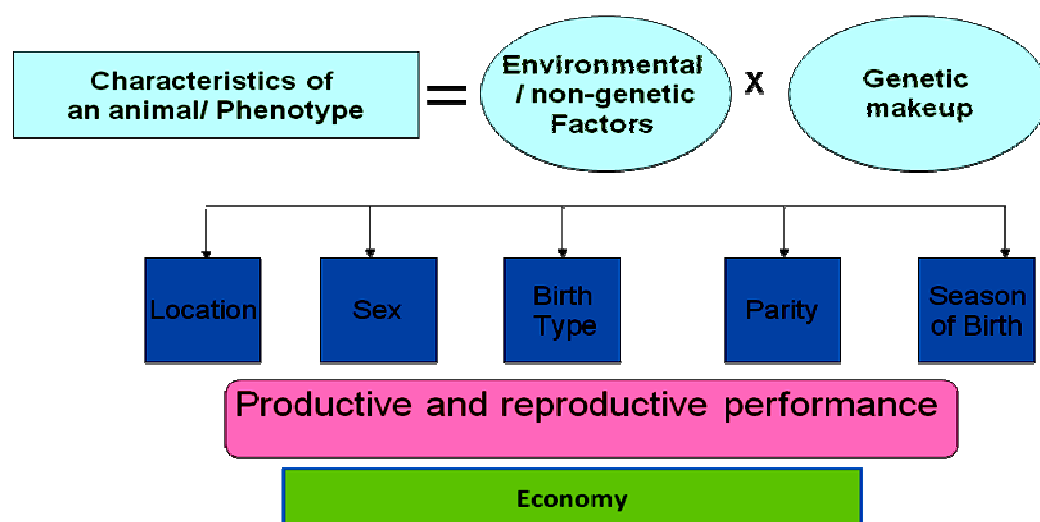
A field study was carried out to find out the productive and reproductive performance of goats of Chitwan district under on farmers' managed conditions from June 2006 to February 2007. Altogether, 122 kids of various age group and 60 does of different parity were taken for the study purpose. Data on productive and reproductive traits were collected through direct recording and periodic observations. The data were analyzed using Harvey (1990) statistical package based on least square means of variance analysis for unequal sub-class as suggested by Henderson (1953). The findings revealed that goat in Chitwan district had 211 ± 13 , 356 ± 13 , 147 ± 0.91 , 236 ± 12 and 87 ± 6 days of age at first conception, age at first kidding, gestation length, kidding interval and post-partum estrus, respectively. The mean body weight of adult does was 31.07 kg. Accordingly, birth weight, weaning weight (4 months) and post weaning weight (8 months) were 2.48 kg, 13.22 kg and 17.64 kg, respectively. Mean daily weight gain from birth to two months age, two months to weaning age, weaning age to 6 months and 6 months to eight months were 91.4, 92.3, 60.7 and 67.4 gm, respectively. Comparatively shorter age at first kidding, lower kidding interval and post-partum estrus as well as better growth performance of Chitwan goats indicate the scope of improvement utilizing these goats.

INTRODUCTION

Goat is a multipurpose livestock species and one of the principal livestock commodities in Nepal contributing about 4% to the total Agricultural GDP (MOAC 2011). Goat rearing is a low input demanding enterprise and can play important role in poverty alleviation. Goat plays crucial role in the household economy of the Nepalese farmers.

The estimated population of goat in Nepal during the year 2010/2011 was 9.2 million with the distribution of about 28.6% in central region. In addition, the estimated population of goat in Chitwan district is 184,016. The share of the meat in agriculture GDP is 13.5% (MOAC 2011). Goat shares about 20% of the total meat production of the nation (MOAC 2011) which ranks to second among the livestock species for meat production. Goat meat is acceptable for all religious groups and is preferred over other meat (Dhakal et al 1985). However, demand of the goat meat has not been fulfilled from the domestic production. A large number of live animals are imported annually from India mostly for slaughter.

Within the local population of goats, there appears to be wide genetic variation, which is based on the principle that phenotype is related to the genetic makeup and associated environment (non-genetic factors).



The present study was undertaken to reveal the growth and reproductive performances of goats of Chitwan district and help to find out the key issues regarding goat production systems focusing for the inner-terai region of Nepal.

MATERIALS AND METHODS

This study was carried out between May 2006 to January 2007 at two sites of Chitwan district namely: Krishnapur-6 and Gitanagar-1; identified on the basis of goat pocket area by District Livestock Service Office (DLSO), Chitwan. This district has sub-tropical types of monsoon and relatively high humidity (>90%) with average annual temperature of 25°C (data source: National Maize Research Program, Rampur, Chitwan). Primary data were collected on the basis of direct recording and observation at the identified households. Primary information was also collected through household survey with the help of semi-structured questionnaire techniques to the identified key informants. Besides, secondary information was collected from published literatures. The participant farmers whose goats were studied under this research were considered as total study population. Within the population, sampling goats were identified randomly and the sampled animals were the does (focusing the advanced date of kidding and known parity) available on the research sites with their respective male and female kids from birth to three months age the kids were weighed and measured monthly up to eight months. Measured attributes include productive parameters (body weight, wither height, body length and heart girth) of both does and kids. Reproductive parameters such as age at first conception (AFC), age at first kidding (AFK), gestation length (GL), kidding interval (KI) and post-partum estrus (PPE) were recorded. Altogether, 122 kids and 60 does were taken for the study. The collected data were entered onto MS-Excel Program with necessary cleaning, checking and coding. Text files were made and the statistical package Harvey 1990, which is based on least squares technique of variance analysis for unequal sub-class number was employed for the analysis (Henderson 1953). Mean comparison was done using Duncans' Multiple Range Test (DMRT), 1955.

RESULTS AND DISCUSSION

Dam performance

Reproductive performance: The age at first conception, age at first kidding, gestation length, kidding interval and post-partum estrus for the does of Chitwan district were 211±13.00, 356±13.00, 147±0.91, 236±12.00 and 087±6.00 days, respectively (Table 1). These figure shows that does of

Chitwan district have comparatively better reproductive performance than Khari and Terai does as presented in table 1.

Table 1. Comparison of least square means of some of reproductive traits of does (Chitwan, Khari and Terai)

Reproductive parameters	Least square mean $\pm$ Standard error (days)			Significance level
	Does (Chitwan)	Does (Khari)	Does (Terai)	
Age at first conception	211b $\pm$ 13.0 (60)	311a $\pm$ 5.6	348ab $\pm$ 10.7	**
Age at first kidding	356c $\pm$ 13.0 (60)	453a $\pm$ 6.2	491b $\pm$ 5.1	***
Gestation length	147 $\pm$ 0.9 (60)	145 $\pm$ 0.15	150 $\pm$ 0.3	ns
Kidding interval	236c $\pm$ 12.0 (47)	302b $\pm$ 3.7	336a $\pm$ 4.2	***
Post-partum estrus	087b $\pm$ 6.0 (58)	100ab $\pm$ 8.0	122a $\pm$ 8.0	**

***, significant at 0.1% level ($P < 0.001$); **, significant at 1% level ($P < 0.01$); ns, not significant at 5% level; Means, within an effect, with the different letters are significantly different.

This is due to the fact that, good nutrition and management practices leads to the earlier activation of reproductive hormones (Tiwari 2000) leading to the shorter days of AFC, AFK, KI and PPE. Similarly, reproductive organs perform in full potential with good nutrition (Hafez 1989). In addition to this, shorter days for reproductive traits increase the overall productive life and is directly related with economic value.

Body weight and body measurements: The adult body weight of does of Chitwan district was 31.07 $\pm$ 0.55 kg with 67.45 $\pm$ 0.53, 63.29 $\pm$ 0.50 and 72.34 $\pm$ 0.53 cm of body length (BL), wither height (WH) and heart girth (HG), respectively as presented in table 2. Significantly higher live body weight along with BL, WH and HG of does of Chitwan with respect to Khari and Terai does might be due to the superior genotype and better management practices provided by the farmers of Chitwan district.

Table 2. Least square (LS) means for body weight and body measurements of adult does (Chitwan, Khari, Terai)

Parameters	Least square mean $\pm$ Standard error			Significance
	Does (Chitwan)	Does (Khari)	Does (Terai)	
Body weight (kg)	31.07a $\pm$ 0.55	24.1b $\pm$ 0.34	23.3b $\pm$ 0.1	**
Body length (cm)	67.45a $\pm$ 0.53	63.1ab $\pm$ 0.39	60.6b $\pm$ 0.87	*
Wither height (cm)	63.29a $\pm$ 0.50	55.9b $\pm$ 0.28	57.9ab $\pm$ 0.32	**
Hearth girth (cm)	72.34a $\pm$ 0.53	65.5b $\pm$ 0.37	65.2b $\pm$ 0.44	***

***, significant at 0.1% level ($P < 0.001$); **, significant at 1% level ($P < 0.01$); *, significant at 5% level ($P < 0.05$); ns, not significant at 5% level; Means, within an effect, with the different letters are significantly different.

Kidding performance

The performance of goats of Chitwan district are significantly different in terms of litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW) than Khari and Terai goats. Goats of Chitwan gave larger litter size as well as heavier litter weight both at birth and at weaning. This might be due to the heavier weight of dams and good management practices followed by the goat raising households.

Table 3. Least square (LS) means for litter traits (size in number and weight in kg) of goat of Chitwan, Khari and Terai

Litter traits	Least square mean $\pm$ Standard error			Significance level
	Chitwan	Khari	Terai	
Litter size at birth	2.00 $\pm$ 0.10 (60)	1.6 ab $\pm$ 0.02	1.4b $\pm$ 0.21	**
Litter size at weaning	1.94 $\pm$ 0.09 (55)	1.42b $\pm$ 0.03	1.3b $\pm$ 0.26	**
Litter weight at birth	3.70 $\pm$ 0.15 (60)	3.38ab $\pm$ 0.06	2.5b $\pm$ 0.33	*
Litter weight at weaning	17.33a $\pm$ 0.98(55)	11.9b $\pm$ 0.36	11.1b $\pm$ 1.0	*

**, significant at 1% level ($P < 0.01$); *, significant at 5% level ($P < 0.05$); Means, within an effect, with the different letters are significantly different.

The weight of the dam has been reported to influence the litter size/weight at birth Arriola (1963). Litter size/weight is affected both by genetic and environmental factors (Wilson et al 1989).

Morphometric attributes of kids

The mean birth, weaning and post-weaning (8-9 months) weight of kids of Chitwan was found to be 2.48, 13.22 and 17.64 kg (Table 3). These values are almost similar to birth weight of Ganjam goat (2.25 kg) as reported by Rao et al (2007), four months age of kids (12.2 kg) for the blended goats (Das 1992) and 12.5 kg for local hill goats (Kuwar and Shrestha 2002) and 18.2 kg of body weight at nine months post-weaning age (Shrestha 2004 and Kolachhapati 2006) under field conditions. However, these values are significantly higher than those kids from Khari and Terai goat breeds. Similarly, the body length, wither height and heart girth at birth, weaning and post weaning age for the kids born at Chitwan were significantly higher with respect to other local breeds (Khari and Terai goats).

Table 4. Least square (LS) means for body weight and body measurements of kids of Chitwan, Khari and Terai goat

Traits	Least square mean $\pm$ Standard error			Significance
	Kids (Chitwan)	Kids (Khari)	Kids (Terai)	
Body weight (kg)				
Birth	02.48a $\pm$ 0.07 (43)	01.65b $\pm$ 0.02	01.58b $\pm$ 0.50	**
Weaning	13.22a $\pm$ 0.33 (86)	07.50c $\pm$ 0.12	10.70b $\pm$ 0.34	***
Post weaning (8 to 9 months)	17.64a $\pm$ 0.50 (47)	12.40c $\pm$ 0.17	16.20b $\pm$ 0.88	***
Body length (cm)				
Birth	29.58a $\pm$ 0.36 (43)	27.23b $\pm$ 0.33	28.99b $\pm$ 0.42	*
Weaning	51.55a $\pm$ 0.56 (86)	44.21c $\pm$ 0.65	46.01b $\pm$ 0.58	***
Post weaning (8 to 9 months)	57.08a $\pm$ 0.62 (47)	54.01b $\pm$ 0.67	54.13b $\pm$ 0.63	**
Wither height (cm)				
Birth	31.29a $\pm$ 0.36 (43)	28.18c $\pm$ 0.30	30.26b $\pm$ 0.43	***
Weaning	52.49a $\pm$ 0.53 (86)	43.67c $\pm$ 0.62	47.01b $\pm$ 0.55	***
Post weaning (8 to 9 months)	56.08a $\pm$ 0.61 (47)	52.04c $\pm$ 0.66	54.04b $\pm$ 0.62	***
Heart girth (cm):				
Birth	30.76a $\pm$ 0.43 (43)	27.90b $\pm$ 0.39	29.86ab $\pm$ 0.51	*
Weaning	52.81a $\pm$ 0.55 (86)	45.71c $\pm$ 0.65	47.47b $\pm$ 0.58	***
Post weaning (8 to 9 months)	57.99a $\pm$ 0.62 (47)	52.77c $\pm$ 0.66	55.54b $\pm$ 0.63	***

***, significant at 0.1% level ($P < 0.001$); **, significant at 1% level ($P < 0.01$); *, significant at 5% level ($P < 0.05$); Means, within an effect, with the different superscript are significantly different.

Phenotypic correlation

Phenotypic correlation coefficients measure the degree and direction of association between two variables (Gomez and Gomez 1984 and Mead 1996). Table 5 shows that there is significant correlation among the weaning and birth weight as well as weaning and Post weaning weight. Kumar et al (1993) also reported the correlation between birth weight and weaning weight was positive and correlations between weaning weight and weights at later stages were positive, suggesting that weaning weight could be a good selection criterion for genetic improvement in weights at later stages.

Table 5. Phenotypic correlation coefficients among body weights (birth, weaning and post-weaning) of kids of Chitwan district

Weight	Birth (0 months)	Weaning (4 months)	Post weaning (8 months)
Birth (0 months)	1.00		
Weaning (4 months)	0.66**	1.00	
Post weaning (8 months)	0.48**	0.69**	1.00

**, significant at the 0.01 level (2-tailed)

Mean daily weight gain

Mean daily weight gain (MDWG) is the rate of increment and threshold point of growth per day. The trend of MDWG in grams (g) for the goat during the various growth stages has been presented in Figure 2. It was observed that MDWG of kids for Chitwan for the early age (birth to 4 month weaning) was higher i.e. average of 91 g per day than Khari and Terai goats.

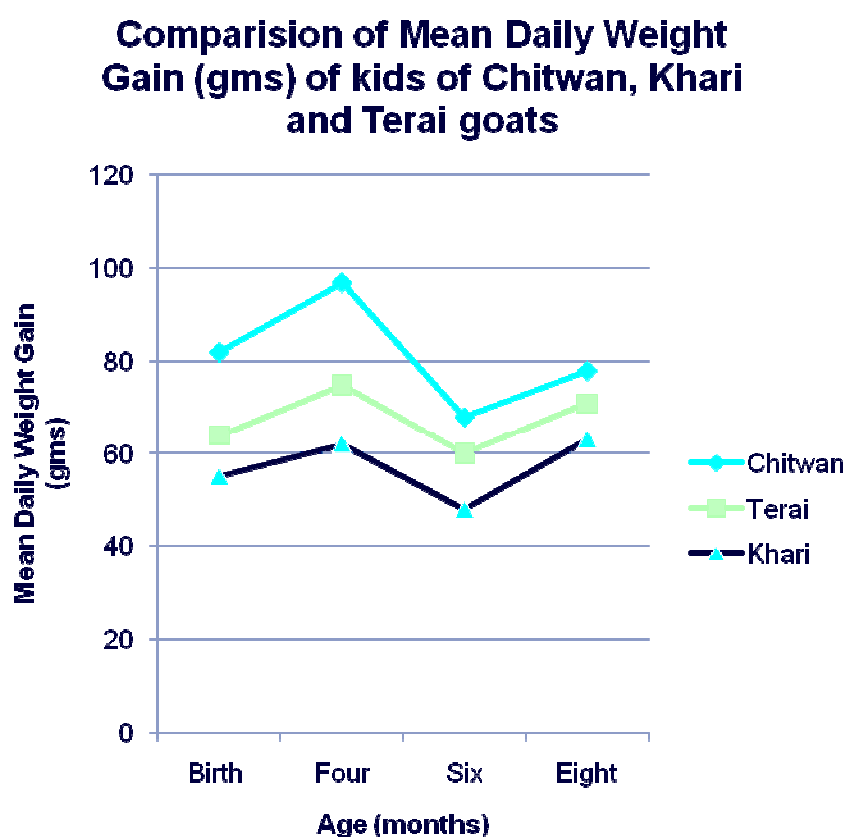


Figure 2. Mean daily weight gain (MDWG) of kids of Chitwan, Khari and Terai goat

MDWG after the weaning age (120 days) was declined indicating that the kids were under the adjustment stress after weaning. Similar results have been observed in the study of Tamarakar and Chapagain (2000), who reported that MDWG of kids decreased to 76.3 g (120-180 days) from 82.9 g (0-120 days). Nevertheless, this condition was improved after 180 days. Again the trend of MDWG increased but with decreasing rate. This might be due to the physiological ruminal development of goat kids after some period of weaning and also after the acclimatization of grazing environment. But

the overall growth rate was lower after the weaning age. This trend was supported by Neopane (1997), Aryal and Neopane (1996) and Oli (1987) while studying in Nepalese hill goats.

In brief, goats of Chitwan were superior with respect to productive and reproductive performance. This could be due to better genetic make-up they possess and management practices followed by the farmers. Moreover, positive and significant correlation of post weaning weight on weaning weight suggest that weaning weight could be a good selection criterion for genetic improvement in weights at later stages.

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Forage Based Fattening of Male Goat

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ABSTRACT

An experiment on forage based fattening of male goats was conducted at livestock farm of Regional Agriculture Research Station, NARC, Khajura, Banke for a period of 89 days in the year 2011. The treatments comprised of T1: Commercial concentrate feed @1% of the body weight/day with conventional grazing practice, T2: 25% rice straw, 37.5% Tanki fodder, 37.5% oat and 100 g concentrate per day, T3: 25% rice straw, 37.5% berseem, 37.5% oat and 100 g concentrate per day, and T4: 25% rice straw, 25% Tanki, 25% oat, 25% berseem, and 100 g concentrate per day. Daily feed intake and weight of the animals were taken at beginning and on every 15 days intervals and also at the end of experiment. The results showed that the total body weight gain and average daily body weight gain were significantly different ($P < 0.05$) between different treatment groups. The average daily weight gain was found highest in T1 (63.77 g) followed by T4 (58.99 g), T3 (43.12 g) and lowest in T2 (35.68 g). Whereas, the net return per animal was found highest in T4 group. The results indicated that 25% rice straw along with oat, berseem, Tanki and concentrate 100g/day can be used in stall feeding management.

INTRODUCTION

Goat is an important livestock species and considered as a living bank of poor. There are 4 native breeds of goat: Chyangra, Sinhal, Khari and Terai goats. Chyangra goats are found in high altitude and raised under transhumance system; represents only 1% of the total goat population. It is popular to produce Pashmina. Sinhal is found in most of the hills of the country. It represents 16% of the total population. Khari is the principle breed of goat and represents 56% of the total goat population, distributed in mid hills and is considered as most prolific breed (Kharel et al 1998). Terai goat is another native breed of goats, constitutes about 27% of the total goat population and found in the southern plains of Terai. It is comparatively heavier (30-50 kg) than other breed which might be due to composite population from the Indian breed Jamunapari (Shrestha 2002).

Goat keeping is one of the income generating activities and farmers are rearing goat on extensive and semi-intensive production system. The farmers have lack of information regarding the scientific rearing of goat. There is lack of communal grazing land and the quality of community grazing land is poor due to higher stocking of the animals. The present study was conducted to know the productive performance of castrated male goats using the locally available feed resources for fattening of the goats to get higher return on stall-fed management system.

MATERIALS AND METHODS

The feeding experiment was conducted at livestock farm of Regional Agricultural Research Station, Khajura, Banke for a period of 89 days to evaluate the growth performance of goat on fodder-based diet during winter 2011.

Experimental animals

Sixteen castrated male goats aged 8-11 months were kept on trial. Prior to the experiment, animals were drenched with albendazole @ 10 mg/kg body weight and seven days were allowed as adjustment period. The goats used in the experiment were Terai local, Barberi and its crosses. The animals were allotted randomly in individual crates inside the shed. The crates measured 1.0 meter length, 0.45 meter width and 1.0 meter height.

Experimental diet

The experimental diets were comprised of:

- T1: Commercial concentrate feed @1% of the body wt/day with conventional grazing practice (grazing-7 hours from 8:00 am to 12:00 noon and 1:00-4:00 pm),
 T2: 25% rice straw, 37.5% Tanki fodder, 37.5% oat and 100 g concentrate per day,
 T3: 25% rice straw, 37.5% berseem, 37.5% oat and 100 g concentrate per day, and
 T4: 25% rice straw, 25% Tanki, 25% oat, 25% berseem, and 100 g concentrate per day.

To calculate the fodder and straw, the dry matter (DM) requirement was fixed at 4% of the body weight in addition to 100 g concentrate per day per animal in all three groups (T2, T3 and T4). Clean drinking water was provided ad libitum. The body weight of animals was taken at an interval of 15 days and DM requirement was adjusted accordingly. Locally available rice straw (87.6% DM) was chaffed (6 cm long) and incorporated in the diets at the given amounts in individual diet based on the daily DM requirement of animal. The commercially available concentrate was provided in the morning. Freshly cut berseem, oat, Tanki twigs were made available during the day time. Daily intakes of rice straw, Tanki, berseem, concentrate were recorded for a period of 89 days.

Chemical analysis

Dry matter content of feed stuff was determined by drying the sample at 68°C for 48 hours. The chemical composition of feed stuff was analyzed in Animal Nutrition Division, NARC, Khumaltar, Lalitpur. The composition is presented in the table 1. The data were analyzed using a statistical package MSTATC and Microsoft excel.

RESULTS AND DISCUSSION

Analysis of feed stuff showed that the CP of Tanki, oat, berseem and rice straw were 18.3, 10.2, 21.6, 3.8%, respectively which are almost similar to as reported by Upreti and Shrestha (2006).

Table 1. Chemical composition of feed stuff

Feed items	Chemical composition		
	DM (%)	CP (%)	Total ash
Oat	21.78	10.2	6.25
Tanki	27.3	18.3	9.27
Berseem	13.24	21.6	5.36
Rice straw	87.66	3.8	7.52
Concentrate	87.3		

Feed intake

The nutrient intake of different diet groups is presented in table 2. The highest DM intake was found in T3 (1003 g/d), followed by T2 (983 g/d) and T4 (950 g/d). These DM intakes were 5.29, 5.46 and 4.4% of the body weight for treatment 3, 2 and 4, respectively. The daily intake in T1 group couldn't be accessed due to allowance of free grazing of the goats. It showed that the incorporation of rice straw at 25% of DM requirement had no negative effect on DM intake.

Table 2. Nutrient intake of animals of different treatment groups on dry matter (DM) basis

Nutrients	Diet groups			
	Concentrate and grazing (T1)	25% rice straw, Tanki, oat and concentrate (T2)	25% rice straw, berseem, oat, concentrate (T3)	25% rice straw, Tanki, oat, berseem and concentrate (T4)
DM intake (g)	150.6#	983.0	1003	950
DM intake (% of LW)		5.46	5.29	4.4
DM intake (kg)/kg live weight gain		29.85	23.24	16.1
DM intake through concentrate only				

Growth rate

Body weights of the animals in different treatment groups were taken initially and at different interval (Table 3). The initial body weight of the animals in different treatment groups didn't differ significantly. However, there was significant difference ($P<0.05$) in total weight gain and average daily weight gain between different diet groups. The highest total weight gain per goat for 89 days was found in T1 (5.68 ± 1.03 kg) followed by T4 (5.25 ± 1.69 kg), T3 (3.84 ± 1.02 kg) and T2 (2.93 ± 1.11 kg). Average daily weight gain was found significantly higher ($P<0.05$) in T1 (63.77 g/d), followed by T4 (58.99 g/d), T3 (43.12 g/d) and T2 (35.68 g/d). These growth rates were higher than the experiment conducted by Upreti et al (2007) using rice straw (15 -20%) and black gram straw in fodder based goat's diet.

Table 3. Average live weight and body weight gain in experimental goats

Nutrients	Diet groups			
	Concentrate and grazing (T1)	25% rice straw, Tanki, oat and concentrate (T2)	25 % rice straw, berseem, oat, concentrate (T3)	25% rice straw, Tanki, oat, berseem and concentrate (T4)
Initial body weight, kg	17.5 $\pm$ 3.31a	15.08 $\pm$ 3.01a	15.13 $\pm$ 4.13a	16.3 $\pm$ 3.72a
Final body weight, kg	23.18 $\pm$ 4.37	18.00 $\pm$ 4.01	18.96 $\pm$ 3.88	21.55 $\pm$ 4.38
Total weight gain, kg	5.68 $\pm$ 1.03a	2.93 $\pm$ 1.11b	3.84 $\pm$ 1.02ab	5.25 $\pm$ 1.69a
Avg. daily weight gain, g	63.77 $\pm$ 11.62a	35.68 $\pm$ 13.87b	43.12 $\pm$ 11.48ab	58.99 $\pm$ 18.95a

Value in the rows having different letters were significantly different ($P \leq 0.05$)

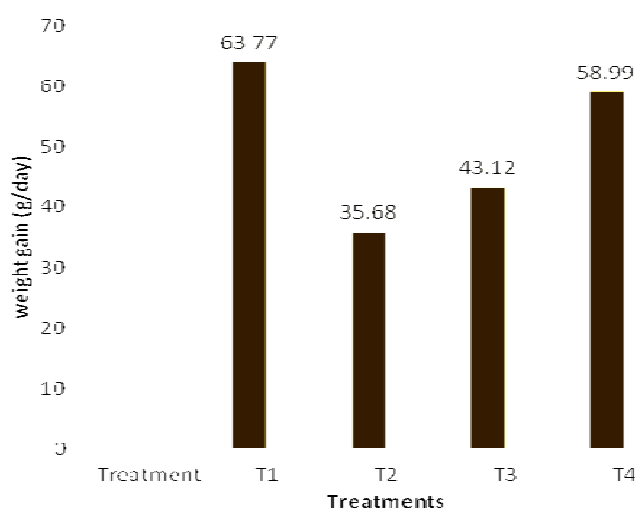


Figure 1. Average daily weight gain of goats fed with different diets

The growth rate of animals in treatment 1 and 4 were higher than the growth rates of goats in other treatment groups. The trend of body weight of goats in four different treatment groups taken at different days of feeding trial has been presented in Figure 2.

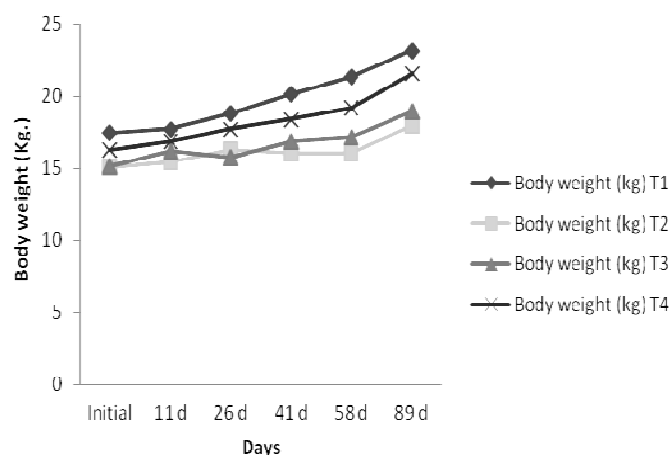


Figure 2. Growth trend of goats fed with different diets

Economics of production

The economic analysis of goat production under different feeding regimes was carried out. The results showed that the net return per animal was found highest in T4 (Rs 324.75) followed by T1 (Rs. 281.8), T3 (Rs. 101.81) and least in T2 group indicating that supplementation of berseem in addition to Tanki, oat and rice straw was beneficial for fattening of goats.

Table 4. Economics of production (Per animal)

Nutrients	Diet groups			
	Concentrate and grazing (T1)	25% rice straw, Tanki, oat and concentrate (T2)	25 % rice straw, berseem, oat, concentrate (T3)	25% rice straw, Tanki, oat, berseem and concentrate (T4)
Return (Rs)				
Animal sale	3708.80	2880.00	3033.60	3448.00
Manure	35.00	67.00	67.00	67.00
Total return cost	3743.80	2947.00	3100.60	3515.00
Animal Purchase	2800.00	2412.80	2420.80	2608.00
Labor	267.00	267.00	267.00	267.00
Concentrate	385.00	173.75	201.50	202.00
Medicine	10.00	10.00	10.00	10.00
Straw		2.64	2.67	3.25
Tanki		33.80	0.00	30.00
Oat		59.00	62.82	45.00
Berseem		1.25	34.00	25.00
Total cost	3462.00	2960.24	2998.79	3190.25
Net return (Rs)	281.80	-13.24	101.81	324.75

The results indicated that forage-based fattening could be more profitable than concentrate based fattening from economic view point. The net return per animal is found highest in T4 group. It can be conclude that 25% rice straw along with oat, berseem, Tanki and concentrate 100 g/day can be used in stall feeding management.

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Study on Association of different Animal and Management Factors for the Occurrence of Pneumonia in Goat in Kanchanpur District

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ABSTRACT

The present study was aimed at finding the association of different animal and management factors with the occurrence of pneumonia in goats based on diagnosis of pneumonia in goats by clinical symptoms. The study was carried out on a total number of 80 goats with respiratory disorder that were brought to the veterinary clinic, affiliated to CTEVT at Krishnapur, Kanchanpur district during June to September months of 2009. Sick goats showing signs of pyrexia, serous, mucoid or mucopurulent nasal discharge, cough, moist and respiratory rales on auscultation of the lungs were diagnosed as pneumonic. Risk factors including animal and management factors were measured. It was observed that the age group of <1 year, male goat and animal with poor body conditions were in the greater risk to pneumonia. On the other hand among management factors free range (night shelter only), muddy floor with poor drainage system showed susceptibility to pneumonia. Similarly, goats allowed for grazing, and group or community-based grazing pattern were susceptible to pneumonia. High percentage of occurrence of pneumonia was recorded (45%) in < 1 year age group, 70% in male and 70% of goats with poor body conditions. Similarly, prevalence of pneumonia in free range housing (night shelter only), muddy floor type, poor drainage system and grazing pattern in group were 50, 75, 60 and 50%, respectively.

INTRODUCTION

Pneumonia is an inflammation of the lung parenchyma usually accompanied with the inflammation of the bronchioles (broncho-pneumonia) or with pleura (pleuro-pneumonia). It is manifested clinically by rapid shallow breathing, cough and ronchi. All species of animals irrespective of ages suffer from pneumonia (Blood et al 1989). The etiology and incidence of respiratory diseases in goats vary with the geographical location and management system.

Many bacteria, viruses and helminthes parasites are known to cause respiratory diseases in goats. In addition to the infectious agents, which cause the pneumonia, there are predisposing factors that contribute to the susceptibility of the animals. These are of paramount importance in any consideration of pneumonia (Chakrabarti et al 1994). The predisposing factors are exposure of animal in damp place and cold environment, housing in an ill-ventilated room, exertion due to extensive work, long transport by vehicles, severe hunger, malnutrition, chronic under-nutrition, exposure to cold wave during winter month, sudden changes in weather, cardiac weakness, recumbency for a long period of time, other debilitating diseases, inhalation of dust, irritating vapours etc. according to etiology. Among all other diseases, pneumonia causes high mortality and poor production of goat. Therefore, the present study was undertaken to know the association of different animal factors and management factors for the occurrence of pneumonia.

MATERIALS AND METHODS

A total number of 80 indigenous and Jamunapari cross goats with respiratory disorder were examined which attended at the veterinary clinic, Krishna Higher Secondary School, Annex program, affiliated to CTEVT at Krishnapur, Kanchanpur district during June to September months of 2009. The age of the animal ranged from months to four years. The system of diagnosis was based on history and clinical examination (inspection, palpation, percussion and auscultation). Here, the sick goats showed pyrexia, serous, mucoid or mucopurulent nasal discharge, cough, moist and respiratory rales on auscultation of the lungs and diagnosed as pneumonia.

Different risk factors related with pneumonia were discussed, recorded. For convenience of study, risk factors were divided into two viz. animal and management factors. Age, sex and body condition score were included in animal factors. Types of housing, type of floor, drainage system, feeding pattern and grazing pattern were included in management factors.

The data were analyzed using STATA-7 (Statistical software). Results of strength of association between the pneumonia and their risk factors were expressed as risk ratio. The strength of association was measured using the lowest risk group as baseline.

RESULTS AND DISCUSSION

Effect of age on occurrence of pneumonia

The age group belonging to <1 year age had higher percentage (45%), while with increase of the age exceeding 2 years of age had lower percentage (20%). Effect of age on occurrence of pneumonia recorded in this study supports the report of Donkin et al (2004) who recorded kids were susceptible to pneumonia. The age group belonging <1 year was 2.25 times more and the age group belonging 1-2 years was 1.75 times more prone to have developed pneumonia than the base line group (>2 years) (Table 1).

Effect of sex on occurrence of pneumonia

In this study, it was observed that male (buck) species suffered the most because among whole study population the disease percentage was 70% in case of male and only 30% in case of female. This might be due to sex variation of the species. The male goats also remained 2.33 times more at risk than the female (Table 1).

Table 1. Calculation of risk ratio among the animal factors on occurrence of pneumonia

Variable	Category	Total no. of animal affected	Percent	Risk ratio
Age	<1 year	36	45	2.25
	1-2 yr	28	35	1.75
	>2 yr	16	20	1
Sex	Male	56	70	2.33
	Female	24	30	1.00
Body condition score	2 (Poor)	56	70	2.33
	3 (Good)	24	30	1.00

Effect of body condition score on occurrence of pneumonia

Poor body condition score (BCS-2) of goat was recorded to be more susceptible than good body condition (BCS-3) to pneumonia, where disease percentage was 70 and 30%, respectively. Effect on body condition score on occurrence of pneumonia recorded in this study supports the report of Hale et al (2003) who recorded that weak and stressed goats were susceptible to pneumonia. The goats

obtaining score 2 were 2.33 times more likely to have pneumonia than the goats obtaining score 3 (Table 1).

Effect of type of housing on occurrence of pneumonia

From this study it is known that goats remaining on free range (night shelter only) are more vulnerable to pneumonia (50%) while those housed in loose (35%) and stall (15%) are less prone to get pneumonia. According to Hale et al (2003), poor ventilation, overcrowding, dirty or poorly ventilated barn are associated with severe outbreak of pneumonia. Jha (1999) reported the overcrowding of goats in the pen during night and long storage of dropping and urine below goat pens in villages may be predisposing factors for the occurrence of respiratory disease. Loose and free-ranged goats were also remained in 2.33 times and 3.33 times more at risk than the stalled goats (Table 2).

Effect of type of floor on occurrence of pneumonia

Among the three types of floor, muddy floor appeared to be the predisposing factor to develop pneumonia in goat. The disease percentage was 75% in muddy floor while 15% and 10% in case of concrete floor and *machan* system, respectively. Goats reared in muddy and concrete floor remained in 7.5 times and 1.5 times more at risk than the goats reared in *machan* system (Table 2). An unexpected cold snap can increase pneumonia in goat (Smith et al 1994). According to Hale et al (2003), dirty floor, a manure pack, high humidity was considered as risk factors to develop pneumonia.

Effect of drainage system on occurrence of pneumonia

According to the history of drainage system, poor drainage system was more prone to develop pneumonia in goat. In this study, 60% disease was in poor drainage system while 30% and 10% in fair and good drainage system, respectively. Goats housed with poor drainage system remained in 6 times more at risk than the goats housed with good drainage system for developing pneumonia (Table 2). According to Hale et al (2003), poor waste management was considered as risk factor to develop pneumonia.

Table 2. Calculation of risk ratio among the management factors on occurrence of pneumonia

Variable	Category	Total no of animal affected	Percent	Risk ratio
Types of housing	Stall	12	15	1
	Loose	28	35	2.33
	Night shelter only	40	50	3.33
	Muddy	60	75	7.5
Types of floor	Concrete	12	15	1.5
	<i>Machan</i>	8	10	1
	Good	8	10	1
Drainage system	Fair	24	30	3
	Poor	48	60	6
Feeding pattern	Stall feeding	4	5	1
	Grazing	68	85	17
	Stall feeding +grazing	8	10	2
Grazing pattern	Individual	32	40	4
	Group or community	40	50	5
	Others	8	10	1

Effect of feeding pattern on occurrence of pneumonia

Regarding feeding pattern, the study revealed that 85% of goats having grazing and only 5% goats having stall feeding developed pneumonia. The grazing group remained 17 times more at risk than

the stall-feeding group (Table 2). According to Hale et al (2003), dusty feed and feeding can also be detrimental to health, which enhance development of pneumonia.

Effect of grazing pattern on occurrence of pneumonia

As usually, group or community-based grazing pattern developed more pneumonia in goat where the disease percentage was 50% and at the same time individual grazing pattern developed less pneumonia where the disease percentage was 40%. Group or community based goats were 5 times more at risk than the non-grazed goats (Table 2) because there might be more chances to transmission of pathogenic microorganisms via the aerosol route. Effect of grazing pattern on pneumonia recorded in this study supports the report of Hale et al (2003) who reported higher percentage of pneumonia occur due to overcrowding in grazing places.

Generally animal factors and management factors seemed to develop pneumonia in goats, so care should be taken towards minimize the related risk factors. Goats of <1 year age group were more susceptible to pneumonia than other age groups. Poor ventilation, overcrowding, dirty or poorly ventilated barn, muddy floor, and high humidity may be the predisposing factors for occurrence of pneumonia. Therefore, awareness to the farmers needs to be created so as to follow the good management practices for rearing goats.

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Performance Study of Terai Local, Barbari and Crossbred Goats

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ABSTRACT

The study of productive and reproductive performance of Terai Local, Barbari, and Terai Local x Barbari (BL-50%) goats was conducted at livestock farm of Regional Agricultural Research Station, Khajura, Banke during 2009-2010. Important productive traits such as weight traits (weight at birth, 4, 6, 9 and 12 months), litter traits (litter size and weight at birth, weaning, 9 and 12 months) and reproductive traits (age and weight at 1st service, gestation length and kidding interval) were recorded and analyzed. Goats were kept scientifically and allowed to graze for 7 hours per day. The highest birth weight was found in Terai Local (1.84 ± 0.075 kg) as compared to Barbari and 50% crossbred. The litter size and litter weight at 12 months is found highest in crossbred goats (1.29 ± 0.185 and 15.57 ± 2.1 kg, respectively). The study revealed that the productive and reproductive performance of cross breed (50% Terai Local and Barbari) is found better than Terai Local and Barbari.

INTRODUCTION

Goat is one of the principle commodities of mixed farming system of Nepalese agriculture. In Nepal, the goats are primarily raised for income generating activities, and are being promoted by government and non-government organizations (Pelant et al 1999, Lohani and Paudel 2000) as the efforts to reduce poverty. Local hill goats have better reproductive performance, hardy to poorer feeding system and are suitable for local environmental and management conditions. However, they might have low birth weight, weaning weight and adult body weight (Neopane 1997). There are four different breeds of goats recognized in Nepal. They are Chyangra, Sinhal, Khari (Hill) and Terai goats. These breeds are raised in different ecological zones of Nepal. Chyangra and Sinhal are raised in high Himalayan region. Chyangra is popular for *pashmina* production whereas the hair of Sinhal is used for making *Feruwa* (carpet). Khari is raised in mid hills of Nepal for meat production, which is recognized as highly prolific goat breed. Terai goats are raised in Terai region of Nepal for meat and milk production. The present study was carried out to evaluate performance of Terai Local, Barbari and their crosses to recommend for the western Terai region of Nepal.

MATERIALS AND METHODS

The productive and reproductive performance study was conducted at goat unit of Regional Agriculture Research Station, NARC, Khajura, Banke. Important productive traits such as weight traits (birth weight at 4, 6, 9, and 12 months), litter traits (litter size and weight at birth, and weaning at 6, 9 and 12 months) and reproductive traits (age and weight at 1st service, gestation length and kidding interval) were recorded and analyzed statistically. Goats were kept scientifically and allowed to graze for 7 hours in a day. The kids were separated from their mothers at an age of 4 months. Both male and female goats were kept separately. Periodical vaccination, drenching and dipping of goats were done and required concentrate and forage were supplied to goats.

RESULTS AND DISCUSSION

Data of productive and reproductive performance of three different goat breeds (viz. Terai Local, Barbari and Terai Local x Barbari (BL-50%)) were recorded and analyzed.

Weight traits

The birth weight of Terai Local (1.84 ± 0.48 kg) is found heavier than Barbari (1.66 ± 0.24 kg) and 50% BL (1.72 ± 0.36 kg) (Table 1). However, the contrary results were obtained in RARS Annual Report (2004/2005) where birth weight was found heavier for 50% BL (1.97 ± 0.059 kg) as compared to Barbari (1.97 ± 0.059 kg) and Terai Local (1.78 ± 0.074 kg).

Table 1. Body weight (Mean $\pm$ Standard Deviation) of goats at different ages

Genotypes	Body weight (kg) at				
	Birth	4 Month	6 Month	9 Month	12 Month
Terai Local	1.84 ± 0.48 (41)	4.69 ± 0.82 (23)	6.29 ± 0.96 (21)	9.94 ± 2.14 (16)	12.28 ± 1.86 (14)
Barbari	1.66 ± 0.24 (7)	5.25 ± 1.26 (4)	7.5 ± 0.71 (2)	11 ± 1.41 (2)	14.5 ± 0.71 (2)
Terai Local x Barbari	1.72 ± 0.36 (21)	5.9 ± 1.52 (10)	8 ± 1.56 (10)	9.67 ± 0.87 (9)	12.11 ± 1.27 (9)

Numbers in the parentheses are the number of observation.

Litter traits

Litter size at birth to 12 months age: The litter size at birth for Terai Local was found higher (1.52 ± 0.51) as compared to 50 % BL (1.40 ± 0.51) and Barbari (1.17 ± 0.41) (Table 2). This revealed that Terai Local is more prolific than other breeds used in the study. However, litter size is lower at 12 months for Terai Local than BL-50% and Barbari due to high kid mortality. Kid mortality was lowest in BL-50% goats.

Table 2. Litter size at birth to 12 months (Mean $\pm$ standard deviation)

Genotype	Litter size at birth	Litter size at weaning	Litter size at 6 months	Litter size at 9 months	Litter size at 12 months
Terai local	1.52 ± 0.51 (27)	1.28 ± 0.46 (18)	1.24 ± 0.44 (17)	1.06 ± 0.26 (14)	1.0 ± 0 (14)
Barbari	1.17 ± 0.41 (6)	1.0 ± 0 (4)	1.0 ± 0 (2)	1.0 ± 0 (2)	1.0 ± 0 (2)
50 % BL	1.4 ± 0.51 (15)	1.25 ± 0.46 (8)	1.25 ± 0.46 (8)	1.29 ± 0.49 (7)	1.29 ± 0.49 (7)

Litter weight at birth to 12 months age: The litter weight was found higher in Terai Local (2.76 ± 1.04 kg) than Barbari (1.93 ± 0.46 Kg) and 50% BL (2.40 ± 1.01 kg) (Table 3). However, in later stage the litter weight was found higher in BL as compared to other.

Table 3. Litter weight at birth to 12 months of age (Mean $\pm$ standard deviation)

Genotype	Litter weight at birth	Litter weight at weaning	Litter weight at 6 months	Litter weight at 9 months	Litter weight at 12 months
Terai local	2.76 ± 1.04 (27)	6.0 ± 2.09 (18)	7.76 ± 2.77 (17)	10.6 ± 2.32 (15)	12.29 ± 1.86 (14)
Barbari	1.93 ± 0.46 (6)	5.25 ± 1.26 (4)	7.5 ± 0.71 (2)	11 ± 1.41 (2)	14.5 ± 0.71 (2)
50 % BL	2.40 ± 1.01 (15)	7.38 ± 4.78 (8)	10 ± 5.15 (8)	12.43 ± 5.26 (7)	15.57 ± 5.56 (7)

Reproductive (Dam) trait

The age at first service of Terai goat has been found to be lower compared to that of Barbari and crossbred (BL 50%) goats. The kidding interval of Terai goats and Barbari was also lower than that of the crossbred goats.

Table 4. Reproductive traits of goats (Mean $\pm$ standard deviation)

Traits	Terai	Barbari	BL 50 %
Age at first service (days)	356.8 $\pm$ 12.23 (14)	454 $\pm$ 17.10 (4)	421 $\pm$ 16.59 (3)
Wt. at 1 st service (Kg)	14.33 $\pm$ 2.07 (6)	16.5 $\pm$ 0.71 (2)	16 $\pm$ 0.89 (7)
Gestation length (days)	148 $\pm$ 4 (6)	144.5 $\pm$ 0.71 (2)	145.16 $\pm$ 3.47 (7)
Kidding Interval (days)	281.42 $\pm$ 10.02 (52)	287.43 $\pm$ 13.37 (49)	335.14 $\pm$ 17.03 (15)

From this study the productive performance of 50% BL is found better whereas for the reproductive performance Terai Local performed well. The farmers are looking for better performing breeds to improve overall performance of their goat. The production performance could be improved through selection and sound breeding program.

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Productive Performance of Baruwal Sheep under Migratory System in Lamjung District of Nepal

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ABSTRACT

A field study was carried out to evaluate and estimate the effect of non-genetic factors on the productive performance of Baruwal sheep under migratory system during August 2008 to May 2009 in Lamjung district of Nepal. All together 156 adults and 186 lambs including male and female of different age groups were included for this study. The different traits of productive performance were collected based on field study and measurements. Least square analysis was performed using Harvey (1990) computer software package, and means were compared using DMRT. The mean body weight of lambs at birth, three month, six month and twelve month was 3.06 ± 0.05 , 14.27 ± 0.14 , 18.83 ± 0.11 and 26.53 ± 0.36 kg, respectively. The weight gain from birth to 3 months, 3 to 6 months and 6 to 12 months age was 140.7 g, 55.65 g and 42.77 g per day, respectively. Similarly, the body weight of sexually mature and adult sheep was 33.80 ± 0.47 and 43.88 ± 0.27 kg, respectively. All the non-genetic factors such as parity, sex and season influenced significantly in all productive traits. The annual and per cm² wool production of mature sheep were 1.02 kg and 1.34 ± 0.02 g, respectively with $70.39 \pm 3.96\%$ of clean wool. In this study, season was observed as an important source of variation for the productive performance. Likewise, sex of lamb was an important source of variation for growth performance of Baruwal sheep. Thus, the finding of this study suggested that the overall productivity of Baruwal sheep could be improved through breeding practices, especially by considering the non-genetic factors such as, season and sex of lambs.

INTRODUCTION

Major livestock species in Nepal are cattle, buffaloes, goat and sheep (APP 1995). Specially sheep is increasingly important species in developing countries as subsistence food producers. Sheep is one of the most important sources of income for resource poor farmers in Nepal which provides meat, wool and manure. Total sheep population in Nepal is 805,070 and there are 110,276 in mid-hill of western region. These total numbers of sheep produce 2,722 MT meat and 586,232 kg wool annually (MOAC 2011). The sheep population was decreased by 11% during 1981 to 1991, by 21.8% during 1991 to 2001 and by 5.3% during 2001 to 2011. Among four breeds of sheep, Baruwal comprise 63% (LMP 1990). Wool is a main raw material for the production of warm garments such as sweaters, blankets, *Radi* and *Pakhi*. The export of carpets and other woolen goods contributed nearly 50% of the total national earning from the export of agricultural and livestock commodities. An estimated 15,600 people were engaged in carpet industry and other 230,000 in washing, carding, spinning, dyeing and weaving of wool (LMP 1990). The present study was undertaken to assess the effect of non-genetic or environmental factors, such as parity of dams, season of lambing, and sex on weight traits as well as wool production traits of Baruwal sheep. This study could help to find out the key issues on productivity of Baruwal sheep under migratory system in Lamjung district of Nepal, so that the strength of the present practices of sheep keeping could be promoted while the weaknesses could be minimized.

MATERIALS AND METHODS

This study was carried out from August 2008 to May 2009 in Lamjung district of Nepal and two migratory routes were selected with the close coordination of District Livestock Services Office (DLSO), Lamjung. One was Ghermu site (lower belt of Lamjung Himal to Bajhakhet) and another was Ghalegaun site (lower belt of Manaslu Himal to Bhoje). Altogether, 186 lambs for growth performance from one to six month age, 40 sheep for yearling weight, 156 sheep for adult as well as sexually mature weight and 318 sheep for wool production were taken. The data were collected on the basis of direct recording and observation from these identified migratory flock and analysis was done by using the statistical package Harvey, 1990. The coding of data for non-genetic factors such as sex, season of birth, age group and parity for productive traits was done. Seasons were categorized into downward (1 September - 28 February) and upward (1 March - 30 August) for body weight traits and spring and autumn for wool production. The estimation of fixed effects (non-genetic factors) and variance components was done by using Henderson (1953) model. Productive traits of sheep were analyzed by using the model: $Y_{ijkl} = B + a_i + b_j + c_k + e_{ijkl}$

Where, B is the overall mean, a_i is the effect of i^{th} number of parity of dam ($i=1, 2, 3, 4$ and 5), b_j is the effect of j^{th} sex ($j=1$ and 2), c_k is the effect of k^{th} season of birth ($k=1$ and 2), e_{ijkl} is the random element (error mean) assumed to be normally and independently distributed among the sampled population

RESULTS AND DISCUSSION

Effect of non-genetic factors on growth performance of lambs

The results of the study revealed that there was a direct influence of non-genetic factors such as dams' parity, sex of lambs, and season of lambing on growth performance of the lambs. The effects of non-genetic factors on body weight of lambs from birth to six month, and one year sheep are presented in Table 1. Anon (2000) reported comparatively lower birth weight (2.51 kg) of Baruwal sheep in Guthichaur, Jumla. Mishra et al (2008) reported higher birth weight of lambs born from ewes on their third parity and related this with the better mothering capacity. Dagma et al (2003) reported that heavier dams reared heavier lamb and produced more milk during lactation. Abegaz and Duguma (2000) suggested that the maiden ewes produce lambs with lower body weight and their mothering ability is poor due to lack of experience and a poorly developed udder.

Table 1. Least square means and standard errors of body weight (kg) traits of lamb

Factors	Birth weight	3 month weight	6 month weight	12 month weight
Overall	3.06±0.05 (186)	14.27±0.14 (186)	18.83±0.11 (186)	26.53±0.36 (40)
Parity				
1	2.85 ^b ±0.04 (40)	12.97 ^c ±0.20 (40)	17.00 ^c ±0.17 (40)	
2	3.12 ^a ±0.04 (40)	14.49 ^{ab} ±0.20 (40)	19.13 ^b ±0.18 (40)	
3	3.17 ^a ±0.04 (40)	14.94 ^a ±0.21 (40)	20.59 ^a ±0.18 (40)	
4	3.10 ^a ±0.04 (36)	14.70 ^a ±0.21 (36)	18.76 ^b ±0.19 (36)	
5	3.05 ^a ±0.04 (30)	14.26 ^b ±0.22 (30)	18.69 ^b ±0.20 (30)	
	***	***	***	
Sex				
Male	3.14 ^a ±0.05 (98)	15.18 ^a ±0.15 (98)	19.70 ^a ±0.13 (98)	27.83 ^a ±0.50 (20)
Female	2.98 ^b ±0.03 (88)	13.37 ^b ±0.16 (88)	17.96 ^b ±0.14 (88)	25.23 ^b ±0.50 (20)
	***	***	***	**
Season				
Downward	3.26 ^a ±0.02 (166)	15.46 ^a ±0.09 (166)	20.29 ^a ±0.07 (166)	
Upward	2.85 ^b ±0.05 (20)	13.09 ^b ±0.26 (20)	17.38 ^b ±0.22 (20)	
	***	***	***	

, significant at 1% level ($P<0.01$); *, significant at 0.1% level ($P<0.001$). Numbers in parentheses are number of observation.

Higher birth weight of male compared to female may be associated with male sex hormones which have anabolic effects and stimulate growth rate (Hafez 1989). Mishra et al (2008) reported that the significant effects of season of lambing in respect to body weight of lambs indicating difference in availability of feed/fodder and climate condition. Sankhyan et al (1999) showed that the digestible crude protein intake was significantly lower in summer (15 g/head/day) as compared to winter (31.7 g/head/day) and monsoon (45.1 g/head/day), which affect the milk yield and weight of lambs.

Weight gain of lambs

The average weight gain from birth to 3 months, 3 to 6 months and 6 to 12 months age was 140.7 g, 55.65 g and 42.77 g per day, respectively.

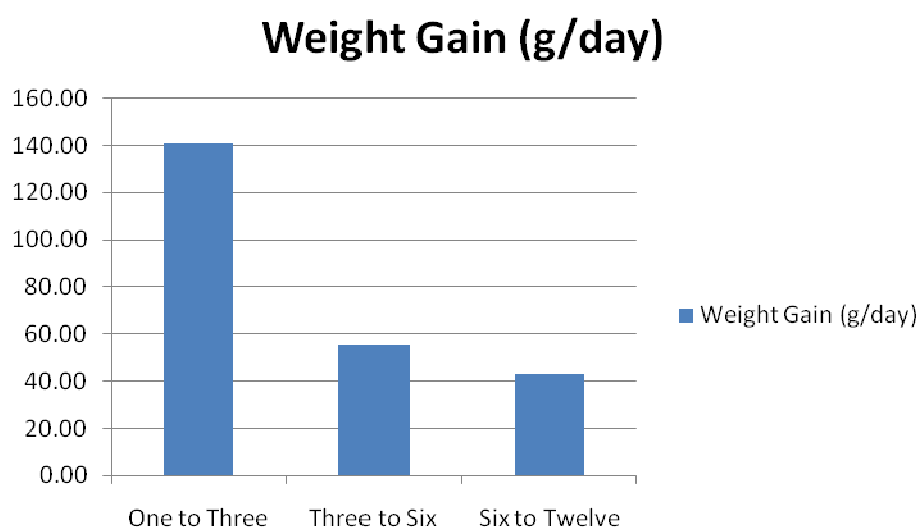


Figure 1. Weight gain of lambs from one to twelve months age

Effect of non-genetic factors on growth performance of sexually mature and adult sheep

Sexually mature sheep are those that are capable to conceive and produce new one and the sheep above 2 years old is called adult. This research revealed that the average age of sexual maturity of Baruwāl sheep was 628.95±05.83 days. The sexually mature and adult sheep weight were significantly ($P<0.001$) different between male and female (Table 2).

Table 2. Least square means and standard errors of weight (kg) of sexually mature and adult sheep

Factors	Sexually mature weight (kg)	Adult weight (kg)
Overall	33.80±0.47	43.88±0.27
Sex		
Male	37.53	46.72
Female	30.07	41.04
	***	***

***, significant at 0.1% level ($P<0.001$)

Karki (1985) reported that the average body weight of Baruwāl sheep from migratory flocks of Gandaki zone was 50.8 kg for rams and 42 kg for ewes during the autumn and 45 kg for rams and 36 kg for ewes during winter.

Effect of non-genetic factors for wool production of sheep

The overall wool production of Baruwal sheep was 1.02 kg, whereas single shearing value was 509.59±0.07 g (Table 3). Karki (1987) reported that the total annual wool production of a Baruwal sheep in Lumle command area, Karnali sheep farm Jumla, and Pansayakhola sheep farm were 1.29 kg, 0.78 kg and 1.01 kg, respectively. The average annual wool yield of the Baruwal has been reported to be 1.07 kg, with a range of 0.78–1.29 kg (Karki 1985).

Tiwari and Shrestha (2004) studied the wool production of Baruwal sheep in different locations and reported that the average wool production/year/sheep was 750 g and was highest in Kalikot (1040 g) followed by Mugu (830 g) in migratory sheep. However, Karki (2004) reported that the annual wool production in migratory system was 1.3 kg/sheep/year.

Table 3. Least square means and standard errors of wool production (g) of sheep/shearing

Factors	LS means ±S E	Significance level
Overall	509.59±00.07 (318)	
Age (Year)		***
1-2	549.52 ^b ±12.12 (118)	
3-4	591.85 ^a ±14.57 (90)	
5-6	502.68 ^c ±20.19 (50)	
M7	412.44 ^d ±24.18 (60)	
Sex		***
Male	554.21 ^a ±13.35 (90)	
Female	464.97 ^b ±07.08 (228)	
Season		***
Autumn	671.19 ^a ±09.68 (159)	
Spring	347.99 ^b ±09.68 (159)	

***, significant at 0.1% level (P<0.001)

Effect of non-genetic factors for per cm² wool production

The overall wool production/cm² of Baruwal sheep under migratory system was 1.34±0.02 g during autumn season (Table 4). The wool production/cm² was highly significant (P<0.001) with respect to age and sex.

Table 4. Least square means and standard errors of wool production/cm² (g) of sheep during autumn

Factors	LS means ±S E	Significance level
Overall	1.34±0.02 (154)	
Age		***
1-2	1.41 ^{ab} ±0.03 (46)	
3-4	1.51 ^a ±0.03 (55)	
5-6	1.33 ^b ±0.05 (23)	
M7	1.10 ^c ±0.04 (30)	
Sex		***
Male	1.46 ^a ±0.04 (54)	
Female	1.21 ^b ±0.02 (100)	

***, significant at 0.1% level (P<0.001)

The per cm² wool production in third and fourth years sheep was higher because the wool production in these year was also high and animal at in full developed stage.

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Effect of Different Level of Effective Microorganism (EM) on Egg Production of Giriraja Chicken

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ABSTRACT

This study was conducted to evaluate the effect of different ratios of effective microorganisms (EM) on the performance of Giriraja layers at poultry research farm of Regional Agriculture Research Station, Tarahara, Sunsari. Six month old Giriraja layers having uniform weight were divided into four groups of 18 birds each viz. control (T1) and three treatments (T2, T3 and T4). Birds of control group were fed plain drinking water (without EM) and the rest treatment groups T2, T3 and T4 were supplied EM in drinking water at the ratio of 1:1000, 1:3000 and 1:5000, respectively. Performance parameters were recorded and analyzed. The results showed that there was significant effect of EM administration dose ($p < 0.05$) on egg production of Giriraja chickens. The egg weight gain was found higher in EM treated groups but no significantly different among the treatment groups. Fertility and hatchability were found higher in treated groups but no significant differences among the treatments during the entire period. The supplementation of EM in drinking water of Giriraja at the ratio of 1:3000 is recommended for best economical operation and general well being of the birds.

INTRODUCTION

Poultry is one of the most important commodities to improve the livelihood of the rural people. Most of the rural Nepalese farmers are rearing the native poultry breeds, whose productivity is only 60-70 eggs per year (Aryal 1994). Feed cost alone constitutes about 70% of total cost of production of poultry meat and eggs. Any effort to improve feed efficiency through knowledge of poultry nutrition and feeding will go a long way to improve the profit margin of poultry farmers (Singh 1997).

Effective microorganisms (EM) are a liquid concentrate produced by scientific procedure from the cultivation of over 80 strains of microorganisms collected from the natural environment. The main microorganisms are *Lactobacillus*, photosynthetic bacteria and yeast. EM includes both aerobic and anaerobic species of bacteria. EM is being used in over 120 countries worldwide in the field of animal husbandry (poultry, ducks, piggery, cattle, goats, horses). Supplementation of EM in poultry drinking water with EM has been suggested for following effects. EM will boost the health of poultry, improve feed conversion and eliminate ammonia and odors in the housing. Its application decreases skin related problems in animals. It suppresses stomach related diseases of animals. If EM is provided in drinking water of animals, it suppresses the foul smell of animal wastes. The manure produced is of high quality. Meat, milk and eggs produced are of superior quality. It reduces the cost of expensive medicines and vaccines. It reduces the stress of animals. Continuous use of EM reduces cost of input by 5-10%. The experiment was conducted to study the effect of EM supplementation in drinking water on egg production of layers.

MATERIALS AND METHODS

Experiment was conducted on poultry farm of Regional Agriculture Research Station of NARC at Tarahara. Six month old Giriraja laying birds having uniform weight were randomly selected and divided into four treatment groups viz., control (T1) and three treatments (T2, T3 and T4). Each group had 18 birds. The birds of T2, T3 and T4 groups were supplied 1:1000, 1:3000 and 1:5000 ratio of EM in drinking water, respectively. The control group was supplied plain water without EM. Five female and one male birds were kept in each chamber. All birds were maintained under similar management conditions and fed layer ration. The effect of EM supplementation on the performance of laying birds was studied for 8 months.

RESULTS AND DISCUSSION

Egg laying performance

The data of egg production in birds fed different levels of EM (Table 1) show that the highest egg production was recorded in T3 (41.47%) and followed by T2 (41.18%), T4 (38.61%) and lowest by T1 (33.6%), respectively. The differences in egg production were significant differences among the treatments.

Average egg weight

The highest egg weight was obtained in T2 (61.04 g), followed by T3 (60.92 g) and T4 (60.66 g) and the lowest in T1 (59.45 g), respectively. There were no significant differences in egg production among treatment groups (Table 2).

Fertility and hatchability

The highest fertility was recorded in T2 (95.85%) followed by T3 (95.66%), T4 (93.83%) and the lowest in T1 (92.44%), respectively. The average fertility of the farm is 93.75%. The highest hatchability was recorded in T2 (91.20%), followed by T3 (90.35%), T4 (90.0%) and lowest in T1 (88.59%), respectively. The difference in fertility and hatchability were not significantly different among the treatments (Table 3).

Table 1. Average egg production in different treatment groups at 240 days

Replication	Treat 1	Treat 2	Treat 3	Treat 4	Mean
Rep 1	106.6	115.6	104.9	108.4	108.87
Rep 2	88.0	103.2	111.4	116.6	104.8
Rep 3	87.8	127.8	127.6	99.4	85.56
Total	282.4	346.6	348.4	324.4	325.45
Mean	94.13	115.5	116.1	108.1	108.46
	(33.6%)	41.18%	(41.47%)	(38.61%)	(38.78%)
F test	ns	*	*	*	
SE =39.88	LSD =114	CV = 10.53			

Table 2. Average egg weight (gm.) obtained by different treatments

Parameter	Treat 1	Treat 2	Treat 3	Treat 4	Mean
Egg weight	59.45	61.04	60.92	60.66	60.51
	±	±	±	±	±
	0.785	1.560	0.485	0.573	0.8515

Table 3. Average Hatchability and Fertility obtained by different treatments

Parameters	T1	T2	T3	T4	Mean
Fertility %	92.44	95.85	95.66	93.83	94.44
Hatchability %	88.59	91.20	90.35	90.0	90.03

In a similar study reported that there was increase in weight gain with the same level of feed consumption up to 67 g per day, reduction in mortality, improved health and quality meat with the reduction of cholesterol (up to 17%), laying of heavier eggs (+3.7%) and larger eggs (6.5%) with a much darker-colored yolk due to better carotene synthesis; a more consistent egg white due to improved synthesis of albumin and a harder shell due to better assimilation of calcium. On the basis of present study the addition of EM liquid in drinking water in the ratio of 1:000 or 1:3000/day have shown beneficial effect in the term of egg production, egg weight, fertility and hatchability. This experiment has indicated that supplement of EM is profitable in layer production. For the best economical operations, and for the general welfare of the birds, it is recommended that birds should be supplemented with EM in drinking water at the ratio of 1:3000 and 1:5000/day.

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Comparative Performance of Soviet Chinchilla and Californian Hyline in Western Hills of Nepal

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ABSTRACT

Data recorded at the Livestock Research Farm of Regional Agricultural Research Station, Lumle from 2001 to 2009 were analyzed using the statistical package Harvey (1990) with the objective to identify the best compatible genotypes of rabbit in terms of productive and reproductive performances considering non-genetic factors. The litter size at birth, weaning and twelfth week was significantly ($p < 0.001$) affected by the year of kindling and breed. Similarly, the litter weight at birth (LWB), weaning and twelfth week was significantly ($p < 0.001$) affected by the year of kindling and breed. Analysis also showed that individual weight at birth was significantly ($p < 0.001$) affected by the year of kindling and breed. Accordingly, individual weight at weaning (IWW) was found insignificant, but significantly ($p < 0.001$) affected by the breed. Individual weight at twelfth week (IWT) was found significantly ($p < 0.001$) affected by year of kindling, whereas, individual weight at twelfth week (IWT) was found insignificant by the breed. Gestation length (GL) was significantly affected by year and breed ($p < 0.001$). The overall least square mean and standard error for gestation length was 30.74 ± 0.05 days.

INTRODUCTION

Contribution of livestock to the agricultural gross domestic products (AGDP) is about 27.6 percent (MoAC 2006), whereas it is a major source of animal protein and household cash income. The Agriculture Perspective Plan (APP 1995) has planned to increase livestock growth rate from 2.64 % to 6.25 % and livestock share to AGDP from 31% to 43.2% by the end of its plan period 2014-15.

Rabbits are small mammals belonging to the *leporidae* family. In the sixteenth century, different breeds of rabbit were established for meat purpose in France, Italy and England (Lebas et al 1986). Now, over 30 meat breeds of rabbit have been developed to suit different agro-ecological zones in different countries (Jiabi and Pelnat 1990). Now most of the rabbit meat production is in the countries of the Mediterranean and in 2003 the world meat production of rabbits was 1,067,948 tones, with China the largest producer with 425,000 tones, followed by Italy with 222,000 tones and Spain with 115,000 tons, (FAO-STAT 2003). In Nepal, no authentic data are available for the country's scattered rabbit industries to describe the production system, marketing opportunities, management system and output. This is because large scale commercial rabbit farming is virtually non-existent. However, recently the meat breed of rabbit is increasingly gaining popularity under low input and low output subsistence backyard rabbit production systems in the villages of the western hills of the Nepal. Commercial rabbitry was started in Nepal by a retired British Gorkha soldier in Pokhara in 1960. Later on, they were supported technically by Lumle Agricultural Research Centre (LARC) (Dhaubhadel and Rasali 1994). LARC, now called Regional Agriculture Research Station (RARS), Lumle, has been pioneering on the research and development of meat breeds of rabbit and serving as a resource centre for meat rabbits with breeding stocks of Californian Hyline and Soviet Chinchilla breed. Due to their prolific nature and short breeding cycle, 10 millions of rabbit can be produced

from few hundreds of pairs in a few years, as had happened in Australian subcontinent (Cheeke et al 1982). This high reproductive rate is very important, especially in a poor country like Nepal, where a cheap means of meat production is in high demand, with the wide physiographic variations in Nepal, varieties of vegetation and other agricultural weeds, grasses and fodder trees are available in plenty, that can be used to sustain small scale rabbit farming in the village at the household level (Dhaubhadel and Rasali 1994). The present study was carried out mainly aiming at identifying the best compatible genotypes of exotic breeds of rabbit in relation to their genetic and breeding efficiency under mid-hill conditions of Nepal.

MATERIALS AND METHODS

Location of study

This study was carried out in of Livestock Unit of Regional Agricultural Research Station (RARS), Lumle, Kaski, Nepal.

Sampling design and sample selection

A sampling frame of the study covered nine years (2001 to 2009) of production data to analyze and estimate the different productive and reproductive parameters of two meat type breeds of rabbit including Soviet Chinchilla and Californian Hyline.

Non-genetic factors considered

Factors	Categories
Year of kindling	1=2001-2003, 2=2004-2006, 3=2007-2009
Breed/Genetic group	1=Californian Hyline, 2=Soviet Chinchilla

Traits recorded and their description

Traits	Description
Productive	
Birth weight (g)	Weight of individual kits at birth
Weaning weight (g)	Weight of individual kits at weaning (six weeks)
Twelve weeks weight (g)	Weight of individual kits at twelfth week aged (84 days)
Reproductive	Description
Gestation length (days)	Period between conception and kindling
Litter size	
at birth (nos.)	Total number of kits born alive per kindling
at birth (g)	Weight of all kits born alive at birth
at weaning (nos.)	Number of kits weaned per kindling
at weaning (g)	Weight of all kits weaned per kindling
at twelfth week (nos.)	Total number of kits borne alive per kindling
at twelfth week (g)	Weight of all kits at twelve weeks per kindling

Data analysis

Data generated for this study were entered into MS-excel and converted into text documents i.e. Text (MS-DOS). To study the main causes of variation and effect of non-genetic factors on productive and reproductive traits, as well as to overcome difficulty of disproportionate sub-class numbers, data were analyzed by least square procedure using Harvey (1990) software package.

Statistical models

Fixed effect model for estimating weight traits and litter traits

$$Y_{ijk} = H + J_i + b_j + e_{ijk}$$

where,

Y_{ijk} = Weight of individual weight/litter size/litter weight at different stages of growth

H = overall mean

J_i = effect of i^{th} year of kindling (1=2001-2003, 2=2004-2006, 3=2007-2009)
 b_j = effect of k^{th} breed/genetic group (1=Callifornian Hyline; 2=Soviet Chinchilla)
 e_{ijk} = is the random (residual) element assumed to be normally & independently distributed.

Fixed effect model for estimating reproductive traits

$Y_{ijk} = H + J_i + b_j + e_{ijk}$
 Y_{ijk} = average gestation length of rabbit
 H = overall mean
 J_i = effect of i^{th} year of kindling (1=2001-2003, 2=2004-2006, 3=2007-2009)
 b_j = effect of k^{th} breed/genetic group (1=Callifornian Hyline, 2=Soviet Chinchilla)
 e_{ijk} = is the random (residual) element assumed to be normally and independently distributed.

RESULTS AND DISCUSSION

Litter size at birth

Litter size is the most important economic character in rabbit production (Abou-Khadiga 2004). The overall mean of litter size at birth (LSB) of the rabbits considered in this study was 5.40 ± 0.09 (Table 1a). This result was in line with the results of Das et al (2005), who reported the overall mean LSB of different genetic groups of rabbit as 5.59 in a study carried out in Meghalaya, India. Lebas et al (1986) recorded that the litter size at birth of Californian Hyline and Soviet Chinchilla were 7.6 and 6.8, respectively which were relatively higher than the result of this study whereas Opoku and Lukfahr (1990) reported relatively lower than this study (4.9 ± 0.19) of Californian and Chinchilla.

Results of this study revealed that year of kindling had highly significant effect ($p < 0.001$) on litter size at birth (Table 1a). Accordingly, highest litter size at birth was observed during 2004-2006 (5.96 ± 0.09) followed by the years 2007-2009 (5.95 ± 0.13) and 2001-2003 (4.29 ± 0.22). Similarly, Khalil et al (1988) reported significant effect ($p < 0.001$) of year of kindling on litter size at birth of Bauscat, White Flander, Giza White and Baladi Red that is in line with the results of present study. There was highly significant effect of genetic group ($p < 0.001$) on litter size at birth (Table 1). Accordingly, the litter size at birth of kits born from Soviet Chinchilla dams was maximum (5.96 ± 0.15) as compared to those born from Californian Hyline (4.84 ± 0.11). Hassanien and Baiomy (2011) reported that breed effect led to significant ($p < 0.05$) effect on litter size at birth of different genetic groups (Rex, New Zealand White (NZW), California and Baladi Red).

Litter size at weaning

The overall mean of litter size at weaning (at 6th week) was found 4.91 ± 0.08 (Table 1b). Similarly, Sundaram and Bhattacharya (1991) reported average size at weaning in Soviet Chinchilla breed rabbit as 5.0 in India. Finji (1985) reported average litter size at weaning in New Zealand White breed rabbit to be 6.3 in Italy. The present results revealed that year of kindling was an important source of variation ($p < 0.001$) with respect to litter size at weaning of rabbits. Accordingly, highest litter size at birth was observed during 2007-2009 (5.41 ± 0.11) followed by the years 2004-2006 (5.39 ± 0.08) and 2001-2003 (3.94 ± 0.20). Khalil et al (1987) reported that no important differences were detected among breeds for litter traits studied except litter size at weaning ($p < 0.001$).

Results of this study revealed that there was highly significant effect of genetic group ($P < 0.001$) on litter size at weaning (Table 1b). Accordingly, the litter size at weaning of kits born from Soviet Chinchilla dams was maximum (5.42 ± 0.13) followed by those from Californian Hyline (4.41 ± 0.09). Similarly, Lukefahr et al (1983) observed no significant differences in litter size at weaning between Californian Hyline and New Zealand White breeds.

Litter size at twelfth week

The overall mean litter size of twelfth week age of Soviet Chinchilla and Californian Hyline rabbit was 4.38 ± 0.07 (Table 1c). Das et al (2005) studied some litter traits in New Zealand White and Soviet Chinchilla and found litter size at twelfth week 5.32 ± 0.15 and 5.11 ± 0.05 , respectively. Results of this study revealed that year of kindling had highly significant effect ($p < 0.001$) on litter size at twelfth week (Table 1). Accordingly, highest litter size at birth was observed during 2007-2009 (4.86 ± 0.11) followed by the years 2004-2006 (4.84 ± 0.08) and 2001-2003 (3.45 ± 0.19). It was further revealed that, genetic group was an important source of variation ($p < 0.001$) with respect to litter size at twelfth week (Table 1c). Accordingly, the litter size at weaning of kits born from Soviet Chinchilla dams was higher (4.89 ± 0.12) compared to that of Californian Hyline (3.88 ± 0.09).

Table 1a. Least square means and standard error for litter size (numbers) of rabbits at birth

Factors	Number of observations	LS Mean $\pm$ SE
Overall Mean	681	5.40 ± 0.09
Year of kindling		*** (0.001)
2001-2003	81	4.29 ± 0.22
2004-2006	399	5.96 ± 0.09
2007-2009	201	5.95 ± 0.13
Breed		*** (0.001)
Callifornian Hyline	408	4.84 ± 0.11
Soviet Chinchilla	273	5.96 ± 0.15
CV%	19.33	

***, significant at 0.1 % level

Table 1b. Least square means and standard error for litter size (numbers) of rabbits at weaning

Factors	Number of observations	LS Mean $\pm$ SE
Overall Mean	681	4.91 ± 0.08
Year of kindling		*** (0.001)
2001-2003	81	3.94 ± 0.20
2004-2006	399	5.39 ± 0.08
2007-2009	201	5.41 ± 0.11
Breed		*** (0.001)
Callifornian Hyline	408	4.41 ± 0.09
Soviet Chinchilla	273	5.42 ± 0.13
CV%	18.77	

***, significant at 0.1 % level

Table 1c. Least square means and standard error for litter size (numbers) of rabbits at 12 week

Factors	Number of observations	LS Mean $\pm$ SE
Overall Mean	681	4.38 ± 0.07
Year of kindling		*** (0.001)
2001-2003	81	3.45 ± 0.19
2004-2006	399	4.84 ± 0.08
2007-2009	201	4.86 ± 0.11
Breed		*** (0.001)
Callifonian Hyline	408	3.88 ± 0.09
Soviet Chinchilla	273	4.89 ± 0.12
CV%	16.89	

***, significant at 0.1 % level

Litter weight at birth

The overall mean of litter weight at birth of rabbit in this study was found 336.20 ± 5.21 g (Table 2a). Nunes and Moura (1985) found that the average litter weight at birth were recorded for Baladi Red

(368±27 g) followed by California (364±22 g). Dhaubhadel and Rasali (1994) studied on litter traits in Californian Hyline and Soviet Chinchilla and found litter weight at birth 460±0.23 and 410 ± 0.03 g, respectively. The litter weight at birth was 350.6 g for Californian rabbit in China as reported by ((Jiabi and Pelnat 1990)). Das et al (2005) studied some litter traits in New Zealand White and Soviet Chinchilla and found litter weight at birth 346.55±18.14 and 356.03±24.37, respectively.

Results of this study revealed that year of kindling had highly significant effect ($p<0.001$) on litter weight at birth. Accordingly, highest litter weight at birth was observed during 2007-2009 (372.71±7.32 g) followed by the years 2004-2006 (352.30±5.40 g) and 2001-2003 (283.59±12.67 g) (Table 2a). Accordingly, the litter size at weaning of kits born from Soviet Chinchilla dams was maximum (386.37±8.46) followed by kits born from Californian Hyline (286.03±6.08 g). Hassanien and Baiomy (2011) reported that highest values of litter weight at birth were recorded for Baladi Red (368±27 g) followed by California (364±22 g). While, the values of litter weight at birth for Rex, and New Zealand White were 357±25 and 351±25 g, respectively.

Litter weight at weaning

The overall mean of litter weight at weaning in this study was observed 2871.19±52.87 g (Table 2b). Das et al (2007) studied on the reproductive traits in New Zealand White, Soviet Chinchilla and Meghalaya local rabbits and observed the litter weaning weight of the value 2.00±0.08, 2.09±0.09 and 2.03±0.08 g, respectively. Dhaubhadel and Rasali (1994) reported that the litter weight at weaning of Hyline Californian and Soviet Chinchilla were 2062±0.24 g and 3028±0.09 g, respectively. Litter weight at weaning was significantly ($P<0.001$) influenced by the year of kindling (Table 2). Accordingly, highest litter weight at weaning was observed in the years 2004–2006 (3193.35±54.78) followed by the years 2007-2009 (3111.22±74.31) and 2001-2003 (2309.01±128.56).

Results of the present study revealed that breed had highly significant ($P<0.01$) effect on litter weight at weaning (Table 2b). Accordingly, the litter weight at weaning of kits born from Soviet Chinchilla dams was maximum (3042.46±85.84 g) followed by kits born from Californian Hyline (2699.92±61.74 g). Das and Buzarbaruah (2005) reported that the lower litter weight at weaning than this study of New Zealand White and Soviet Chinchilla and overall weights were 2480±105, 2051±91 and 2265±89 g, respectively.

Litter weight at twelfth week

The average litter weight at twelfth week of Soviet Chinchilla and Californian Hyline rabbit were 5421.93±96.95 g (Table 2c). Litter weight at twelfth week was significantly ($P<0.001$) influenced by the year of kindling (Table 2). Accordingly, highest litter weight at twelfth week was observed in the years 2004-2006 (6254.26±100.47 g) followed by the years 2007-2009 (5801.30±136.27 g) and 2001 – 2003 (4210.24±235.76 g).

Results of this study revealed that, breed had highly significantly ($P<0.001$) effect on litter weight at twelfth week (Table 2c). Accordingly, the litter weight at twelfth week of kits born from Soviet Chinchilla dams was maximum (6126.19±157.41 g) followed by kits born from Californian Hyline (4717.68 ±113.23 g).

Table 2a. Least square means and standard error for litter weight (g) of rabbits at birth

Factors	Number of observations	LS Mean±SE
Overall mean	681	336.20±5.21
Year of kindling		*** (0.001)
2001-2003	81	283.59±12.67
2004-2006	399	352.30±5.40
2007-2009	201	372.71±7.32
Breed		*** (0.001)
Callifornian Hyline	408	286.03±6.08
Soviet Chinchilla	273	386.37±8.46
CV%	20.36	

***, significant at 0.1 % level

Table 2b. Least square means and standard error for litter weight (g) of rabbits at weaning

Factors	Number of observations	LS Mean±SE
Overall Mean	681	2871.19±52.87
Year of kindling		*** (0.001)
2001-2003	81	2309.01±128.56
2004-2006	399	3193.35±54.78
2007-2009	201	3111.22±74.31
Breed		** (0.01)
Callifornian Hyline	408	2699.92±61.74
Soviet Chinchilla	273	3042.46±85.84
CV%	17.98	

***, significant at 0.1 % level; **, significant at 1% level

Table 2c. Least square means and standard error for litter weight (g) of rabbits at 12 week

Factors	Number of observations	LS Mean±SE
Overall Mean	681	5421.93±96.95
Year of kindling		*** (0.001)
2001-2003	81	4210.24±235.76
2004-2006	399	6254.26±100.47
2007-2009	201	5801.30±136.27
Breed		*** (0.001)
Callifornian Hyline	408	4717.68±113.23
Soviet Chinchilla	273	6126.19±157.41
CV%	16.96	

***, significant at 0.1 % level

Birth weight

The overall least square mean birth weight of rabbit in this study was found 63.29±0.54 g (Table 3a). In rabbits, individual birth weight is about 60-70 g, but can range from 35-40 to 80-90 g. Generally, individual birth weight decreases with increase in litter size. Kits of larger litters generally also show a lower weight at weaning than the corresponding weight for kits of smaller litters (Poigner et al 2000).

Nunes and Moura (1985) found that the average of body weight for Norfolk, California and New Zealand White rabbits were 73, 87 and 78 g at birth. Dhaubhadel and Rasali (1994) reported that the average kit weight at birth of Hyline Californian and Soviet Chinchilla were 78±0.02 and 64±0.02 g, respectively at Lumle, Kaski. Weight at birth was significantly ($P<0.001$) influenced by the year of kindling (Table 3a). Accordingly, highest weight at birth was observed in the years 2001-2003 (66.08±1.31 g) followed by the years 2007-2009 (63.44±0.76 g) and 2004 – 2006 (60.35±0.56 g).

Yamani et al (2005) reported that the effect of year kindling was significant on most traits studied in NZW and BOS does, but less affected in Californians ones. Results of this study revealed that breed

affected highly significantly ($P < 0.001$) on weight at birth (Table 3). Accordingly, the weight at birth of kits born from Soviet Chinchilla dams was maximum (66.28 ± 0.87) followed by kits born from Californian Hyline (60.30 ± 0.63 g). Das et al (2007) reported that individual litter weight at birth of New Zealand White, Soviet Chinchilla and Meghalaya local were 54.3 ± 1.47 , 52.8 ± 1.64 and 56.2 ± 1.62 , respectively.

Weaning weight

Least square means and standard errors for weight at weaning in this study was 601.18 ± 8.61 g (Table 3b). Weaning weight of English spot rabbit were 0.92 ± 0.30 kg, FG rabbit were 0.90 ± 0.17 kg, NZ rabbit were 0.80 ± 0.07 kg, and RR rabbit were 0.71 ± 0.05 kg. Muryanto et al (2005) reported that average body weight of FG rabbit were 840.1 ± 229.6 g. Dhaubhadel and Rasali (1994) reported that the average kid weight at weaning of Hyline Californian and Soviet Chinchilla were 650 ± 0.03 and 680 ± 0.05 g in 42 days, respectively at Lumle, Kaski. Das et al (2007) studied in New Zealand White and Soviet Chinchilla and found the average individual kit weight at weaning were 461 ± 10.2 g and 464 ± 10.7 g, respectively.

Results of this study revealed that, genetic group affected highly significantly ($P < 0.001$) on weight at weaning (Table 3b). Accordingly, the weight at birth of kits born from Californian Hyline dams was maximum (638.55 ± 10.068 g) followed by kits born from Soviet Chinchilla (563.81 ± 13.98 g). Dhaubhadel and Rasali (1994) reported that the average kit weight at weaning of Hyline Californian and Soviet Chinchilla were 650 ± 0.03 and 680 ± 0.05 g in 42 days, respectively at at Lumle, Kaski.

Twelfth week weight

Over all least square means and standard errors for weight at twelfth week in this study was $1249.74 \pm 11, 84$ g (Table 3c). Marykutty and Nandakumar (2000) reported that Soviet Chinchilla rabbit showed the heaviest body weight at twelfth week (1238 g) New Zealand White (1133 g) and Grey Giant (1121 g). Rastogy (2001) concluded that the average kit weight at twelfth week was 1610 g. Litter weight at twelfth week was highly significantly ($P < 0.001$) influenced by the year of kindling (Table 3c). Accordingly, highest twelfth week weight was observed in the years 2004 – 2006 (1315.30 ± 12.27 g) followed by the years 2001-2003 (1225.63 ± 28.79 g) and 2007–2009 (1208.35 ± 16.64 g). Results of this study revealed that, breed affected not significantly ($P > 0.05$) on weight at twelfth week (Table 3). Accordingly, the weight at birth of kits born from Soviet Chinchilla was maximum (1252.28 ± 19.22) followed by Californian Hyline (1247.24 ± 13.83).

Marykutty and Nandakumar (2000) reported that Soviet Chinchilla rabbit showed the heaviest body weight at twelfth week (1238 g), New Zealand White (1133 g) and Grey Giant (1121 g).

Table 3a. Least square means and standard error for individual weight (g) at birth of rabbits

Factors	Number of observations	LS Mean $\pm$ SE
Overall mean	681	63.29 ± 0.54
Year of kindling		*** (0.001)
2001-2003	81	66.08 ± 1.31
2004-2006	399	60.35 ± 0.56
2007-2009	201	63.44 ± 0.76
Breed		*** (0.001)
Callifornian Hyline	408	60.30 ± 0.63
Soviet Chinchilla	273	66.28 ± 0.87
CV%		17.47

Note: No.=Number of observation, ***=Significant at 0.1 % level, **=Significant at 1 % level, *=Significant at 5 % level, NS=Not significant, CH=Callifornian Hyline, SC=Soviet Chinchilla and CV=Coefficient of variation.

Table 3b. Least square means and standard error for individual weight (g) at weaning of rabbits

Factors	Number of observations	LS Mean±SE
Overall Mean	681	601.18±8.61
Year of kindling		ns
2001-2003	81	593.74±20.94
2004-2006	399	618.71±8.92
2007-2009	201	591.09±12.10
Breed		*** (0.001)
Callifornian Hyline	408	638.55±10.06
Soviet Chinchilla	273	563.81±13.98
CV%		17.95

***, significant at 0.1 % level; ns, not significant

Table 3c. Least square means and standard error for individual weight (g) at 12 week of rabbits

Factors	Number of observations	LS Mean±SE
Overall Mean	681	1249.74±11.84
Year of kindling		*** (0.001)
2001-2003	81	1225.63±28.79
2004-2006	399	1315.30±12.27
2007-2009	201	1208.35±16.64
Breed		ns
Callifornian Hyline	408	1247.24±13.83
Soviet Chinchilla	273	1252.28±19.22
CV%	18.43	

***, significant at 0.1 % level; ns, not significant

Reproductive traits

Least square means and standard errors for gestation length (days) was found 30.74±0.05 in this study (Table 4). Gestation length of rabbit was influenced by litter size and litter weight, longer time on gestation were made lowest on litter size with high litter weight and gestation period of rabbit were about 28-32 days (Cheeke et al 1987). Average of gestation length of Flemish Giant, New Zealand White, Rex and English Spot were 30.30±1.22 days, 29.55±0.95 days, 29.05±0.89 days and 29.25±0.89 days, respectively.

Gestation length was found significantly ($P < 0.001$) influenced by the year of kindling (Table 4). Accordingly, longest gestation length was observed in the years 2007-2009 (31.02±0.07 days) followed by the years 2004-2006 (30.81±0.05 days) and 2001-2003 (30.39±0.12 days). Mancha and Chollom (2011) concluded that year had no significant effect on gestation length and the overall gestation length of different breed of rabbits were 30.28±0.04 days and they also reported that gestation length in 2001, 2002, 2003, 2004 and 2005 were 30.62±0.19, 30.27±0.11, 30.20±0.09, 30.04±0.09 and 30.55±0.09 days, respectively.

Results of this study revealed that, breed affected significantly ($P < 0.001$) on gestation length (Table 4). Accordingly, the gestation length of Californian Hyline dams was maximum (30.95±0.06) followed by Soviet Chinchilla (30.53±0.08 days). Length (GL) in this study is contrary to the report of Tahir (2001) that pure NZW breed had longest GL of 33±0.23 days whereas the local genotype had shortest, 31.70±0.13 days. Aduku and Olukosi (1990) reported that GL in rabbit last between 28 and 32 days which is in agreement with what was obtained in the study.

Table 4. Least square means and standard errors for gestation length (days)

Factors	Number of observations	LS Mean±SE
Overall Mean	681	30.74±0.05
Year of kindling		*** (0.001)
2001-2003	81	30.39±0.12
2004-2006	399	30.81±0.05
2007-2009	201	31.02±0.07
Breed		*** (0.001)
Callifornian Hyline	408	30.95±0.06
Soviet Chinchilla	273	30.53±0.08
CV%	3.38	

***, significant at 0.1 % level

In brief, results of this study revealed that the year of kindling, and breed had significant effect on litter size at birth, litter size at weaning, litter size at twelfth week, litter weight at birth, litter weight at weaning and litter weight at twelfth week. Highly significant effect of different traits of the rabbit indicated the need of careful adoption of management practices. The study had considered the important non-genetic factors such as year of kindling and breed with respect to weight traits. Accordingly, year of kindling had significant effect on individual weight at birth and individual twelfth week weight and year had significant effect on individual weaning weight. Breed had highly significant effect on individual birth weight and individual weaning weight, where as the breed had no significant effect on individual weight at twelfth week. Similarly, year of kindling and breed had significant effect on gestation length. Selection based on weight traits (birth and weaning weight) would bring improvement. Similarly, selection based on litter traits (litter weight at birth and weaning) would be effective in making improvement in these traits. Year and type of breed were the important sources of variation with respect to major economic traits of rabbit reared in Nepal. Therefore, these non-genetic factors should be given due consideration to make genetic improvement in these species.

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Value Chain Analysis: Fishing Tourism Can Support Fish Conservation and Livelihood of Fishers

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ABSTRACT

The present study attempts to elucidate using the value chain analysis how fishing tourism or recreational fisheries could be resilient to fish conservation and livelihood of artisanal fishing communities. Fishing tourism is a multi-billion dollar outdoor leisure and time pass activities worldwide. However, it has yet to be systematically regularized and practiced. Nepal has commendable freshwater resources for fishing tourism. It is expected that promotion and streamlining of tourism-based recreational fisheries could generate immense value chain opportunities for artisanal fishers 'the poorest of the poor' and resilient to fish conservation. The value chain analysis showed that household incomes of fishers are likely to be pronouncedly enhanced by involving in fishing-based tourism support services with fewer fishing activities, which in turn could be supportive for fish conservation efforts. The present modality of promoting and systematizing fishing tourism might have implication to address the issues of fish conservation and poverty alleviation in many developing countries having similar socio-economic and agro-ecological setups.

INTRODUCTION

Nepal has abundant *lotic* and *lentic* freshwater resources flowing down from world renowned pristine highest Himalayan mountains of the world. The Himalayan *Shangri-La* could be one of the world paradises for fishing tourism industry. Fishing tourism has been well recognized as contributors to local, national and regional economies throughout the world (April et al 2011, Cordell et al 1999). In general, primary objective of fishing tourism might inclining towards sport and leisure; but secondarily the purpose could also mean for consumption (FAO 1997, Pitcher and Hollingworth 2002, EIFAC 2008, Arlinghaus and Cooke 2008), management and conservation etc. The fishing tourism is an outdoor activity, thus could be the part of international and global concern (Cowx et al 2010). The tourism industry accounted for 8% of the world's gross domestic product and about 9% of the world's employment (Goeldner et al 2000).

The value chain of fishing tourism covers a wide and multiple activities including transportation (planes, buses, boats etc.), accommodations (hotel, motel, restaurant etc.), attractions (quality fishing, river beach, national parks, culture and religious festivals etc.), food and beverages (restaurants, bars, fast-food, groceries etc.), clothing (fishing wear, souvenirs) equipment (fishing tackle and bait, rod and line, camping essentials, outfits, out boat engines, house boats etc.) concerns, information systems (tourist centers, internet, travel guide book, advertising, maps, musical, cultural, historical, geographical information, brochures etc. (Goeldner et al 2000).

Fishing tourism possesses high potential in Nepal, because of unique, pristine and peaceful landscape, and associated conditions (Gurung 2011). The contribution of tourism in national economy is known to be steadily increasing; the addition of recreational fishing tour might add further values to this sector in the country. Until present, the communities associated directly are ethnic artisan fishers involved in subsistence fishing for livelihood since tradition. As Sowman (2006) has mentioned

fishers involved in subsistence fisheries are poor. It is true in Nepal, as s fishers mainly capture fish for food and may exchange or sell surplus harvest to meet basic needs. In general, for commoners and fishers fishing had been seldom a leisure time pass in Nepal. Instead, it was one of the main activities of livelihood, food and nutrition security to deprived fisher's living nearby rivers, tributaries, lakes and wetlands, so they can access easily to harvest aquatic food such as fish, crabs, snails, water chest nut, and other vegetation mostly free of cost. The importance and dependency of certain community on aquatic food might be due to scarcity of agricultural land for food production in particularly in the Himalaya.

Inland native fishers have limited knowledge on their role on fish resource conservation (Gurung 2003, Granek et al 2008). This might also be the reasons that fish biodiversity is in decline, fishers getting more poorer and; conflict in between fishers and conservation implementers are widening. It can be argued that the conflict between fishers and National Park in Nepal (Jana 2005) might be due to the lack of such analytical synthesis on fish conservationist and fishers. Therefore, for practical fish conservation we propose that the role and responsibilities of traditional fishers should also be analyzed and cared for effective conservation. Nevertheless, recreational fishers can be instrumental in successful fish conservation through active involvement to reduce both direct and indirect stressors contributing to fishery declines. Understanding fishers concerns for sustained access to the resource and developing methods for their meaningful participation can have positive impacts on conservation efforts (Granek et al 2008).

Recently, several studies have shown that the aboriginal fishing communities have suffered a great deal of deprivation due to conceptual changes of nature conservation such as in Chitwan National Parks in Nepal (Bhattarai et al 2002, Jana 2005, Paudel et al (2007). The studies concluded that the government policies indeed the main encroachers to the ethnic rights of common, especially those depending on traditional practices of their fishing activities (Bhattarai et al 2002, Jana 2005). In such circumstances, it is anticipated that promoting tourism-based recreational fisheries involving the traditional and deprived fishers into the value chain might be effective tools for compensating benefits to deprived fishers facing rampant poverty and also to support fish diversity conservation activities. Thus, the present paper elucidates a value chain analysis how promotion of recreational fisheries might benefit traditional fishers as well as support fish conservation. The present analysis was performed using the tools of value chain analysis (Riley 2012), literature search, interactions with entrepreneurs, fishers and anglers in Nepal.

VALUE CHAIN IN TOURISM-BASED FISHERIES

Act, law and policy exist for mainstreaming tourism-based fisheries in Nepal

Regulation of recreational fisheries by government agencies is common practice worldwide. Accordingly, Government of Nepal has also promulgated '*Jalchar Sarachhan Ain 2017*' or '*Aquatic Life Conservation Act 2017*' in the year 1940 with aim to regulate aquatic life conservation and use. However, due to lack of by-laws and low priority, fish biodiversity conservation has not been focused adequately. Thus, needs to formulate laws and by-laws to priorities aquatic life conservation in national policies. Contrarily, much emphasis has been given on regulation and management of terrestrial wildlife as a result several national parks and protected areas have been declared in the country. The aquatic fauna and flora on which approximately 12% of total population is known directly or indirectly depending have been ignored. This probably has caused a gap in understanding and is the reason of conflict in between the park and communities subsisting on aquatic ecosystem for their livelihood.

In Nepal, Aquatic Life Conservation Act 2017 permits the use of water bodies to be utilized for public contract for fishing. According to this Act, it has been provisioned that the designated government officials could authorized the nearby water body for fishing activities. There are additional ordinance from the Ministry of Agriculture and Cooperatives, which delineates size of fish and species in particular season to protect the fish species during the spawning season. Recent compilation has shown occurrence of 229 fishes in Nepal (Wagle and Pradhan 2012).

Following the Act 2017 Fisheries Research Station, Pokhara is issuing license since its establishment for angling, cast net fishing and use of gill net etc. National Parks are also known to issuing the license for fishing. Other agencies issuing the license for fishing in Nepal have not been known.

There exist amateur fishing clubs and associations in Nepal. Some aquaculture farmers are also insisted to incorporate their fish farms as one of the spots as tourism-based fisheries activities. These fishing clubs and farms are known to organize fishing activities in private-owned farms and potential sites, such as Arun Valley Rivers in east and Lake Phewa, Begnas etc. The clubs, associations and farms might need to be streamlined to initialize recreational tourism-based fisheries for better benefits.

Is Nepal an ideal destination for fishing tourism?

Promotion of recreational fishing tourism is likely to be a success similar to other sectors of tourism in Nepal. For successful fishing tourism enterprise abundant piscivore species are considered ideal for angling which can be captured using bait. Pristinely pleasing and secured surroundings close to the fishing location are preferred as an ideal location. Such fishing location should be close to the roads for easy access facilities. The tourism service facilities for outfits, guides, fishing equipment and lures should also be close. Money exchange and overnight staying facilities for several weeks stay, other leisure and recreation besides fishing and angling would also be desirable.

One of the authors met a British national fishing tour expert in Pokhara Fisheries Research Station with the proposition to establish Nepal as one of the fishing tourism destinations in year 2003. The expert was very happy to observe the geographical setting of country, fish species and water bodies in Nepal. He recommended Nepal as one of the best location for fishing tourism destination. It was agreed to take several initiatives such as initializing travel agents and companies and formation of fishers association, and selection of fishing sites, training to fishers and certain facility development of fishing sites etc. However, our plan could not be implemented because the country loomed in the internal conflict thereby. Presently, there are governmental plans to protect endangered fish in regulated rivers (ALPA 2061), increase productivity (Gurung 2010) and livelihood improvement of fisher's communities.

Fish angling as major activities of the recreational fisheries is enjoyable time pass outdoor life. These all activities have potentialities to be a powerful economic engine (Ditton et al 2002, Bauer and Alexander 2004). However, the sector is merely known due to poor understanding, lack of accessible information, initiatives to promote fishing tourism economic dimensions and importance in Nepal.

The fishing tourism markets in Nepal

Nepal possesses nationally and internationally well renowned fishes having high reputation as sport fish. Generally, fisheries management plan aims to foster not only conservation but also opportunities in relation to fishing size, catch, quality and locations, healthy fisheries. It is known that fisheries that attracts and draws national and international visitors, contributes to the economically healthy, strong and exciting fishery (IFS 2007). Here, it can be argued that basic principle of game fisheries is better profit through mobilizing value chain associated with recreational sport fisheries.

Detail study for developing fishing destination in Nepal is yet to be done. In general, fishing is in taken as time pass as well capturing fish for food and nutritional requirement. Nepal is endowed about 6000 rivers and tributaries feeding three main river systems in Nepal. These rivers, tributaries and other forms of aquatic ecosystem are known to harbor about 229 fish species in Nepal (Wagle and Pradhan 2011). Out of these some are known to be the best sport fish of the world such as *Tor putitora* including, *Acrossocheilus hexagonolepis*, *Shizothorax* spp., *Oncorhynchus mykiss* and several other competitive fishes. These fishes are available in Nepalese waters in most of water bodies from east to west (Gurung and Baidya 2012). These fishes have earned international reputation to be the best fishes for sport and recreational purposes because of their sporty, tackling and fighting capabilities.

The natural landscape of Nepal is world renowned for its world tallest peaks, scenic beauty and diversity. Similarly, the fish composition in Nepal is almost similar to rest of the world dominated by cypriniformes (Mayden et al 2008). Moreover, ethnic and cultural diversity of the country is additional attraction for travelers in the country. Accumulatively, the resources and geographical setting of Nepal is expected to be highly suitable for developing the fishing tourism.

Fishers' livelihood enhancement and fish conservation via tourism fisheries

Several studies suggested that tourism fishing is detrimental for fish conservation approaches (Regier et al 1997, Westera et al 2003). This fact, in general has been acceptable. However, in prevailing socio- economical context unconventional fishing is deteriorating fish biodiversity (Gurung 2003, 2012) due to poverty, banning on food gathering from community-owned forestry and national parks etc. Therefore, in such circumstances promoting tourism-based recreational fisheries could be one of the safeguarding approaches for fish conservation by providing other livelihood options developed by promoted job and income opportunities to traditional fishers through tourism fisheries. It is expected that involving the poorest of the poor fishers into the tourism might rescue the fishes being over fish and to fisher from redundancy.

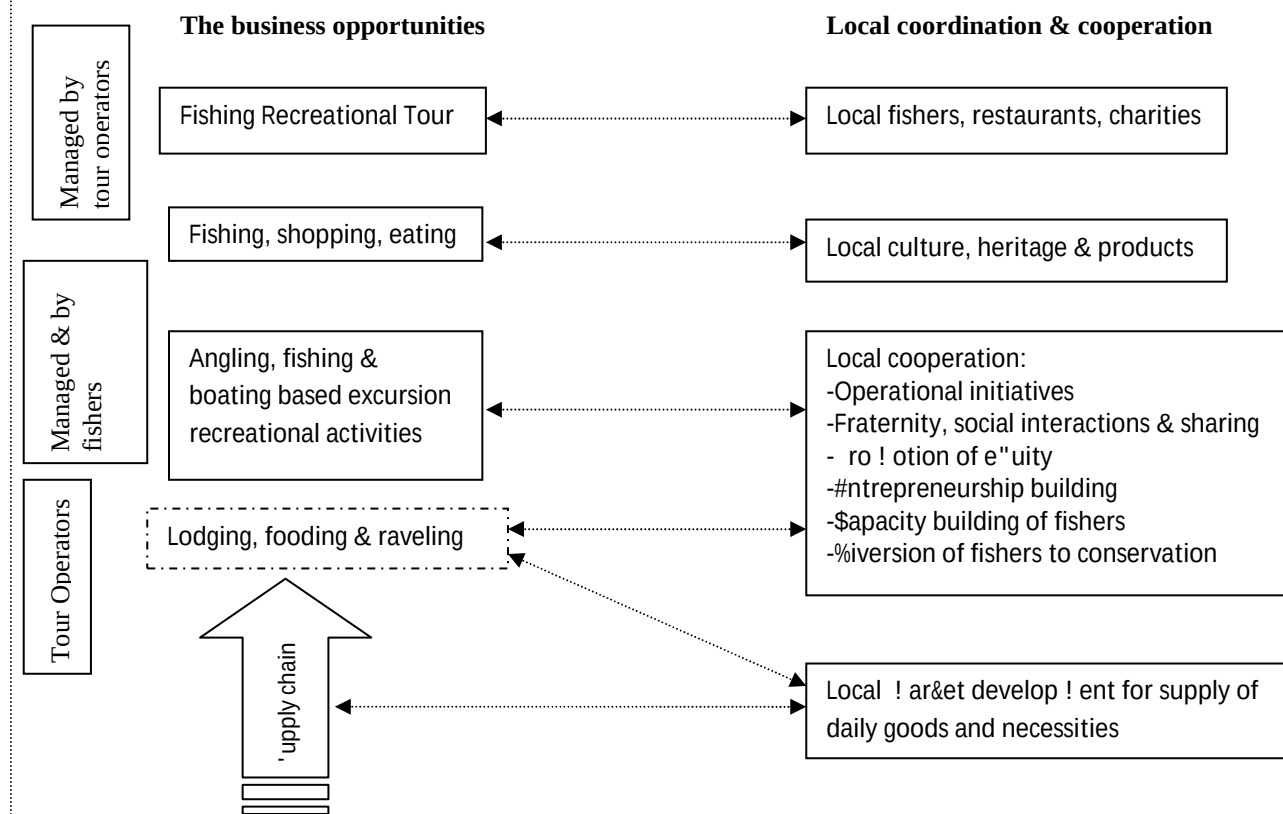
As the approach of fishing tourism will support conservation as fishers efforts will be diverted by involving in other value chain activities for employment and income (Fig 1 and 2). In many parts of the world, the approaches of involving poor into the tourism have been successful to mainstreaming them for improving livelihood (Caroline et al 2000, Ditton et al 2002). However, in Nepal such an effort to involve poor fisher communities with aim to their livelihood enhancement and conserving fish resources is a new approach. The initiation of this approach might also solve the conflicting relationship of fishers with national park administration.

The fundamental principle of fishing tourism is high effort and low catch contrasting to low effort with high catch of traditional fisheries (Pereira and Hansen 2003). This approach is highly relevant in Nepalese waters for fish conservation, which supposed to have been overfished (IUCN 2004, Gurung 2010, 2011). Therefore, the recreational fisheries can be highly relevant to conservation strategies in natural waters.

Resolving conflict between national parks policies and fishers

Management of fishing tourism may be the parts of regulation, policy, and guidelines of the national government or local regulatory bodies. The frameworks of tourism fishing are also defined by the national fishing legislation (Hofer 2002). For fishing tourists, adherence to these regulatory frameworks should be a pre-requisite, ignorance to the regulation could be a reason to their exclusion, and stopping them from fishing activities, in extreme cases the result might lead to regulatory prosecuted.

Figure 1. Fishing tourism linkage into the local economy for livelihood



Some of the national parks in Nepal have included several villages and other forms of human settlement inside. This kind of inter dependency often invites conflicts in between the park administration and local communities (Bhattarai et al 2002, Jana 2007). However, there could be advantages of such human settlement inside the park, if some model of beneficial interaction in between the park and people could be drawn. On this aspect, much of the models and theories have been described and tested, however, the interaction between the park and fishing community emerged as one of the problems of management (Jana 2007).

Recently, interesting works on conflict between fishing communities living along the bank of Narayani river in south central Nepal within Royal Chitwan National Park has been highlighted by several authors (Bhattarai et al 2002, Jana 2007, Paudel et al 2007). There are several other incidences where fisher communities have been deprived from their traditional occupation of fishing due to territorial land acquisition for park and conservation program and other activities. As a result, fishers as well as local inhabitants living in those areas for centuries now have been deprived to collect wild vegetables, fish and other foods along with banning on ferrying across river (Dahal and Chapagai 2008, Paudel et al 2007).

The poor fisher communities have demanded several issues to be resolved on their right to fish in the river through persistent campaigns (Jana 2007). The *Bote* and *Majhi* fishing communities initially tried to campaign through the local political parties. It is learnt that the park administration harasses

the fishers (Bhattarai et al 2002, Jana 2007). Different political parties showed their sympathy towards their cause, but they did very little in changing the situation. Such a conflict has been reported from Chitwan, Nawalparasi and Saptari districts. It is also known that park authorities allowed fishers to fish in the river for six months. The establishment of park has opened new venues and opportunities in the tourism value chain.

Park administration is allowed to collect revenue by tourist entry fee as well as permitting the fishing through licensing. To reduce the conflict in between park administration and local fishers, it might be advisable to develop mechanisms by which the local fishers could extend their services to components of value chain developed through the establishment of park in the area. In such recreational fishing tourism could be one where the local fishers could be deviated from 'high' fishing pressure to other jobs.

Plan of action involving value chain actors

A brief policy outline and initiatives from the government on awareness might be important to catalyze the fishing tourism opportunities in Nepal. Since the motives of the recreational fisheries is to reduce pressure, increase awareness of illegal fishing, involvement of fish communities in the value chain of recreational fisheries. Thus, the program should be implemented cautiously because, majority of the fishers living near the shoreline of lakes and rivers may not be able to take new responsibilities due to their literacy to deal. Past experiences suggest that participatory approach with fisher communities should give promising and successful results (Gurung 2003, Gurung et al 2005). However, securing their role would be important and could be questionable due to their little awareness and skill in new areas of value chain options. In line with these assumptions, several studies demonstrate that recreational fishers constitute a social group that offers unique potential to positively enhance fish conservation (Granek et al 2000, Bate 2001, Arlinghaus 2006). Recreational fishers have an inherent interest in the conservation and management of the fisheries resources (Arlinghaus 2006). Thus, allowing fishers to participate in developing regulations, within the bounds set by available stock information from biologists could lead to increased management success (Sullivan 2003).

For the development of participatory approach of fishing tourism involving poor and deprived fisher, following the business model of 'Push and Pull' theory would be useful (Fritsch and Rusakova 2011, Maki 2010) to assure the participation of the fishers in newly developed value chains. It is essential to involve the fishing communities in recreation tourism fisheries, because largely the fishers groups having almost non-agricultural land and livestock resources but entirely depending on fishing for livelihood with extremely poor social values and recognition. These groups have been largely ignored by government policies as there are few supporting program worldwide which might have been prepared to address this special class of people under the food and nutritional security plan as low priority is also given by agencies to them.

Possible impacts of recreational fishing tourism on fishers and fish conservation

Several studies have been carried out on the impact of tourism-based recreational fisheries worldwide (Coleman et al 2004, Cowx et al 2010). The impact of the recreational fisheries would be wide spread in many aspects. However, impacts of recreational fishing tourism, on fish populations, are evident in freshwater habitats such as lakes, streams, rivers, and ponds (Steven et al 2006). As the depletion of fish resources by recreational tourism fishing is common the restocking practices of dams, lakes, and rivers could be expected to be widespread (Regier et al. 1997). It is expected that fishing tourism can generate local cash income from formal employment, earnings from selling goods, services, or casual labour (e.g. food, crafts, building materials, guide services), profits from locally-owned enterprises, profits from a community-run enterprise etc. Since the fishers would also be the

partners in recreational fisheries, therefore, it is expected that the enterprise would create jobs opportunities to fishers in different aspects of value chain.

A general consensus on importance and positive attributes of fishers on conservation of fish is building up slowly worldwide, except little opinion that fishing tourism might be destructive. However, to reduce the fishing pressure which might directly impact over fish biodiversity, involvement of fishers into the value chain of fishing tourism must have positive attributes. Due to high effort and low catch fundamental principles of fishing tourism could be one of the options of fish conservation together with livelihood enhancement of marginalized fishers in present socio-economical context. The value chain of fishing tourism includes transportation; and lodging in hotels and outdoor villages; participation in fishing, cultural, festivals excursions, purchasing, hiring of fishing rod, line, tent, clothing, boat, out-boat engines etc. The fishing tourism is highly potential but inadequate access to suitable location is hindering the promotional activities. Since the traditional fishers are world's 'poorest of the poor', the inclusion of such community in fishing tourism only not support their livelihood but also conserve fish diversity in a new approach.

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Potential and Opportunity of Aquaculture Intervention in Irrigation System for Enhancing Water Productivity in Nepal

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ABSTRACT

Many water bodies such as dams, lakes and rivers destined to become part of irrigation schemes serving about 42% of the net cultivated land in Nepal of which 41% of the irrigated land receives year-round irrigation. Irrigation systems, primarily targeted for land-based crop, distributed throughout the southern terai region of the country with its 700 km primary canal and about 7200 km branch canal have varying crop water productivity. When water productivity is aggregated for irrigation command areas, the highest water productivity values decreased gradually. Enhancement of water productivity relates to the need to increase crop yields or values per unit of water. This would require integration of more compatible agriculture commodity in whole range of aquatic habitat created by irrigation systems. Integration of aquaculture and enhancement fisheries is thought to a more practical option to enhance water productivity in reservoir, canal themselves and water-logged lands in canal commands. Water storage such as mid-hill lakes and reservoirs are used as multiple systems and have significant impacts on livelihoods of the local people through the most important benefit arising from aquaculture and fisheries. Rice-fish farming activities demonstrated in several irrigation commands in mid and far western region has also been found to be useful in productive utilization of seasonally waterlogged lands.

Irrigation systems using diverted and stored (to some extent) water have increased remarkably in Nepal during the past decades, but fish farming within these irrigated systems has not expanded correspondingly. Multiple use policy and a systematic approach to fish farming development at irrigation system level which will make this integration a viable enterprise is needed. Legal and socio-economic implications of fish farming in irrigation command also need to be addressed to ensure successful development of this resource. Research efforts should be directed towards productivity assessment of irrigation reservoirs and distribution canals, and development of appropriate fish farming technology at all level of irrigation systems.

INTRODUCTION

Nepal is a food deficit country, having a population of more than 26 million people. Around 31 percent people in the country live below poverty level. Around 49.3 percent of under-five children are chronically malnourished. Nepalese economy dominated by agriculture, 65.6% of total population is directly or indirectly depend on agriculture. Country poverty is root cause for food insecurity, under nutrition, social, education, healthcare and employment deprivations. Low productivity in agriculture is a major contributor to poverty and food insecurity. Food and financial crisis is gradually increasing, chronic food insecurity since 1990 in Western hills and total number of food insecure people are 6.9 million (OCHA 2008). Government of Nepal is attaching a high priority to the improvement of food security and nutrition, including food security monitoring and early warning. However, central issues such as unequal access to food, basic services, economic opportunities and perceived inability of poor, marginalized groups are still remaining unaddressed.

Aquaculture is widely considered as important for enhancing food security, alleviating poverty and improving nutrition. Aquaculture can benefit the livelihoods of the poor either through an improved food supply and/or through employment and increased income. However, at present little or no hard statistical information exists concerning the scale and extent of rural or small-scale aquaculture, nor concerning the direct/indirect impact of these and the more commercial-scale farming activities on food security and poverty alleviation. Despite the lack of information concerning the role of rural aquaculture, there is one sure benefit of consuming fish, and that is the nutritional and health benefit to be gained from its valuable nutritional content. Food fish has a nutrient profile superior to all terrestrial meats. It is an excellent source of high quality animal protein and highly digestible energy, as well as an extremely rich source of omega-3 polyunsaturated fatty acids (PUFAs), fat soluble vitamins (A, D and E), water soluble vitamins (B complex), and minerals (calcium, phosphorus, iron, iodine and selenium). In fact, if there is a single food that could be used to address all of the different aspects of world malnutrition, it is fish - the staple animal protein source of traditional fishers (FAO 2013). Analysis revealed clear evidence of positive income and consumption effects of aquaculture on households. Ahmed and Lorica (2002) from an extensive survey made in southeast Asia concludes that national policies for aquaculture development will need to concurrently address the food security and poverty questions more sharply than has been done at present, by providing institutional and infrastructure support for access to resources such as land and water and to markets by poor households.

Water is one of the principal natural resources supporting the economy of Nepal, the others being the forestry and tourism sectors, based on the idyllic landscape of the country. However, Freshwater is quickly becoming one of the scarcest resources of the twenty-first century (Halwart and Van Dam 2006). Significant investment is required to optimize use of this highly-demanded resource by increasing total water productivity and efficiency of the multitude of irrigated systems. Nepal's water resources need to be developed for delivery of a wider variety of services contributing to increased production of food and enhanced economic growth for each unit of water consumed.

Irrigation has been established as the prime contributor to improving agricultural production and to stabilizing agricultural production in the country. The scope of further expansion of arable land has diminished, and, therefore, the increase in food production depends mainly on the growth in agriculture productivity. Irrigation systems do not only supply water to field crops but have many other productive and non-productive uses. Aquaculture is a productive, non-consumptive use of water that does not compete with irrigation (Gowing 2006). Theoretically, integration of aquaculture into irrigation systems may contribute to more efficient use of scarce freshwater resources. Fish farming and other forms of aquaculture could be one of the most significant components of integrated water management that produces food of high nutritional quality, and often high economic value. It is the practice of two technologies associated in the aim of increasing productivity per unit of water used. However, there is a need to study opportunities and constraints to integration of aquaculture in irrigation systems. In this paper, integrated irrigation-aquaculture (IIA) has been proposed as a way of increasing the efficiency of water use and producing much-needed animal protein for the country.

FISHERIES AND AQUACULTURE IN NEPAL

The national fish production reached 54,357 MT in 2012 with a growth rate of 8.5% per annum (DoFD 2013). Fisheries sector contributed little over 0.94% in national gross domestic production (GDP) and 2.72% in AGDP. The contribution of aquaculture components to the national fish production has increased significantly over the last two decade period to reach 53.5% in 2010 (Figure 1). Aquaculture is often referred as the fastest growing primary production sector in the last three decades, having witnessed an annual rate of growth of nearly 11.6%. Fish production from capture

fisheries is almost stagnant (1.5% growth rate) in past five years. This means that growing needs for fish consumption, as a consequence of population increase and increasing per capita consumption among certain sectors (driven by the health benefits of consuming fish) will have to be provided primarily through aquaculture.

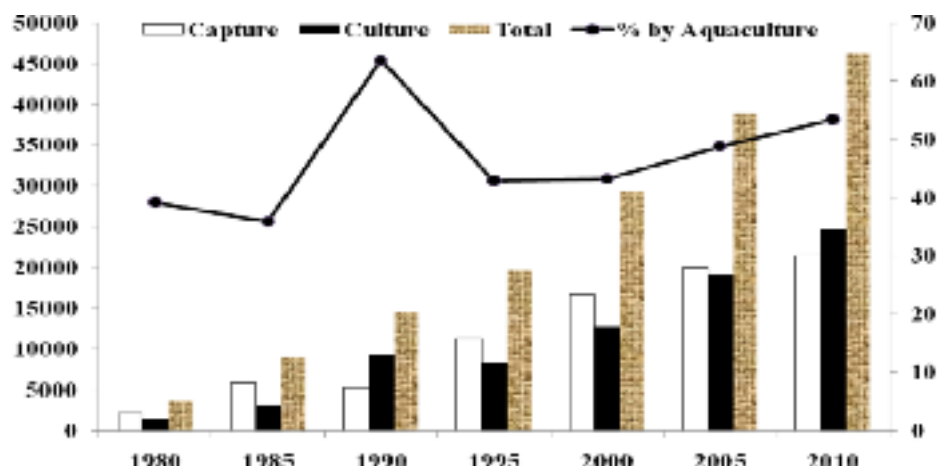


Figure 1. Fish production from aquaculture and capture fisheries and percentage contribution from aquaculture

Demand of fish is very high in comparison to the production level and in general the production is consumed locally. The demand for aquaculture and fisheries to provide increasing fish needs in the country is estimated to be around 155,000 MT by 2027 (Table 1) in which aquaculture has envisaged to contribute by 56% and the rest is from capture fisheries (NWP-N 2004). Moreover, Directorate of Fisheries Development (DoFD) recently estimated the fish demand of 182,010 MT by 2032 to reach the supply 5.0 kg/caput (Mishra 2013). If fish demands are to be satisfied by 2032, an increase in aquaculture production needs to occur. The above is one scenario that has to be considered in formulating strategies and approaches. Increase in the aquaculture coverage with special attention to deficit but potential areas in order to utilize aquatic resources would be the key strategy for increasing aquaculture production. Aquaculture could represent a new area of potential diversification of irrigation system to meet its growing demand.

Table 1. Projected national fish demands

Attributes	1981/82	2007/08	2017/18	2027	2032
Fish production (MT)	3350	48750	89000	155000	182010
Capture		21500	30000	68000	
Culture		27250	59000	87000	
Pond productivity (MT/ha)	0.8	3.61	4.0		
Capture culture ratio	3.7:1	1:1.27	1:1.67		
Per capita (kg)	0.33	1.8	2.3	4.52	5.0

Source: Mishra (2013)

Harvesting fish in irrigation systems is a common rural practice in Nepal. Although not recorded, it seems to have been widespread in terai, especially in rice fields. In the past, improved management for land-based crops and the demands for the successful raising of aquatic organisms were not generally compatible, but with the advent of integrated crop protection, this situation has changed drastically. Moreover, irrigation systems using stored or diverted water have increased exponentially during the past three decades, but fish farming within these irrigated systems has not expanded equally, and therefore, there is a huge potential for this integrated enterprise.

Balancing mechanism

The focus of IIA is on fish production within irrigation systems and, in particular, opportunities for poor people to derive a livelihood benefit from this activity. It is evident that the extensive hydraulic engineering works associated with large-scale irrigation and hydroelectricity development have had a profound negative impact on many river ecosystems, which is reflected in a dramatic loss of biodiversity (Halls et al 1999, Petr and Mitrofanov 1998). Where this has resulted in loss of important subsistence fisheries, the impact of this change has generally been felt disproportionately by poor people. The opportunity may exist within the newly created irrigation systems to mitigate this negative impact by promoting complementary development of fish production, but this has generally been overlooked. Fisheries do exist in some of the large irrigation canals, but little consideration has been given to the replacement of lost fishery potential through systematic development of aquaculture potential. Research evidences do not exists in the country linking fish production to irrigation, either in terms of the impact on natural fisheries or the potential created for new managed fisheries. Furthermore, the linkages between fisheries management institutions and water management institutions are generally weak (Gowing 2006).

Status of irrigation system in Nepal

Irrigation is one of the most potential sectors for food and nutritional security. Until 1950s, irrigation development in Nepal was a result of farmers' own initiation and investment in the construction and management of irrigation systems. It is estimated that about 70% of the country's irrigated area is covered by such systems, which make a substantial contribution to the national economy (NDF 2002). Besides this, with the start of first five-year plan in 1957, the government also started development of irrigation in planned way. Since then, several medium and major irrigation systems were developed with the assistance of donor agencies.

At present, irrigation water is provided to approximately 47.4% of net cultivated land (2.642 million ha) which forms about 66.8% of net irrigable area (Table 2). About 41% of net irrigated area is being supplied with year round (YR) irrigation water (DOI 2011). It is estimated that existing irrigation systems are the basis for approximately 30% of the current agricultural production of the country (NIS 2010). Thirty-two irrigation systems have been established in the country with discharge capacity ranging from 0.6 to 50 m³/second (IHB 2011). Major irrigation projects with their irrigation command area are provided in Table 3. Irrigation systems distributed throughout the southern terai region of the country with its 700 km primary canal (30-40 m wide & 4 m deep) and about 7200 km branch canal (12-15 m wide and 2.5 m deep) covers 84.5% of the total irrigated area (DOI 2011).

Table 2. Status of irrigation of agriculture field in Nepal

Category	Surface water	Ground water	Total	Percent
Total arable land, ha	-	-	2641742	100
Total irrigable area, ha	-	-	1765840	66.8
Total irrigated area, ha	960237	291169	1251406	47.4
<i>Irrigated area by eco-region</i>				
Total irrigated area, ha	647948	278158	926106	100
Terai, ha	505513	277426	782939	84.5
Hill, ha	117494	732	118226	12.8
Mountain, ha	24941	-	24941	2.7

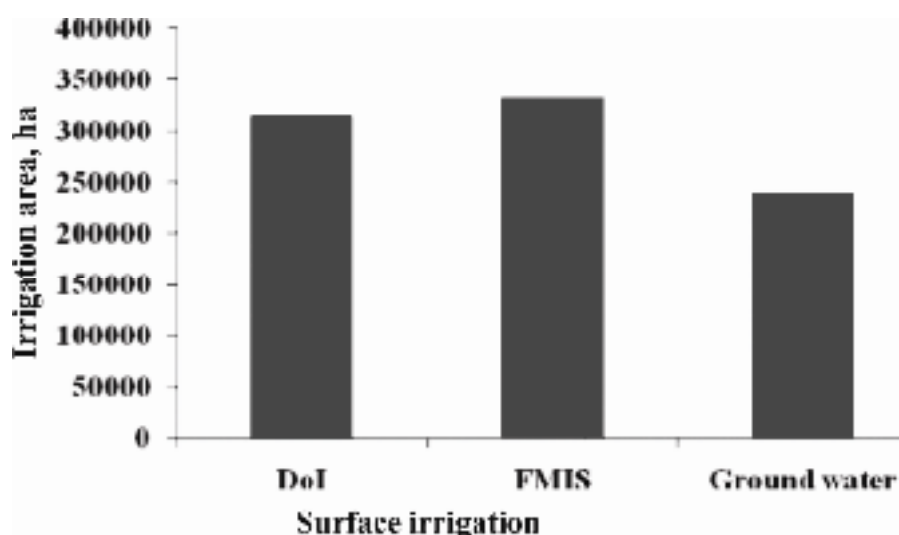
Source: CERD (2007)

Table 3. Major irrigation projects providing services in Nepal

Irrigation projects	District	Irrigated land, ha
Sharada	Kailali, Kanchanpur	6800
Bagmati Multipurpose	Bara, Rautahat, Sarlahi	50,200
Rapti	Banke	3000
BanGanga	Kapilvastu	8000
Kanchan Danav	Rupendehi	10000
Kankai	Jhapa	8000
Chitwan	Chitwan	11100
Sikta	Banke	36000
Koshi	Saptari	22000
Gandak	Bara, Parsa, Rautahat, Nawal Parasi	51000
Babai	Bardiya	13000
Marchawar	Rupendehi	56000
Eastern Rapti	Chitwan	56000
Sunsari	Sunsari, Morang	58000

Source: IHB (2011)

Irrigation system of Nepal comprised of surface irrigation and groundwater irrigation with command area of 648,947 ha and 240,058 ha, respectively provide service to agriculture fields (Figure 1). Twenty projects were under implementation in mid 2011 with a total command area of over 200,000 ha, of which around 85% comprises new irrigation (Cook et al 2012). According to DOI data, there is potential to develop a further 0.5 million hectares for conventional irrigation such as canal and groundwater. Furthermore, growth in hydroelectric and irrigation project would add more water surface area in future. The existing water resources of the country in the form of irrigation storage and canals, and their future growth potential reveal that there is tremendous scope for expansion and intensification of fish production in the country.

**Figure 2. Status of Project for Surface and ground water irrigation in Nepal (source: DoI 2007)**

Despite the large area covered by surface irrigation projects, their potential capacity of water discharge has been greatly influenced by the seasonal fluctuation of flow regime of source water. For example, command area coverage of 32 major irrigation projects severely reduced and supply water for only 15% area compared to that of the area coverage of 314,521 ha during wet (rainy) season

(Figure 2). This has to be taken into account for any investment made to improve water productivity through aquaculture and fishery activities in irrigation systems.

Comparison of irrigation productivity

Information on national staple crop profitability of Nepal in 2009/2010 revealed that paddy generated an average margin over variable and fixed costs of Rs 20,000/ha and it is more profitable than irrigated maize (Rs17,000/ha on average) and wheat (Rs15,000/ha) (Cook et al 2012). For all three crops, irrigated production was only marginally more profitable than rainfed, suggesting that the common belief that irrigation is currently only used to supplement rainfall in the monsoon season is correct.

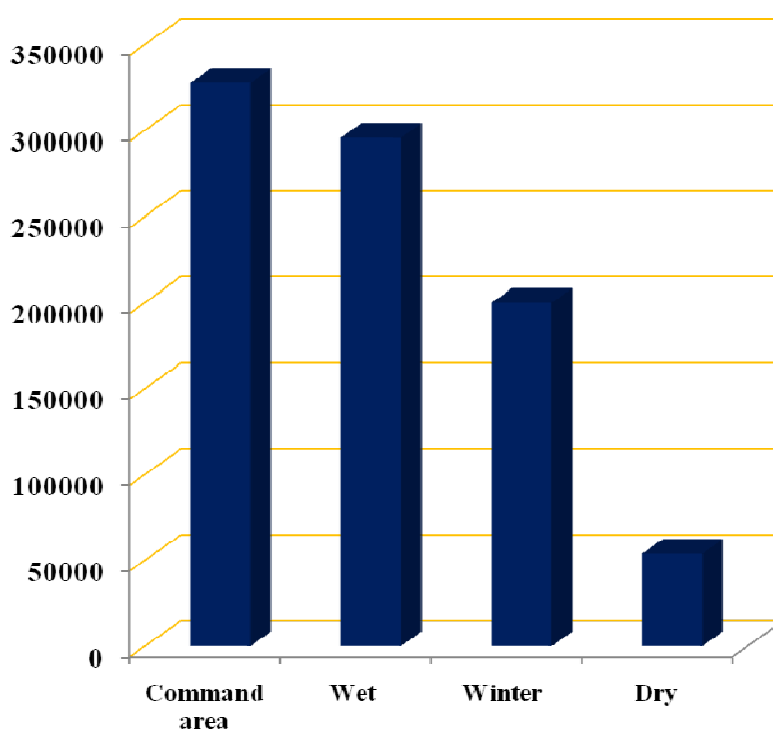


Figure 3. Seasonal trend of irrigated area (ha) by 32 Irrigation Projects, Nepal (Source: NIS 2010)

In an experiment on multiple use of water in irrigation system of Indo-Gangatic basin, Khan (2010) reported that the increase in net income over rice-wheat system was 6.18% in rice-wheat system with fish refuse at the center, and 234.53% in fish in pond. Khan (2010) also estimated water productivity in terms of return in rupees/cubic meter of water used and found that water productivity with water exchange for horticulture crops on dykes ranged between 3.74 to 15.2 whereas in control pond without water exchange it ranged between 10.3 and 14.4. In the trenches with horticulture on raised beds water productivity values ranged between 1.5 and 6.51. Growing water scarcity and competing water demands are expected to reduce diversion of water for agriculture in the future. The water productivity of crops and livestock is low because of negligence on crop-livestock and water nexus and their impact on livelihood. Therefore, as indicated by research results, to improve overall water productivity of irrigation and water resources systems, the productive interventions such as growing vegetables, fruits, livestock, fisheries and other living aquatic systems need to be integrated into the existing irrigation and water resources systems such that more food may be produced out of available water resources. Results from different studies also revealed that aquaculture is common in all most

all the systems and the most beneficial component of multiple use system as it is a non-consumptive use of water resulting in the most productive use of water (Khan 2010).

The whole range of aquatic habitats created by irrigation systems can be integrated with fish farming. Small and large irrigation reservoirs, the extensive network of irrigation canals, the irrigated fields themselves, as well as adjacent ponds or aquatic refuges of various sorts are all potential sites for nursing or grow-out fish. In many areas in terai, there is now relatively easy access to fish seed. A flexible system of moving culture fish within the system of habitats should be feasible. For example, stocking material for reservoirs can be obtained from irrigated rice fields where the short maturation period of the crop only permits the harvest of fingerlings. If a pragmatic and flexible approach is made to use all habitats for fish production, there could be a year-round supply of fish and a minimum wastage of stocks of cultured fish.

Fisheries in irrigation systems

In addition to the potential for aquaculture to be integrated within irrigation systems, steps have been taken to augment fish production from both large reservoirs and small seasonal water bodies. Bighead carp in reservoirs in Singapore (Yang 1982) and silver carp in reservoirs in Israel (Leventer and Teltsch 1990) have been used to control algal blooms maintaining water quality for other resource users. Many Indian reservoirs are largely used as culture-based fisheries for carp production (Sugunan 1995). Culture-based fisheries integrated within small-scale irrigation systems have been reported by De Silva et al (2000) and Murray (2004) in Sri Lanka, with the latter taking an explicit poverty focused approach by stocking fish with greatest relevance to the poor communities around these seasonal tanks.

Small scale fishery have been practiced by traditional fisher community known as *Jalari* or *Pode* living near Phewa (443 ha) and Begnas (328 ha) lakes, Pokhara. These lakes serve as irrigation water storage. In order to enhance lake productivity, the restocking program in the lakes was initiated during 1980s with a number of exotic and native species. Since 1990s, the participatory approach for restocking of hatchery produced fish seed and recapture later when they grow bigger has been encouraging the fisher community to utilize their traditional skills and helping them earn livelihood easily. The capture fishery of Phewa and Begnas lakes is based on five regularly stocked species (i.e. *Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Labeo rohita*, *Cirrhina mrigala* and *Catla catla*). The most important indigenous contributing substantially in total yield are *Puntius* spp., *Cirrhina rewa* and *Barilius* spp. (Gurung et al 2005, Wagle et al 2007). In addition, a number of other indigenous species are caught, but these collectively account for <5% of the total estimated yield. About 95% of the total fish landed are caught by gill nets. Total production of fish from capture was 35.4 MT and 36.0 MT in Phewa and Begnas lake contributing 393.4 kg and 858.1 kg/fisher family, respectively, during the year 2010. Variability of annual landings is common in Phewa and Begnas Lakes and correspond accordingly variation in share of catch per household of fisher community. This practice of restocking program in irrigation water storage demonstrated that it has potential to support directly to livelihoods of poor community and enhance water productivity by multiple use of water in cascade. It would also show the potential for horizontal expansion at water storage site.

Aquaculture in irrigation systems

Aquaculture within the farming sub-system can also be integrated with rice production (Halwart 1998, Fernando 1993). Concurrent rice-fish culture, where fish are raised at the same time as rice, is the common practice in Nepal. Fish are grown with rice as the crops are irrigated with water. This actually increases the economic viability of rice culture by providing a double crop and reducing the pesticide input with positive environmental and financial benefits (Halwart and Gupta 2004).

Rice-fish farming in Nepal is known to exist since last 30-40 years. Although rice-fish farming is considered highly suitable agriculture system, the technology has not yet been scaled up due to many constraints despite highly physical and technical feasibility of the farming system. It has been estimated that if only 10% of total irrigated rice field could be brought under the rice-fish integration, the present cultivable national fish production of about 22,000 MT could be doubled (Gurung and Wagle 2005). At present, the area under rice-fish farming is only 100 ha in year 2011 (Mishra and KC 2013). There are two main constraints to increased productivity in integrated rice-fish farming systems - water control and seed supply. Emphasis on integration of agriculture and aquaculture (IAA) is needed from irrigation for water; agronomy for less pesticide use; and fisheries for readily available fingerlings (Gurung 2012). Simple cost-benefit analysis of rice-fish integration from 73 farmers revealed that the integration generated 43.4% net income over the rice monoculture. If integrated rice-fish farming is practiced in irrigation command area, the system would support directly to livelihoods of rice farming community, enhance water productivity by diversifying farming system. Rice-fish integration has potential for expansion in all types of irrigation command area.

Cage fish culture in Phewa lake, Begnas lake and Kulekhani reservoir is another successful example of IIA in the country. These two lakes has supplied water to fish farm and to crop fields operatives over the last two decades without any negative effect on irrigation water for crop production downwards (Gurung 2012). High rate of return to investment (231%) has been estimated from cage fish culture which at present supports the livelihoods of over 500 resources deprived and displaced fisher community. The cage fish farming system enhance water productivity by multiple use of water in cascade. However, for the horizontal expansion at water storage site and canals requires assessment of hydrological regime and collaboration among other water users and service provider. Irrigation canals in engineer-managed systems are principally operated to meet crop water requirements and irrigation is not usually concerned with supporting fisheries, aquaculture or other water uses (IWMI/GWP 2005). Therefore, the challenges that the integration of aquaculture within canal networks face are both technical and institutional. Non-consumptive aquaculture in running water delivery structures of irrigation systems is particularly appropriate for water-stressed regions of South Asia. The technical feasibility requires further research although anecdotal evidence of fish culture in the delivery system is cited (Redding and Midlen 1991).

Environment for integrated irrigation and aquaculture

All large-scale irrigation systems comprise four functional subsystems: water source, water delivery, water use and water disposal. Possible aquaculture technologies than can be adopted in these subsystems are given in Table 4. Most irrigation systems probably sustain capture fisheries to some extent, although the practice is generally opportunistic. Usually, fish stocks are dependent upon fish entering the canal system from the source. Some species may form self-sustaining populations, but this is limited to those systems having favorable environmental conditions (Fernando and Halwart 2000). A degree of management of fish stocks is required to maintain a more productive and sustainable fishery. Such management may involve restocking and introduction of new species, but there is little recorded experience of such measures being adopted in canal systems, except where they have been primarily aimed at weed control through stocking of grass carp (Armellina et al 1999).

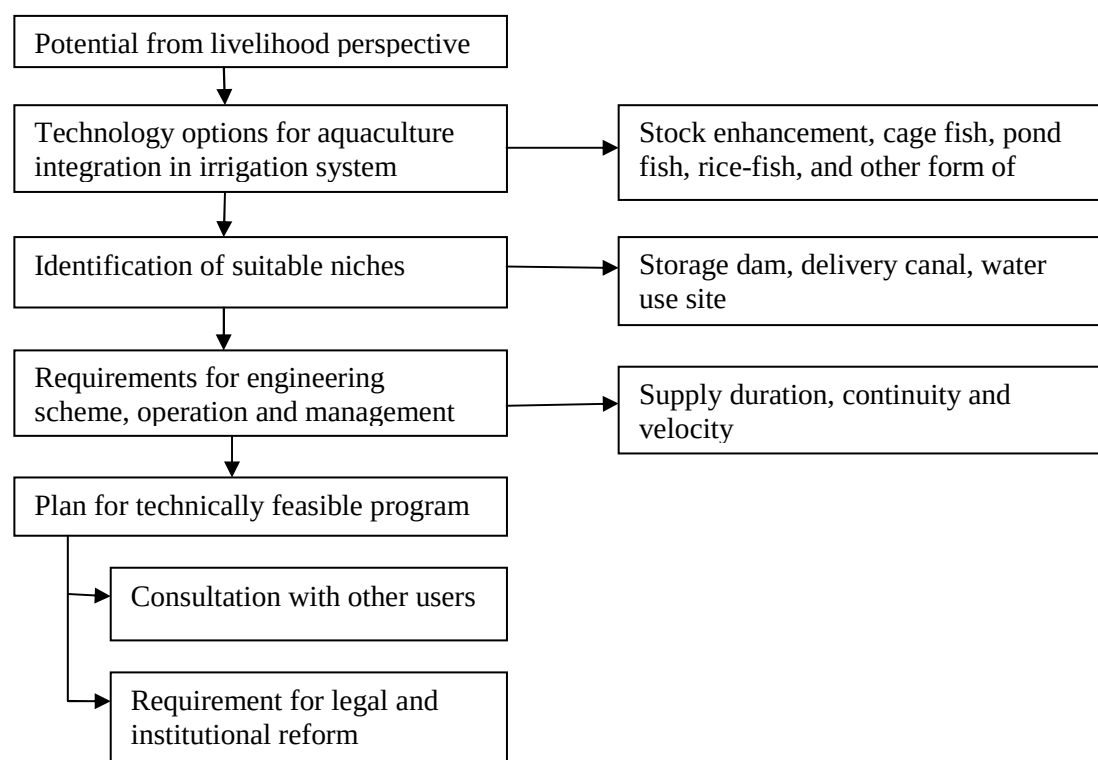
Aquaculture offers greater control over production and access than is the case with capture fishery and even low-cost, semi-intensive systems can produce 1500-2000 kg/ha/year, which compares favorably with estimates for production from capture fisheries in canals. Cage-based aquaculture has been widely promoted in South and Southeast Asian countries (Beveridge and Muir 1997) as a technology which can be easily adopted by resource-poor people.

Table 4. Key environment for integrated irrigation and aquaculture

Environment	Niche	Possible aquaculture technology
Source	Storage dam	Stock enhancement, cage fish culture
Water delivery	Primary canal	cage fish culture, enclosure
	Secondary canal	cage fish culture
Water use	Pond farm	Stocking of carps and other productive fish
	Irrigated rice fields	Rice-fish farming

Framework for assessing opportunity and constraints

The aim of the intervention of aquaculture in irrigation systems is to improve the livelihoods of the rural poor and to promote food security through improved food supply, employment and income. Therefore, efforts are necessary to introduce and promote appropriate technologies for aquaculture within irrigation systems where these are likely to provide livelihoods benefits to poor people without unacceptable impacts on other water users. A general framework for the assessment is shown in Figure 3. In the past, poor people have been largely ignored in aquaculture development and their specific needs require careful consideration. It is by no means certain that the introduction of small-scale aquaculture technologies in irrigation system will contribute to the alleviation of poverty.

**Figure 4. A general framework for the assessment integrated irrigation and aquaculture (IIA)**

Opportunity and challenges

It is a common perception that irrigation systems supply water only to field crops, but the true picture is more complicated. The concept of multiple-use services (MUS) has emerged as an alternative approach to providing water services aiming to meet people's multiple water needs in an integrated

manner. MUS is a participatory, integrated and poverty-reduction focused approach in poor rural areas, which takes people's multiple water needs as a starting point for providing integrated services, moving beyond the conventional sectoral barriers of the domestic and productive sectors. Growing recognition of the multiple uses of water within many established irrigation systems elsewhere has revealed many other productive and non-productive uses. Aquaculture is a water-dependent activity, which is productive, but non-consumptive and therefore, in principle, not in competition with irrigation. According to IWMI (2010) Nepal, along with many countries, is facing acute water shortage despite having vast resources. It is suggested that aquaculture integration within agriculture irrigation could be one of sustainable ways to efficient use of water resource for adapting the climate change vulnerability (Gurung 2012). However, opportunities for and constraints to its integration within irrigation systems have not received attention in the country.

Constraints to the widespread development of the IIA, are linked to the lack of policy and guidelines from the government in terms of aquaculture development in particular, lack of fingerlings, competition for feed resources, and lack of funds, land and water for IIA. Local management institutions exist or are currently being created in many large-scale irrigation systems, but representation of non-irrigation water users is generally poor. Water rights, access and charging issues therefore require careful consideration in order to promote multiple use management of irrigation infrastructure.

Opportunity	Challenges/threats
• Enhance livelihood of rural communities • Increase rate of return on investment (may increase water productivity) • Opportunity of diversification & commercialization • Friendly environment (suitable fish species & technology available) • Way out to sustainable biodiversity and climate change mitigation	• Weak governance system to facilitate cross sectoral water management decision making processes • Water supply reliability is a crucial constraint • Agrochemicals use in ricefields • Could have increased cost of water management • Potential impacts of fish escape to natural water

WAY FORWARD

With little effort and cost large agricultural production could be achieved, if aquaculture is integrated with irrigation system. Studies on IAA at landscape level might show benefits as a result of multiple use of water resources. Many technologies recommended for dissemination of integrated agriculture-aquaculture in Asian context are valid for IIA development (Phillips et al 2001, Prein 2002). In general, synergies between irrigation and aquaculture should be exploited to the fullest extent so that aquaculture operations can produce as much fish as possible while irrigation also benefits, possibly beyond enhanced water productivity. However, Conditions prevailing in the different niches must be evaluated carefully, since they can be expected to lead to different constraints.

IIA development requires a sequence of developing a national strategy, identifying high potential areas, identifying suitable production systems, ensuring an adequate number of development participants in a specific zone, and targeting well-focused participatory extension services to these selected groups regularly and over a substantial period of time. There is a greater need to develop national guidelines for IAA as components of national fisheries and aquaculture strategies. IIA is key subject for interdisciplinary/interdepartmental collaboration. Linkage need to be established between fisheries management institutions and water management institutions.

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Status of Open Water Aquaculture in Nepal and Prospects of their Utilization for Poverty Reduction

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ABSTRACT

Open water aquaculture is culture-based fisheries which are mostly or entirely maintained by the stock enhancement for recapture. It also involves aquaculture practices in open water bodies with appropriate fish species of commercial value. In Nepal, it has been practiced in three lakes of Pokhara valley i.e., Phewa (523 ha), Begnas (328 ha) and Rupa (135 ha) and Kulekhani reservoir (75-220 ha) as a panacea solution to increase benefits from fisheries. This technology provides employment, nutritional food security and livelihood improvements to the local ethnic and deprived community.

The strategy adopted for fish stock enhancement and other aquaculture activities is community based participatory management approach. Lake Rupa is managed through co-operative approach for conservation and sustainable use. Fish stocks are enhanced by both exotic and indigenous fish every year. The harvesting is performed continuously using different fishing gears. The catch statistics of the year 2010 showed that approximately 119 metric ton of fish are removed from the different lakes of Pokhara valley. Now, in the recapture fishery substantial contribution comes from the introduced exotic species (81.2%) with all age groups represented. The highest yield was recorded for lake Rupa (351.6 kg/ha) followed by Begnas (109.9 kg/ha) and Phewa (67.7 kg/ha). The proportion of endemic fish species sahar (*Tor putitora*) is slowly increasing. Over some past years, lakes of Pokhara valley are suffering from problems of eutrophication, sedimentation and aquatic weed infestation. The changes in water quality in lakes are encouraged the exotic fish species like tilapia (*Oreochromis niloticus*) and magur (*Clarias* sp.) to flourish in the lakes. All three lakes also experience plankton diversity change and shift in species composition. There is also a smaller but equally successful catch fishery in Kulekhani reservoir also.

Besides capture fishery, cage fish culture and to some extent pen culture are operated in these water bodies. Planktivorous carps are now commonly used in extensive cage culture. At present, pen culture has been practiced at small scale in Begnas and Rupa Lakes in Pokhara valley contributing total fish production of 34.44 metric tons. Open water aquaculture is considered an effective way of increasing production and additional income thereby contributing to poverty alleviation. The participatory management of natural resources in lakes of Pokhara valley and Kulekhani reservoir has been proved to be an important step for sustainable livelihood enhancement of wetland dependent community. It is anticipated that several water bodies could be judiciously manage to contribute to support the livelihood of deprived community.

INTRODUCTION

A fishery is a small but important sub-sector of agriculture. Although fisheries sub-sector contributes only 1% to GDP and 2.68% of agricultural gross domestic product (AGDP) (Gurung et al 2013), the growth rate of this sub-sector are estimated to grow more by 8.84% than agriculture and forestry sector which is 4.86% (MoF 2012). Inland capture fisheries and aquaculture are the sole domestic source of fish products for Nepalese people. Current estimates report that Nepal has 820,077 ha of

water surface area with inland rivers (395,000 ha), lakes (5000 ha), reservoirs (1500 ha), ponds (7277 ha), marginal swamps (13,300 ha) and 398,000 ha irrigated rice field (KC and Mishra 2013) throughout the country suitable for fish farming. These water resources provide good shelter to a number of indigenous fish. The updated list of fish fauna totals 230 fish species belonging to 104 genera, 34 families and 11 orders. These indigenous fishes are most unique and valuable natural resources of the country (Rajbanshi 2012).

Open water capture fisheries have traditionally played an important role in the overall production. It is particularly important in the rural areas as a relatively cheap and accessible form of nutritious food, and also provides a livelihood for professional fishermen, many of whom are landless and amongst the more disadvantaged sections of the community. However, there has been a gradual decline in the production of fish from these open water fisheries because of overfishing caused by a large and increasing population, the loss of aquatic environment and obstruction on fish migration routes caused by different developmental dams, pollution of the open waters by industrial and agro-chemical effluents etc. The main challenges herewith are to sustain the current fisheries production for welfare of dependent community. One of the main strategies could be fisheries development in these water bodies through stock enhancement (culture-based fisheries) and aquaculture (cage and pen culture). This type of approach also resolves problems in defining ownership that are associated with the size of the resource and other management characteristics (ACIAR 2006). The promotion of culture based fisheries in open water system have recognized as an effective way of increasing the supply of fish as food in rural areas, at an affordable price in most developing countries in Asia like, Bangladesh, India, Indonesia, Myanmar, Sri Lanka, Thailand and Viet Nam (De Silva et al 2005) as well as some in South America (ACIAR 2006, Jorgensen & Thompson 2007). Culture-based fisheries for food and recreation are also well-established components of aquatic resource use in Europe, Africa and in North America (Lorenzen et al 2001, Mageria et al 2006). In addition to open water stocking, fish cages and fish pens also considered effective way to increase productivity of natural water bodies (Araullo 2001). Cage culture technology can increase the overall production of valuable table fish and mitigate the effects of environmental changes. It also has social advantages in that landless people can find habitation and employment in cage aquaculture (Costa Pierce 2002). Tilapia, carp, catfish, and a number of other species are produced in cages (Beveridge 2004). Moreover, pen fish culture has some unique advantages over other aquaculture systems and enhancement strategies. It can maximize the fish production in large lakes where it is difficult to raise the fish yields in the whole water body due to factors such as fisheries management or limitation of the natural environment. In Nepal, fisheries development through open water stocking and cage culture is practiced in lakes of Pokhara valley and Kulekhani reservoir. Beside this, out of 12,700 ha *ghols* (wetland) available in Nepal, about 1,612 ha of *ghols* have been utilized for increased fish production and livelihood improvement through mobilization of local communities (Gubhaju et al 2012).

OPEN WATER AQUACULTURE

Open water stocking

The rationale behind the fingerling stocking (stock enhancement) approach to fisheries enhancement into the lakes and reservoir was based on the need to reverse the decline in fish production by exploiting the under-utilized nutrients available in the water bodies. Lakes of Pokhara valley is one the important natural water resources supporting the livelihood of a nomadic fisher community living around lakes known as *Jalari*. In order to increase their livelihood through capture fishery gill nets was introduced in past. Capture fishery using gill nets of mesh size up to 200 mm was widely adopted during the 1960s (Rajbanshi et al 1984, Swar and Gurung 1988). In the decades of 1960s and 1970s when fish catch declined due to over-fishing, the only source of *Jalari*'s livelihood was threatened. It

became even harder for the fisherman to sustain their livelihood than it was before the introduction of gill nets. To overcome this problem, the strategy adopted for fish stock enhancement and other aquaculture activities is community-based participatory management approach following their own code of conduct for gill net operation, cage/pen fish culture and marketing. At present, Phewa lake is managed by Harpan Matsya Sahakari Sanstha (a cooperative) involving 90 households and Machhapure Mahila Samuh (a women group) involving 36 households while Begnas lake by Begnas Matsya Vabsayi Samit involving 42 households. Lake Rupa is managed through co-operative approach named Rupa tal Punarsthapana ra Matsya Sahkari Sanstha (a cooperative) involving 731 households. Kulekhani reservoir is a hydropower reservoir constructed in 1982 for the storage of excess water for electricity production (FDC, Kulekhani 2054 BS). The construction of reservoir has severely affected the livelihood of the surrounding resource poor farmers. Cage fish culture and open stocking of fish in the reservoir was initiated in 1988 as a means of livelihood to the displaced people by the construction of reservoir. Currently, Kulekhani reservoir is managed by *Indra Sarovar Matsya Vabsayi Sangha* (307 households). Fish stocks are enhanced by introducing indigenous and exotic species of carp into the lakes and reservoir every year (Figure 1). Species composition varied from lake to lake. Past studies have shown that stocking with fast growing carp species appears to be both technically feasible and economically viable (Wagle et al 2012). Generally, the species stocked were silver carp, (*Hypophthalmichys molitrix*), bighead carp (*Aristichthys nobilis*), common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrihinus mrigala*) etc. In past, capture fishery in Kulekhani reservoir was based on escapees and naturally recruited species (Gurung et al 2009) while now regular stocking program was initiated with exotic species to increase reservoir capture productivity.

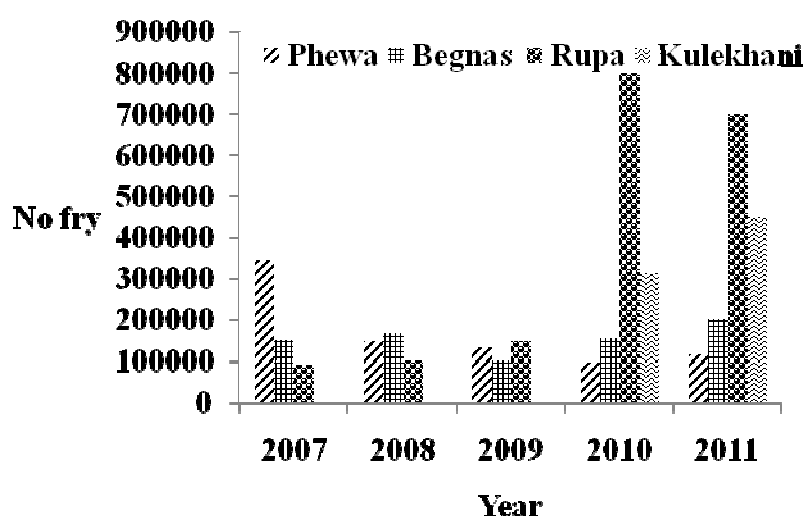


Figure 1. Fingerling stocking in lakes of Pokhara valley and Kulekhani reservoir

The harvesting is performed continuously using different fishing gears. The catch statistics of the year 2010 showed that approximately 118.9 metric ton of fish are removed from the different lakes of Pokhara valley (Figure 2). The highest yield was recorded for lake Rupa (351.6 kg/ha) followed by Begnas (109.9 kg/ha) and Phewa (67.7 kg/ha). The total fish production from Kulekhani reservoir estimated below 1 kg/ha. The differences in productivity could be perhaps due to changes in trophic status of the lake.

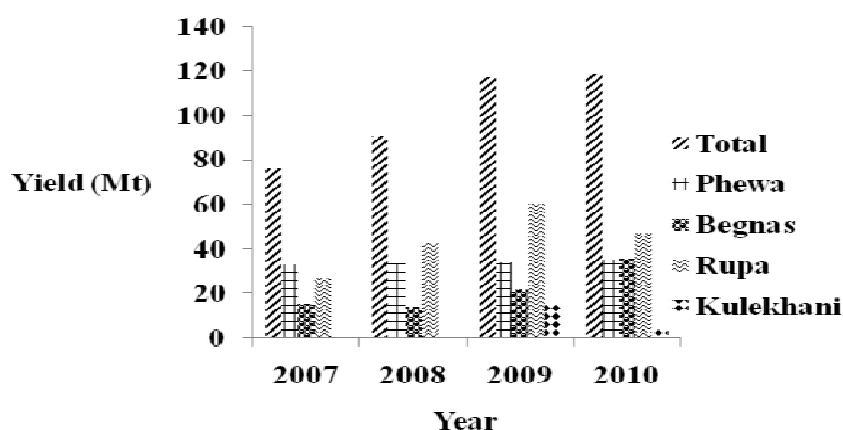


Figure 2. Total yield from open water stocking

The contribution of introduced exotic species in the recapture fishery is increasing every year. The data of year 2010 showed that contribution of exotic species was 85.8%, 69.6% and 88.3% with all age groups represented for lake Phewa, Begnas and Rupa, respectively (Table 1).

Table 1. Contribution of native and exotic fish from open water stocking

Year	Phewa		Begnas		Rupa	
	Native (%)	Exotic (%)	Native (%)	Exotic (%)	Native (%)	Exotic (%)
2007	45.2	54.8	33.3	66.7	45.5	54.5
2008	25.8	74.2	40.7	59.3	29.0	71.0
2009	21.4	78.6	35.2	64.8	25.5	74.5
2010	14.2	85.8	30.4	69.6	11.7	88.3

Nowadays, native species have been encouraged for stocking program. As a result, the proportion of endemic fish species sahar (*Tor putitora*), rohu, naini and catla is slowly increasing. The changes in water quality in lakes are encouraged the invasive fish species like tilapia (*Oreochromis niloticus*) and magur (*Clarias* sp.) to flourish in the lakes (Figure 3, 4, 5). There is also a smaller but equally successful catch fishery in Kulekhani reservoir, also.

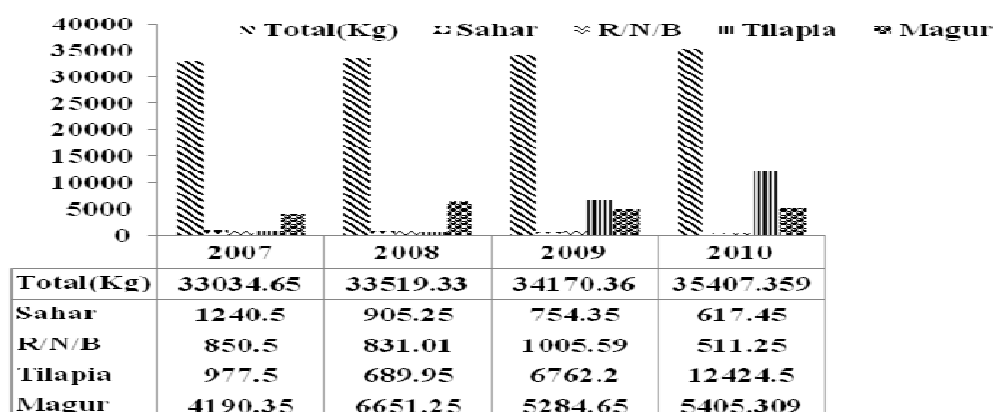


Figure 3. Contribution of native and invasive species at lake Phewa

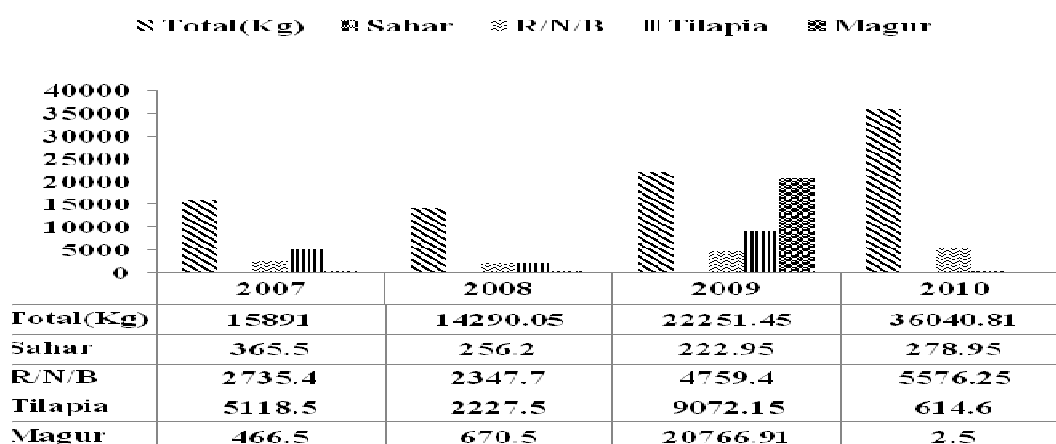


Figure 4. Contribution of native and invasive species at lake Begnas

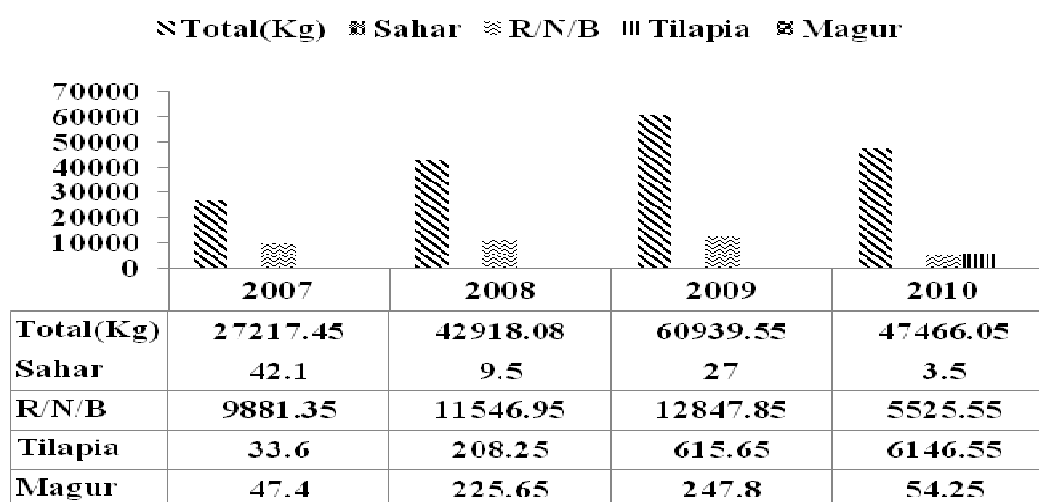


Figure 5. Contribution of native and invasive species at lake Rupa

Cage culture

Cage fish culture in Nepal exclusively depends on natural food of existing water bodies. In 2011, 27,750 m³ of cage volume were landed in lakes of Phewa and Begnas in private sector producing 40.8 MT of fish and supporting the livelihood of 132 fisher households. Although cage culture was collapsed in 2002 due to sedimentation and aquatic weed infestation, it was revived after restoration of lake. Currently cage culture grew at a steady rate in lake Rupa producing 7.0 MT fish in from 8000 m³ of cage volume and directly supporting 40 *Jalari* fishers households.

Like lakes of Pokhara Valley, cage culture of planktivorous fish is one of the popular technologies of fish production in the Kulekhani reservoir (Shrestha et al 2009) using silver carp and bighead carp. Now, there are 307 farmers involved in cage fish culture in the reservoir producing 26.8 MT of fish using 27,900 m³ of cage volume. Recent studies have shown that there is also a great potential for cage culture of rainbow trout (*Oncorhynchus mykiss*) in winter (FDC 2006/07).

Pen culture

At present, pen culture has been practiced at small scale in Begnas and Rupa lakes in Pokhara valley contributing total fish production of 34.44 MT (Figure 6).

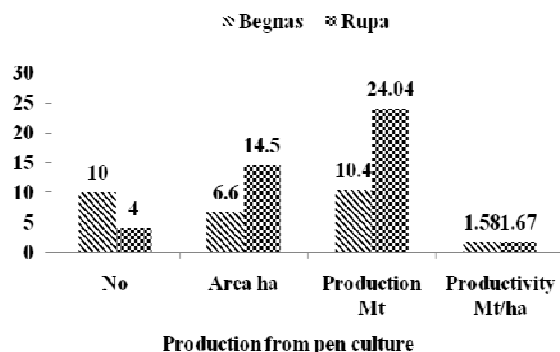


Figure 6. Status of fish production from pen culture

Socio-demographic profile

Currently, the number of household engaged in fishery activities was higher in Phewa lake than Begnas lake. The percentage of literate, high school and university attendant fishermen has increased from past in both the lakes. Almost all fishermen have their own house land, concrete roof house, drinking water facility, toilet, public health service, visual and communication assets like radio, television etc. About 97.8% and 59.5% of fishermen are using cooking gas in lakes Phewa and Begnas (Table 2).

Table 2. Socio-demographic profile of the farmer in Phewa and Begnas lake

Indicator	Phewa			Begnas		
	1980	2005	2011	1980	2005	2011
Total household numbers	47	59	90	31	39	42
Family size number	4.3	5.1	6.0	5.6	6.0	6.0
Literate (%)	17.2	46	51.1	21.2	41.6	47.6
High school (%)	2.1	3.3	6.7	2.6	11.1	7.1
University (%)	0	2	3.3	0.0	1.9	11.9
Housing land (%)	62.7	81.3	97.8	0.0	44.4	80.9
Concrete and tin roof house (%)	73.0	100	100	5.0	95.0	100.0
Access to portable water (%)	8.0	100	100	0.0	93.2	100.0
Access to public health service (%)	10.2	97.6	100	6.8	93.2	100
Use of toilet (%)	0.0	21.8	98.9	0.0	10.1	97.6
Use of cooking gas (%)	3.4	94.6	97.8	0	53.8	59.5
Radio/television/mobile (%)	5.8	83.2	100	5.6	76.3	100
Motorbike (%)	0.0	10.2	6.7	0	7.7	7.1

Livelihood income and expenditure

Table 3 showed that major income of *Jalari* community comes from capture fishery. The annual income was increased to NRs. 200,000 per household and NRs. 156,000 per household in 2011 in Phewa and Begnas, respectively. The annual expenditure of household was NRs. 120,000 and NRs.

96,000 in 2011 in Phewa and Begnas, respectively. Among consumption items, food items stands first followed by education. A significant amount is also spending in clothing and entertainment.

Table 3. Production assets, income and expenditure of fisher community

Asset/Household	Phewa		Begnas	
	2005	2011	2005	2011
Boat (No./HH)	0.96	1.0	0.92	1.0
Gill net (No./HH)	18	20	17	15
Nursery cages (No./HH)	2.5	1.1	1.6	0.36
Production cage (No./HH)	5.3	5.6	2.7	0.48
Annual income (NRs./HH)	126,848.0	200,000.0	99,522.0	156,000.0
A. Cage fish culture	27.3	25.0	18.8	3.8
A. Capture fishery	54.1	75.0	60.9	96.2
Employment and agri. Labor	6.4	5.6	9.6	4.8
Shop/hotel and farming	6.2	0.0	5.5	7.1
Tourism services	2.7	0.0	3.6	0
Annual expenditure (NRs./HH)	80,786.0	120,000.0	76,891.0	96,000.0
Proportion of annual expenditure (%)				
Food items	50.6	53.2	49.1	60.0
Clothing	8.2	5.1	10.7	10.7
Education	20.5	25.0	7.4	11.0
Health care	6.7	7.0	8.1	10.0
Entertainment, transportation	8.0	9.7	9.2	6.3

HH, household

WAY FORWARD

Stock enhancement program could be promoted in existing wetlands, flood plains and upcoming reservoirs to enhance resources for poverty reduction. A multi-disciplinary planning approach should be done so as not to affect programs for other users. The existing stocking density should be increased to enhance productivity with promotion of native species. If food security is emphasized, aquaculture should be given a high priority, although other users should also be accommodated. Injudicious introduction of exotic species could alter the existing population.

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Technological Advancement of Cage Fish Farming in Nepal: Prospect for Aquaculture in Large Water Bodies

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ABSTRACT

Modern cage culture in Nepal has a history of about 30 years. During this period, cage culture became an indispensable part of fisheries on lakes of Pokhara valley and Kulekhani reservoir. Cage culture of carp is considered a major step towards the utilization of natural water fisheries management for increased production. This sub-sector plays a key role in provision of protein food, poverty alleviation of dependent community and reduction of fishing pressure in capture fisheries.

Cage culture production technology is somewhat similar in different locations. The cage systems used in modern aquaculture have essentially changed little compared to the first use. Cages are floating, rectangular units with a suspended closed net bag. Fabrication materials have changed from netlon in wooden frame to polyethylene thread in bamboo frame. The numbers of cages vary according to the financial capability of the operators. The main fish species used for cage culture is planktivore viz. silver carp and bighead carp. Currently, technological advancement in cage fish farming has been done to increase productivity of cage fish from 4 kg to 8 kg/m³ by introducing grass carp in cages. Cage farming is practiced on small scale and yet there has been no sustained commercial development of this subsector. The main constraint to the development of competitive cage culture is unavailability of locally produced large size fry, traditionally low price and a lack of potential investors willing to take a long-term investment risk in different suitable water bodies. This paper reviews the history and status of cage aquaculture in Nepal, discusses the issue affecting their development and proposes a way forward to their sustainable development within the Nepalese context.

INTRODUCTION

Cage fish culture is defined as fish rearing from fingerlings to marketable size in enclosed cages that allow the free circulation of water into and out of cages (Kuronuma 1968, Schmittou 1970). Cages have certain advantages over other aquaculture production systems in terms of uptake by rural poor and landless people (Beveridge 1996, Beveridge and Stewart 1998). Cage culture operations require lower capital investment, offer increased management flexibility and have lower production costs as compared to ponds and raceways (Rojas and Wadsworth 2007). Although the origins of the use of cages can be traced back almost two centuries ago to the Asian region for holding and transporting fish for short periods, commercial cage culture was pioneered in Norway in the 1970s with the rise and development of salmon farming (Pillay and Kutty 2005). Cage aquaculture is common in central and southeast Asia in countries such as China, Philippines, Indonesia and Thailand (Beveridge 1996, Beveridge and Stewart 1998).

In Nepal, cage fish culture was introduced in 1972 and set in Phewa lake of Pokhara valley used mainly to hold brood fish of common carp (Swar and Pradhan 1992). Cage culture of carp is considered a major step towards the utilization of natural water fisheries management for increased production. This sub- sector plays a key role in provision of protein food, poverty alleviation of dependent and displaced community and reduction of fishing pressure in capture fisheries. Since the

system is targeted at poor people, an extensive type of cage fish culture has been practiced using planktivorous fish depending entirely on natural food available in the water. With the gradual development in culture technology, cage fish culture for fish production has become popular in lakes of Pokhara valley and Kulekhani reservoir. Production technology is somewhat similar in different locations.

The cage systems used in modern aquaculture have essentially changed little compared to the first use. Cages are floating, rectangular units with a suspended closed net bag. Fabrication materials have changed from netlon in bamboo, angle iron, wooden frame to polyethylene thread in bamboo frame. The availability of reliable supplies of good quality seed stocks is a major problem in most cage farming. In Pokhara valley, the major role in cage fish culture is played by fisherwomen, which therefore benefit the community. Currently, researches are focused on to explore cage aquaculture into new untapped open-water culture areas such as lakes, reservoirs, rivers and irrigation canal etc. This paper reviews the history and status of cage aquaculture in Nepal, discusses the issue affecting their development and proposes a way forward to their sustainable development within the Nepalese context.

STATUS OF CAGE CULTURE

Modern cage culture in Nepal has a history of over 30 years, dating from the early 1970s (Swar and Pradhan 1992). During this period, cage culture became an indispensable part of fisheries in lakes of Pokhara valley and Kulekhani reservoir. It has contributed remarkably to the improvement of living standards, ensuring food security, generating subsistence income and creating additional jobs for involved community. Aiming to find more efficient ways to utilize natural water resources, cage culture entered a period of great expansion in the 1980s. The technique has extended to Kulekhani reservoir in 1984 for the local people as part of the mitigation efforts following reservoir construction and loss of farmland. In recent times planners and developers have been driven to consider reservoir cage culture as an alternative livelihood for displaced persons and an effective non-water-consumptive secondary use of the reservoir resources in many countries (Abery et al 2005). During this period, the main characteristics of cage culture were the cage polyculture with planktivores species of fish like bighead carp (*Aristichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*). Since the late 1980s experiments on various kinds of cage-culture techniques have all aimed at increasing fish yields or economic returns. Past study had proved that the cultivation of common (*Cyprinus carpio*) carp with low cost feed did not yield good harvest (Pillai & Sollows 1980) while use of grass carp (*Ctenopharyngodon idella*) in cage culture fed with aquatic weeds showed 1.5 times more production than planktivore species and also helped to improve the ecosystem of aquatic water bodies (Prasad et al 2012).

Cage type and size

Fish cages that are used in Nepal have been described in Sharma (1979), Rajbanshi et al (1984) and Swar and Pradhan (1992). In the beginning different types of cages made of wooden, bamboo, iron wire mesh cage, netlon etc were used. Cages were tried to float with plastic drums, oil drums or Styrofoam. As a result of the experience gained from cage culture, farmers have made significant advances in cage design and in management methods. Currently, the floating cage system is the dominate technology used for carp farming in Nepal. Now a days the systems are bamboo frames with nylon cages of varying mesh size suspended from bamboos. Bamboo is consistently found to be the cheapest and is easily managed due to its natural buoyancy.

The size of the net cages depends on the convenience of the farmers. Usually the cages used in Nepal are of 50-62.5 m³ (5x5x2 - 2.5 m) because they are convenient for handling. However, a few large cages of 150 m³ are also in operation. The use of smaller cage sizes in freshwater allows greater

access and control and facilitates more intensive husbandry techniques such as grading, fish movements and net changing. Individual cages are grouped together in varying numbers to comprise a farm site. These are moored to the lake/reservoir in a static grid structure using concrete blocks or stones. Installation requires detailed data on environmental conditions provided by nearby fisheries station. Although there is no legislation controlling installation specifications, many farmers comply with the local cooperative group rule. This has reduced the cage poaching and fish losses over recent years.

Major cultured fish species in cage production

Fish species that are suitable for cage culture varies considerably in their feeding habit, temperature tolerance and other characteristics. Worldwide, a wide range of marine and freshwater species are cultured in cages including seabass (*Lates calcarifer*) (Rimmer & Russel 1998), grouper and snapper (Subfamily: *Epinephelinae*) (Seng 1998), tilapia (*Oreochromis* spp.), milkfish (*Chano chanos*) (Bagarinao 1998), *Pangassius*, Grass carp (*Ctenopharyngodon idella*) and many others. In many countries, cage fish culture is practiced with intensive feeding and high stocking rates for high economic benefits (Manob 1979).

However, cage fish culture in Nepal is of extensive type where fish are fed on naturally available plankton and external feed are not supplied. In such an extensive culture method, fish are stocked in low densities to avoid food consumption. In Nepal, mainly two species of carps are popular for cage culture: bighead carp and silver carp. The potential yield of such production system is limited by the natural food (primary and secondary production) available to the stocked fish. Production of fish in cages could be enhanced by intensive supplementary feeding but such a practice has not yet been adopted in the country for various reasons. Occasionally, other species are also stocked with bighead carp and silver carp such as rohu (*Labeo rohita*) as a biological cleaning agent of fouling in cages (Sharma 1979). Recently there has been considerable interest in grass carp in macrophyte dominated area of Phewa lake because of the decreased natural food for planktivore, high value and demand in market (Prasad et al 2012). An initial trial of growing rainbow trout (*Oncorhynchus mykiss*) in cages in lakes and reservoirs has been started in Nepal (Gurung 2008, Bista et al 2004). Studies have shown that trout farming in lakes and reservoirs of the mid-hills in winter could be one of the alternative opportunities for cage farmers to increase their income. Similar approach has been in many other countries where salmon, trout and tilapia are farmed in cages (Beem and Gebhart 2000, Collao 2003, Rojas and Wadsworth 2007). However, at present, extension of rainbow trout for cage farming has been hindered by the poor access to fish seed and demand for nutrient enriched feedlot, leading to eutrophication, specifically in the natural lakes (Bista et al 2008). Integration of sahar and tilapia in pond-cum-cage culture reported to be effectively controls the number of tilapia recruits by sahar (Yadav et al 2007) which explore the possibility of cage culture in ponds as well with different species.

Management practices of cage fish culture

Extensive method of cage culture with planktivorous carps is dominant culture practices in Nepal. Management of an extensive cage culture is considered easy because feeding is not required. Cage production usually starts in April-May and market size fish of 300-400 g are produced in about 14–16 months for planktivore and 10-12 months for grass. In the case of pre-on grown fish (mainly grass carp of 40-60 g), the goal is to easily accept aquatic grass, harvest market size fish (500 g) before the end of the year, i.e. reducing the production cycle, making the product available in winter due to high market demand and avoiding the risks related to fish decaying.

Stocking densities in cages depends on the natural productivity of the water body and whether supplemental feeding is supplied or not. They first stock the fry into nursery cages (5-15 mm mesh) at 20-100 fish/m³. When fingerlings attain approximately 20-30 g of body weight, they are transferred

to production cages of 50 mm mesh. Recommended stocking density in production cages during the late 1980s were 6-10 fingerlings/m³ in lakes of Pokhara valley (Swar and Pradhan 1992). Recently, stocking density has been adjusted to 6-8 fish/m³ in the face of decreased productivity in lakes of Pokhara Valley and from an enormous increase in the number and volume of cages in the Kulekhani reservoir. Depending upon the type of plankton dominance and market, stocking ration was 50% of bighead carp and 50% of silver carp, and vice versa (Swar and Pradhan 1992). At this stocking ratio, cage culture yielded some production, but the per-unit-area output and economic returns were not considered satisfactory. Therefore, in recent days stocking pattern had been changed and farmers usually stock more percentage of bighead carp than silver carp due to changing pattern of plankton in lakes of Pokhara valley. Recent study had shown that maximum yield per unit area of cage volume could be obtained at 3:7 stocking ratio of silver carp to bighead carp in Phewa lake condition (Husen et al 2012). Additionally, 20–30 rohu are stocked in each cage to control fouling weeds that attach to the nets.

Usually, farmers purchase fry (3-5 g size) or fingerlings (10-15 g size) for rearing in cages from nearby hatcheries and nurseries or broker/middlemen. In most of these instances perhaps the greatest concern is the release of a non-native, highly adaptive and successful fish species into the aquatic environment, either through escapes or intentional release-capture fisheries. This is especially relevant to natural water systems such as lakes of Pokhara valley where tilapia has recently been increased in lake catch.

Nets with different mesh sizes are used during the whole production cycle: knotless nylon thread from 5 mm up to 50 mm or more depending on the size of the fish. Nets are usually changed several times in each cycle (increasing mesh size), and the frequency varies depending on environmental conditions and the mesh size of the nets. Manual net washing of cages with soft brush or stick are usually used. In order to optimize production, it is essential to keep the cages clean to reduce mortality from inadequate food and dissolved oxygen. Sponges, algae and silt are common fouling agents in fresh water. Net fouling by fresh water sponge might negatively influence fish growth by reducing water exchange rate. The fish are usually harvested when they reach an average weight of 300 - 400 g. Cages are harvested in two ways: partially and completely. In the former, only a certain number of selected fish are removed. In such a case, harvested fish are usually the largest or the least healthy individuals. A complete harvest is advised when improvement in overall production is planned by replacing old stock with new fingerlings. Cages are restocked immediately after harvest. The whole production is almost entirely sold fresh or iced in polystyrene boxes.

CAGE FISH PRODUCTION AND PRODUCTIVITY

The current trend in overall production and productivity was at decreasing rate compared with past several years. The total number of farmers involved in cage culture was almost stagnant over past years. The data of the year 2011 showed that currently 172 family members are engaged in about 35750 m³ of cage volume in three lakes of Pokhara valley, producing 47.8 MT of fish. In Kulekhani reservoir, the number of farmers family has reached to 307 using more than 27900 m³ cages for table fish production producing 26.8 MT fish at the rate of 1 kg/m³ (Table 1-4). In addition 6.6 MT of fish produced from Government cages (Table 5).

Table 1. Status of household engaged in cage culture at Phewa lake

Lake	2005	2007	2008	2009	2010	2011
Number of households	55	97	97	90	90	90
Number of cages	470	516	603	537	605	605
Volume (m ³)	16450	20600	24000	21400	26000	26000
Production (MT)	70.7	70.0	103.2	74.2	88.7	39.0

Table 2. Status of household engaged in cage culture at Begnas lake

Lake	2005	2007	2008	2009	2010	2011
Number of households	33	37	37	37	42	42
Number of cages	76	83	120	108	42	35
Volume (m ³)	3800	3600	6000	5400	3600	1750
Production (MT)	12.1	12.6	19.2	12.6	12.2	1.8

Table 3. Status of household engaged in cage culture at Rupa lake

Lake	2005	2011
Number of households	26	40
Number of cages	92	163
Volume (m ³)	3450	8000
Production (MT)	12.1	7.0

Table 4. Status of household engaged in cage culture at Kulekhani Reservoir

Lake	2010	2011
Number of households	307	307
Number of cages	288	558
Volume (m ³)	14400	27900
Production (MT)	13.4	26.8

Table 5. Status of cage culture at Government stations

Lake/reservoir	Production		Nursery		Experimental		Production (MT)
	No.	Vol. (m ³)	No.	Vol. (m ³)	No.	Vol. (m ³)	
Phewa	23	1250	24	1000	58	2900	4.0
Begnas	29	1650	0	0	0	0	1.0
Kulekhani	37	2024	23	1021	0	0	1.6

The productivity of cages largely depends on the nutrients and plankton status of the water bodies. Cage productivity estimated at various times revealed that fish productivity rates in cages limited to 1.0 to 4.5 kg/m³ (Figure 1-2) indicating productivity of caged-fish differed with availability of nutrient and management practices (Gurung & Bista 2003, Wagle et al 2007). The reasons for the decline of fish productivity in recent time are the scarce natural food resources in the lakes for caged fish and feed competition with some invasive species. Farmers have also faced environmental problems caused by invasive aquatic weed like water hyacinth. Frequent reports of mass mortalities related to water quality and oxygen depletion due to turn over have occurred. In some cases, especially those in Kulekhani reservoirs, the ecological balance has been affected due to an overload of cages with consequent disease problems.

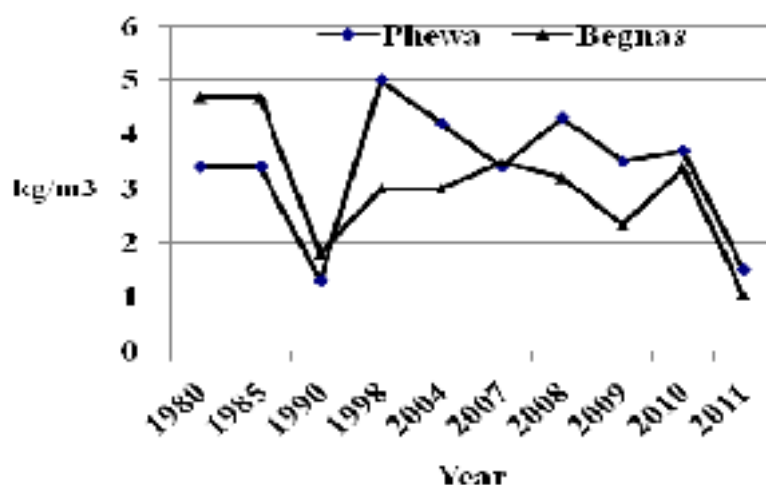


Figure 1. Cage productivity trend at Phewa and Begnas



Figure 2: Cage Productivity trend at Kulekhani reservoir

WAY FORWARD

The production of silver carp and bighead carp is characterized by low productivity. Intensive cage aquaculture practices need to be introduced to enhance the productivity with high value species, at the same time production methods should be sustainable and environment-friendly. Cage culture of grass carp with application of aquatic plants can be promoted to weed-infested different wetland. Cage aquaculture is widely practiced in lakes of Pokhara Valley and Kulekhani reservoir, but is largely small scale. Because of the poor perception of cage culture as an economic activity, it has been difficult to promote its commercialization, as most potential investors are not convinced that cage culture can be a profitable enterprise. Before cage aquaculture can be promoted nationally, there is need to develop various cage aquaculture investment models for different suitable water bodies that

can be presented to potential investors and banks. Year round fingerling supply should be ensured by strengthening private sector (cage operator).

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Research Status of Sahar (*Tor putitora*) and its Potential in Aquaculture

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ABSTRACT

Sahar, *Tor putitora* (Cyprinidae), also known as Mahseer, is one of the most popular freshwater sport fish throughout the trans-Himalayan mid hill waters. Sahar formed a substantial natural fishery in the major riverine and lacustrine ecosystem of Nepal. Biological diversity of this species is being threatened by various anthropogenic activities. In view of the conservational value and the aquaculture potential of Sahar, significant development in artificial propagation and mass scale seed production of this species has been achieved. Sahar shows intermittent spawning behavior in natural waters but the pond reared fish breed distinctly in two seasons in a year. Sahar naturally distributed in cool waters of mid hills and relatively warmer water of inner terai. Domestication and growth studies revealed that the fish can survive and thrives well at water temperature over 30°C in rearing pond and cages in lakes of Pokhara valley without any adverse effect on its growth.

Performance of *T. putitora* on its growth and yield in different eco-region are under evaluation. One of the major challenges for developing the aquaculture production technology of Sahar is its slow growth. It has intermediate feeding habit in general and to some extent more likely to carnivorous. Efforts are being made to formulate better feed for exploiting growth potential of Sahar. One of the major problems of formulation of quality feed for Sahar is unavailability of protein rich ingredient like fish meal. Although this fish perform better in animal protein feed, the growth rates are rather slow compared to the growth of cultivated carps. In the present scenario of global warming and climate change, promotion of indigenous species in aquaculture is vital for sustainable aquaculture production and conservation of aquatic biodiversity. Realization of indigenous fish species in aquaculture would require more rigorous and continuum studies and technology development in the field of reproduction and seed production, suitable and cost effective feed, and grow out management of Sahar and other important indigenous fish species.

INTRODUCTION

The golden Sahar (*Tor putitora*) also known as Mahseer, a trans-Himalayan indigenous species of Nepal is one of well-known massive fresh water sport fish as well as high value food fish of mountainous rocky rivers and lakes. *T. putitora* is reported its distribution from most of trans-himalayan countries ranging Afghanistan, Bhutan, China, India, Myanmar, Nepal and Pakistan including Bangladesh (Skene-dhu 1923, MacDonald 1948, Desai 1994, Khan et al 1994). Two species of Sahar, *T. putitora* and *T. tor* are reported to inhabit Nepalese torrential waters and lakes of mid hills (Shrestha 1981 and Shrestha 1997). Studies have shown that the Sahar are living in deeper water bodies in both cold and warm waters and spawning and growth is better in warm water, temperature ranges from 20-30°C. *T. putitora* is abundantly found in lakes of Pokhara valley. The natural population of Sahar is known to be dwindling in many trans-Himalayan countries due to chemical, physical and biological alterations in most of the aquatic environments of this region, the

home of this species (Nautiyal 1994, Shrestha 1994). Due to an important and high value species of aquatic biodiversity its conservation is vital.

Indigenous species are often promoted as alternatives to introduction of exotic species for aquaculture development. They may be preferred locally, may contribute to preservation of biodiversity, and help maintain integrity of aquatic communities and ecosystems by appropriate management. Being indigenous, Sahar, *Tor putitora*, seem good candidates for aquaculture. Growth potential of Sahar in captivity needs to be exploited for its commercial culture.

With the purpose of conservation and exploration to aquaculture for commercial production, considerable development has been achieved on artificial propagation and its growth and yield performance in different eco-region in Nepal. In this regards, mass scale seed production technology has been developed and the technology for aquaculture in captive condition has been under development (Bista et al 2002, and Gurung et al 2002). However, the area and sector of study on different subjects of this species is wide. Many factors including spawning and growth characteristics and many subjects have yet to be studied. This paper deals with the examination of seasonal response and possibility of mass seed production with finding optimum time of spawning and to analyze the growth potential of Sahar for conservation and exploration to aquaculture.

Reproductive performance

The Sahar shows intermittent spawning behaviour releasing eggs more than one season. Pond reared Sahar spawned first time in 1999 at FRC Pokhara (Gurung et al 2002). This study showed that most of the Sahar female broods under captive conditions responded better during February-March than September-October. Results showed that 60% female responded during autumn season (mid September to early December) at water temperature 25-22°C, whereas most of the female (>90%) responded during spring season (late February to late March) at 19-25°C. The fertilization and hatching rate ranges between 50-95%. The compilation of breeding data showed that golden Sahar could breed in most of months of the year but females were not observed ripening during January in FRC Pokhara. It is not yet clear either they could response in January or not. Results showed that Sahar could spawn from March to the first week of December at water temperature ranging from 19 to 32°C, where average water temperature was recorded at FRC, Pokhara (Begnas) from 15-31°C in 2010 (Fig. 1), while pH values ranged 7.0 to 9.0 and dissolved oxygen from 3 to 9 mg/L.

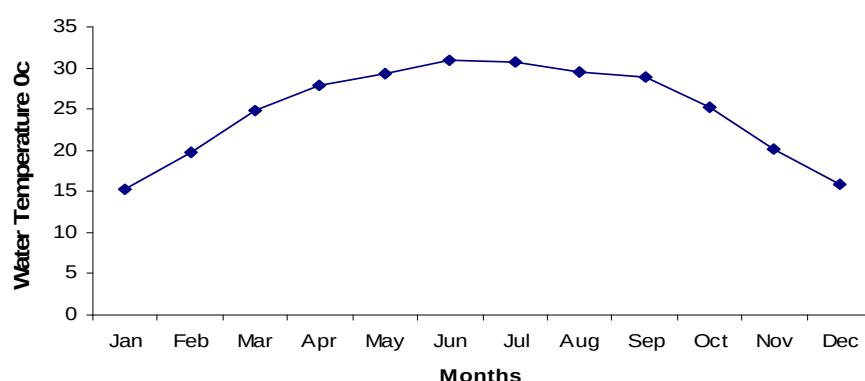


Figure 1. Average water temperature (°C) in Sahar rearing ponds, 2010

All 100% female were responded for releasing eggs during spring season (February-March). Among them about 58% released viable eggs with normal spawning, 12% released poor quality eggs (low fertilization and hatching rate) and rest 30% were found over matured in spring 2010, whereas only

60% female were responded for releasing eggs and 10% females released viable eggs during autumn (September-October) of 2009 (Table 2). The fertilization and hatching rates were ranged as 50-95%.

Table 1. Seasonal spawning performance of Sahar

Description	Sept-Oct 2009	Feb-Mar 2010
Female, number	50	50
Responded female, number	30 (60%)	50 (100%)
Normally spawned brood	5 (10%)	29 (58%)
Female spawned with poor quality eggs	20 (40%)	6 (12%)
Over matured	25 (50%)	15 (30%)
Post spawning mortality	0%	0%

All the experiments on reproductive behavior of Sahar suggests that pond-reared golden Sahar could breed at 19-32°C from March to December by simple hand stripping without any hormone use and brood loss. It also demonstrated that golden Sahar broods could be reared like other carps such as common carp, Chinese and major carps. The broods about 30% in spring and 50% in autumn showed over mature ova during routine check, which implied that broods should be examined more frequently than as practiced often once or twice a year. For higher spawning rate and eggs viability, determination of optimum stripping time by frequent checking of brood fish in every 1-2 days interval is essential.

In the present studies in different Fisheries Research Centres, most of the Sahar female broods under captive conditions were reared in normal conditions where water temperature was ranged from 15-31°C throughout the year (as record of 2010). February- March is the main season and October-November is the next season for spawning of Sahar (Nepal et al 2002). This study shows that the matured broods of Sahar responded better during February-March than September-October and determination of optimum stripping time by frequent checking of brood fish in every 1-2 days interval is essential for higher spawning rate and eggs viability.

Growth performance of Sahar in different eco-region

During the experiment period water temperature was ranged between 20.0 and 30.5°C at Pokhara, 13.9 and 27.3°C at Rampur and 29.1°C at Tarahara. The growth of Sahar was faster in warmer environment at mean water temperature, 26-29°C. Sahar stocked with initial average weight of 4 g at Pokhara (mid-hill) and 3.5 g at Tarahara (Terai) for growth study. Although body weight gain of Sahar fry at the end of first month of rearing did not differed from stocking size, later after 60 days fish growth varied significantly ($P < 0.05$) and attained final weight of 52.8 g in Pokhara and 66.5 g in Tarahara at the end of growing period of 120 days (Fig. 2).

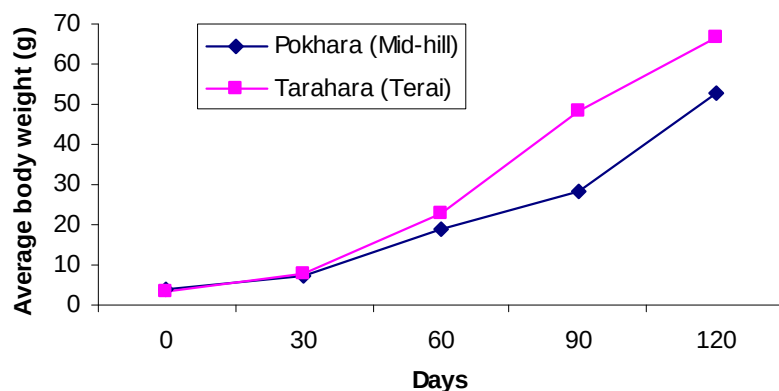


Figure 2. Average growth (g) of Sahar in Mid-hill and Terai, 2006

Location specific comparison of the growth of small size Sahar revealed that the net cumulative weight gain in Tarahara at each growing months was significantly higher ($P < 0.05$) than the net weight gain obtained in Pokhara (Fig. 2). Absolute growth rate calculated for small sized Sahar was 0.40 g/day^{-1} in Pokhara and 0.42 g/day^{-1} in Tarahara, and differences in growth rates between locations were not significantly different ($P > 0.05$). Likewise, a result of experiments in terai shows that the growth of Sahar is faster during warmer season than winter. Warmer water temperature is favourable for the growth of Sahar. A 16.3 g Sahar attended to 109.5 g within 240 days from October 2007 to June 2008 at Rampur, Chitwan (Fig. 3).

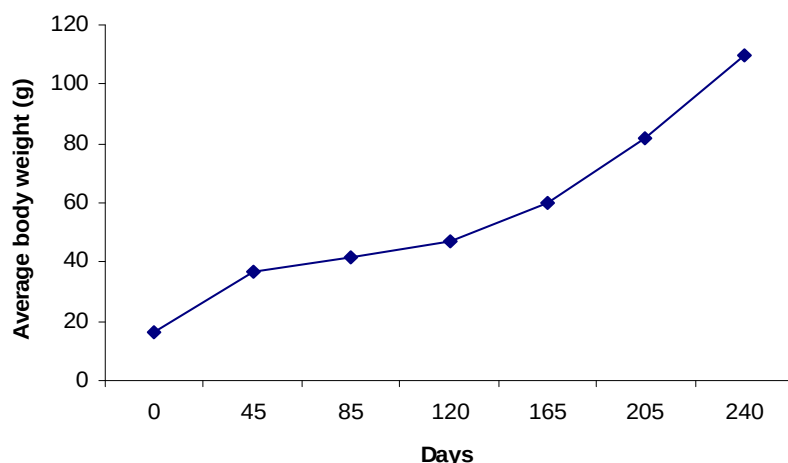


Figure 3. Average growth of Sahar at Rampur, Chitwan (Tarai)

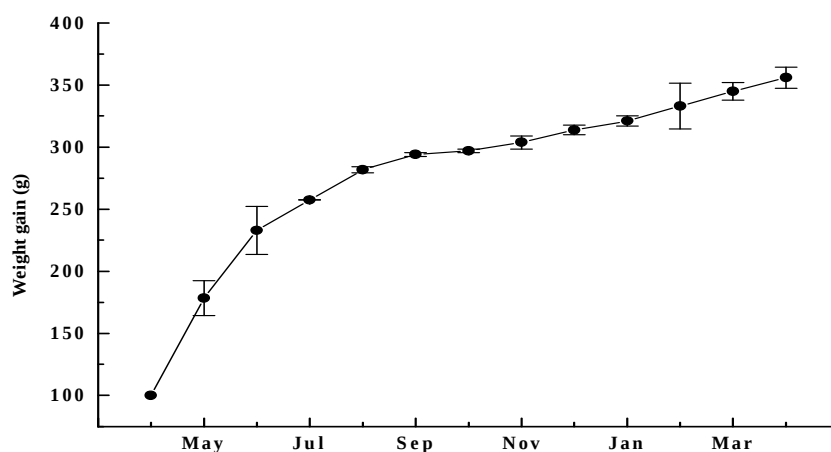


Figure 4. Growth trend of pond reared one-year-old Sahar

Sahar of different sizes and age cohort were raised in ponds of mid hill (Pokhara). Relatively poor body weight gain of Sahar in all treatments during February to March of growing period was associated with low water temperature. Bista et al (2002) reported merely 0.12 g day^{-1} growth rate of large size Sahar at temperatures ranging from $15-18^{\circ}\text{C}$. The high growth rate of Sahar in all treatments observed in these studies might be due to favorable temperature during grow-out period. Significant differences in cumulative net weight gain of Sahar reared in mid hill and terai suggest that warmer region is more favorable for the grow-out of Sahar in captive environment.

Temperature tolerance of Sahar for growth and reproduction is similar to other carps. Observations are found that Sahar can survive and thrives well at water temperature over 30°C in summer season in rearing ponds and cages in lakes of Pokhara valley without any adverse effect on its growth (Bista et al 2002).

Relatively high growth rates of Sahar in terai region were also reported by Rai et al (2006). Marked differences in growth rates were observed with the stocking of small size and large size (including one-year old) Sahar. High growth rate (1.12 g day⁻¹) of one-year old Sahar obtained in the present study suggests that rearing Sahar for two-year old would be more profitable from the economic point of view. Sahar fetches a high market price, almost double than the other Chinese and major carps. However, observed growth rates of Sahar are comparatively below the growth of other carps species being used in fish farming systems of the country.

Descriptions	Percent Composition
Crude protein	35
Crude fat	11
Crude ash	7
Crude fiber	6
NFEE*	31
Moisture	10

Performance of *T. putitora* on its growth and yield in different eco-regions are under evaluation. One of the major challenges for developing the aquaculture production technology of Sahar is its slow growth. It has intermediate feeding habit in general and to some extent more likely to carnivorous. Efforts are being made to formulate better feed for exploiting growth potential of Sahar. One of the major problems of formulation of quality feed for Sahar is unavailability of protein rich ingredient like fish meal (Bista 2001). Although this fish perform better in animal protein feed, the growth rates are rather slow compared to the growth of cultivated carps.

Limited growth potential of Sahar in captivity is being a major constraint for its commercial culture. The results obtained from a series of growth experiments of Sahar in outdoor and indoor tanks using high protein palletized diet were discouraging compared to the growth of exotic carps (Bista et al 2001, Gurung et al 2003, Islam 2002). However, adult Sahar showed encouraging growth with feed containing high animal low plants source. For promotion of Sahar one alternative could be the development of suitable culture technology, which requires knowledge of their growth performance and nutritional requirement from fingerling to adult stage in artificial conditions.

Indigenous species are often promoted as alternatives to introduction of exotic species for aquaculture development. They may be preferred locally, may have less chance of introducing disease, may grow better under local conditions, may contribute to preservation of biodiversity, and help maintain integrity of aquatic communities and ecosystems by appropriate management. Being indigenous, Sahar seem to be good candidate for aquaculture. Technological package of reproduction and mass seed production of Sahar has been developed. Required number of Sahar can produced and research and development efforts have been initiated on measures for culture techniques of this species for introduction as a candidate for aquaculture practices. In the present scenario of global warming and climate change, promotion of indigenous species in aquaculture is vital for sustainable aquaculture production and conservation of aquatic biodiversity. Realization of indigenous fish species in aquaculture would require more rigorous and multiplicity studies and technology development in the field of culture system, suitable and cost effective feed, and grow out management of Sahar and other important indigenous fish species.

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Challenges of Fish Feed Management for Intensive Aquaculture Development in Nepal

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ABSTRACT

There have been concentrated researches on cost effective quality fish feed for all age group of cultured fish species for intensive aquaculture. Although the nutritional requirement and standardization of some feed formula for trout already has been categorized for all age groups but the least cost quality feed production is the main challenging task. Feeding behavior and feed of indigenous fishes like Sahar has also been assessed and formulated. The major constraint in animal husbandry including aquaculture is the feed cost which occupied more than 70% of total production cost. To reduce the price of a well balanced feed, locally available ingredients should be included in the feed, especially agricultural by-products. Being an agricultural country, Nepal has a number of agricultural by-products that can be used as animal feed. Formulation of quality feed is the difficult task due to the unavailability of quality feed ingredients and large variation in nutritional value of major feed stuffs available in different agro-ecological region of the country. There are 261 animal feed industries and are producing 0.5 million metric tons of feed all over the country but only very few of them are producing commercial aqua feed in private sector. Demand for quality fish feed has increased in recent years with the commercialization of trout farming compounded with the growth of large scale carp and catfish farms in private sector. For the substantial growth of commercial and intensive fish farms establishment of feed industry in private sector is indispensable and government should provide some support program in terms of technical, quality control and investment measures.

INTRODUCTION

Feed is vital for fish farming, in order to increase quality fish production. More than 46% of the total global aquaculture production is dependent upon the supply of external feed inputs. The major constraint in animal husbandry, including aquaculture is the feed cost which occupied more than 70% of total production cost. Good quality feeds are produced from good quality feed materials. Availability of quality feedstuffs such as fish meal is insufficient in Nepal. Demand for quality fish feed has increased in recent years with the commercialization of fish farming as well as large scale carp and catfish farming in private sector.

Nutrition is the process by which an organism takes in and assimilates food. Nutrition involves the ingestion, digestion, absorption, and transport of various nutrients throughout the body where the nutrients in foods are converted into body tissues and activities. Growth, health and reproduction of fish and other aquatic animals are primarily dependent upon an adequate supply of nutrient, both in terms of quality and quantity, irrespective of the culture system in which they are grown.

At present the technology for farming Nepal's native coldwater fish is not well developed and few species are economically viable to farm. The introduction of an economically viable coldwater species could allow the coldwater resources of Nepal to be used more effectively. Salmonids including trout

are well suited to commercial cultivation in cold waters and the technology is well developed (Bardach et al 1972, Huet 1975, Shetty et al 1989).

Feedstuffs containing 20% crude protein or more are considered protein supplements. Protein supplements may be classified as animal and plant proteins. Full fat roasted soybean seed and meal constitutes major component of protein supplement (20-45%) in trout feed in Nepal (Rai et al 2002). The national production of soybean was 17,500 metric tons in year 2001 and most of the production comes from hilly areas of the country (CBS 2005). Solvent extracted and extruded soybean meal is particularly important for trout feed because of its high protein and low fat content. However, soybean processing plants are mostly located in Terai region with a production capacity of 750 metric tons of solvent extracted-extruded soybean per year (Roy 2006). This paper is aimed to review specific issues in the fields of nutrition and feed formulation for intensification of aquaculture.

STATUS OF FEED PRODUCTION

Table 1 presents a brief account of feed production in Nepal. Of total 261 feed industries only 19 are of fish feed. Total feed production in the country is 500,000 MT, of which the fish feed is only 500 MT.

Table 1. Status of feed production in Nepal

Feed industries	Number	Production (MT)
Animal feed	261	500,000
Private industries	-	400,000
Small scale farmers	-	100,000
Fish feed	19	500
Private	12	450
1. Small scale	10	300
2. Commercial	2	150
Public	7	50

Research focus

There have been concentrated researches on cost effective quality fish feed for all age group of cultured fish species for intensive aquaculture. The nutritional requirement and standardization of some feed formula for carp and trout already has been categorized for all age groups. Feeding behavior and feed of indigenous fishes like Sahar has also been assessed and formulated.

Qualitatively, 40 nutrients have been identified as necessary for the normal metabolic function of all fresh water fish species including cold and warm water. Principle dietary requirements are:

- Gross energy: 19.0-25.0 KJ/g
- Dietary protein: 30-40%
- Dietary lipid levels: 10-15%
- Essential fatty acids (n-3 PUFA): 1.0 -2.0%
- Soluble carbohydrates: 15-25%
- Vitamins and mineral supplements: 1-2%

Catfish including trout require a source of nonspecific nitrogen and indispensable amino acids (Robinson and Li 1996). Use of protein for energy is expensive, thus lipids are primarily included in formulated diet to maximize their protein sparing. Lipids are a highly digestible source of concentrated energy. Trout have natural diets rich in triglycerides and can adapt to high fat diets (Hasan 2001). Dietary lipid levels as low as 10% has been reported for rainbow trout (Tacon 1990). Generally, however, weight gain and feed efficiency are depressed in aquatic species when fed diets containing 15% or more lipid (Robinson and Li 1996).

Energy, which is defined as the capacity to do work, is essential to life processes during all stages of an animal's life. Feeding standards for many animals are based on energy needs. Considerable information do not exists on energy needs of non-ruminant species, particularly fish. However, energy needs are lower for fish than for warm-blooded animals because fish do not have to maintain a constant body temperature and they expend less energy to maintain their position in space. Gross energy, which is a measure of the heat liberated on complete oxidation of a compound, requirement for cold water fish like trout is in between 19.1-20.8 KJ/g (Hasan 2001).

Dietary lipids provide essential fatty acids (EFA-polyunsaturated fatty acid, PUFAs) that fish, like all animals, cannot synthesize but require for the maintenance of cellular function. Cold freshwater fish have an exclusive requirement of linolenic series (n-3 or omega-3) PUFA (18:3n-3, 20:5n-3, 22:6n-3) in their diet (Hasan 2001). Rainbow trout require a small amount (1% of dry diet) of n-3 fatty acids. Inclusion of too much dietary lipid, however, may result in excessive fat deposition in the visceral cavity and tissues that may adversely affect yield, fish fillet quality and storage of processed products (Robinson and Li 1996).

Carbohydrates are the least expensive form of dietary energy and are frequently used for protein sparing in formulated diets. The utilization of dietary carbohydrates appears to differ depending on the complexity or chemical structure of the carbohydrate source used and fish species.

The ability of carnivorous fish species to hydrolyze or digest complex carbohydrate (glucose or sucrose) is limited due to weak amylolytic activity in their digestive tract, but carps can use 60% of carbohydrate in their diet. For trout, starch digestion decreases as the proportion of dietary starch is increased (Hasan 2001). However, commercial trout feed contains 15-25% soluble carbohydrates. An additional 1-2.5% carbohydrate is generally present as crude fiber. Fiber is considered to be indigestible by carnivores thus it is not desirable in carnivores' feeds because indigestible materials may pollute the water (Robinson and Li 1996). Essential amino acid requirements for rainbow trout are given in table 2.

Table 2. Essential amino acid requirements for rainbow trout

Amino acids, %	Starter	Fingerling	Production
Arginine	2.15	2.02	1.94
Histidine	0.91	0.85	0.82
Isoleucine	1.40	1.32	1.26
Leucine	2.55	2.40	2.30
Lysine	2.96	2.78	2.66
Methionine	0.96	0.90	0.87
Cystine	0.35	0.33	0.31
Phenylalanine	1.45	1.36	1.31
Tyrosine	1.15	1.09	1.04
Threonine	1.61	1.51	1.45
Tryptophan	0.30	0.28	0.27
Valine	1.66	1.56	1.50

Limitation of feed ingredients in Nepal

Due to the feed competition among animal husbandry and human, it is very difficult to balance the feedstuff. Quantitative and qualitative information on practical feedstuff to supply required nutrients for fish in Nepal is limited. Non-plant source of protein such as shrimp meal and fish meal contribute 20-50% to supply protein in aqua feed. Availability of non-plant source of protein is limited and subject to import from abroad.

High cost of formulated feed usually associated with the inclusion of high level of animal protein source in feed to meet the dietary requirement of different fish species.

Table 3. Available agricultural feedstuff in Nepal

Agricultural products	Production (mt. '000)		
	National total	Mountain	Hills
Wheat	1557	66	383
Paddy	4023	47	906
Corn	1855	122	997
Millet	300	-	-
Barley	276	-	-
Soybean seed	21.4	-	-
Solvent ext soy meal	0.75	-	-
Oil seed	135.4	-	-
Cotton seed	0.012	-	-
Lentil	0.17	-	-

Table 4. Amino acid profile of some protein source ingredients available in Nepal (% of dry basis)

Amino acids	Fish meal	Shrimp	Soybean			
			Seed	Meal	Cake	Puff
Lysine	2.70	3.85	2.53	2.77	2.85	3.21
Methionine	0.96	1.32	0.63	0.74	0.69	0.85
Cystine	0.37	0.6	0.58	0.78	0.68	0.87
Arginine	2.30	3.25	3.03	3.56	3.23	3.91
Histidine	0.78	0.96	1.07	1.46	1.21	1.45
Isoleucine	1.61	2.30	1.85	2.23	2.10	2.48
Leucine	2.87	3.89	3.07	3.67	3.50	4.03
Phenylalanine	1.72	2.65	2.19	2.64	2.46	2.78
Threonine	1.66	2.01	1.60	1.97	1.79	2.11
Valine	1.93	2.34	2.04	2.31	2.12	2.52
Tryptophan	0.31	0.44	0.51	0.63	0.57	0.69

Table 5. Nutrient composition of common feed ingredients

Nutrient		Soybean	Maize	Rice Bran	Wheat	Oil cake
Protein %	Range	23.5-47.1	2.9-14.2	4.1-16.0	7.0-14.8	13.7-39.1
	Mean±SE	37.5±0.35	8.5±0.20	9.6±0.60	11.1±0.26	30.2±0.50
Fat %	Range	11.9-30.9	1.3-11.9	0.5-27.5	1.2-9.1	7.0-25.1
	Mean±SE	20.8±0.32	5.8±0.23	11.8±1.25	3.8±0.19	17.4±0.42
Ash %	Range	1.3-16.7	1.3-2.3	6.5-18.7	1.1-5.8	3.1-11.2
	Mean±SE	5.6±0.15	1.7±0.03	12.1±0.72	2.1±0.12	7.8±0.22
Moisture %	Range	5.2-17.2	5.3-16.7	1.7-19.1	7.9-15.4	5.7-13.7
	Mean±SE	9.9±0.17	12.4±0.25	9.8±0.57	11.8±0.22	9.7±0.25
GE Kcal/kg		5825	4481	-	4516	-

Table 6. Nutrient digestibility of some feed stuffs protein source and low-cost ingredients

Items	% Apparent digestibility	
	protein	fat
Oil cake	78	91
Soybean	84	94
Wheat bran	62.6	-
Rice bran	71	-

Limiting factors of feedstuff

- Anti-nutritional factors contained in plant feedstuff, such as
 - Trypsin inhibitor in soybean
 - Gossypol in cotton seed
 - Eric acid in rapeseed
- High fiber content in plant source feedstuffs
- Feed resources are also used for human consumption and animal husbandry.
- Local feedstuffs tend to be of variable quality and quantity, typically dependent upon soil fertility, time of harvest, genetic constitution, moisture content and several other factors

Challenges on availability of feed ingredients in Nepal

Being an agricultural country, Nepal has a number of agricultural by-products that can be used as animal feed to reduce the feed cost. But the needy bulk of the ingredients are not available. The laboratory results also show that large variation in the nutrient availability in the same item but in different origin or in different agro-eco zone which make the unbalanced level of required nutrients.

Shrimp meal, procured from India, has been the main protein supplement for trout feed in Nepal (Nepal et al 2002). Limited market accessibility with relatively high cost, the shrimp remains one of the major elements to raise production cost of trout farming (Roy et al 1999, Pradhan 1999). Feed alone comprised 76% of total variable cost and 40% of the total production cost of commercial farming (Nepal et al 2002) and this is one of the major constraints after seed supply to expand trout farming in Nepal. Therefore, most of the studies have been focused on finding alternate sources of protein supplement in trout feed which are locally available at relatively cheaper cost without affecting the growth-production and quality of trout.

Possibilities for cost effective feed formulation

- Major challenges in fish nutrition are to decrease the dietary amount of fish and shrimp meal globally.
- 60% substitution of shrimp meal with soybean is possible and to reduce feed cost by about 40% without affecting the growth and feed efficiency of high value commercial species like trout and catfishes.
- Feed formulation containing 30-35% protein supplemented with 20-30% shrimp meal may be appropriate for fingerling and grow-out of indigenous fish like Sahar and catfishes and trout.
- Corn, millet, potato and other food stuffs readily available in mountain areas could be evaluated as part of feed for supplying energy to all fish species.
- QPM can be supplemented in future to complement the methionine deficit of soybean when used at high level in fish feed.
- Poultry by-product meal can be made up of clean parts of the carcass (heads, feet, under-developed eggs, and visceral organs) of slaughtered poultry, which can serve protein source to carnivorous feed.
- Opportunity exists to exploit silkworm pupae in high protein demanding fish feed as there is growing trend of sericulture industry in the country.

Aqua feed and environment

There are three components to the problem of aqua feed development: (a) quality, (b) quantity, and (c) varying requirement of different development stages. Local feedstuffs tend to be of variable quality and quantity, typically dependent upon by-products available from the agro-farm. Such resources are also used by agriculture and animal husbandry. Therefore, sustainable development of trout aquaculture in the country should address allocation of inputs based on local circumstances, and balance maximizing profitability with social and environmental costs.

Feed is the biggest source of nutrient loading in trout production from intensive and semi-intensive system. Environment-friendly diets with reduced food conversion ratios (FCR) by improving palatability and digestibility of raw ingredients are required. Reduction of ammonia excretion can be enhanced by adding crystalline DL-methionine to the diet containing high level of soybean meal. Research on processing techniques and additives and enzymes for improving feed performances and digestibility are also required.

Being an agricultural-based country, Nepal has a number of agricultural by-products that can be used as animal feed to reduce the feed cost. Formulation of quality feed is the difficult task due to the unavailability of quality feed ingredients and large variation in nutritional value of major feedstuffs available in different agro-ecological regions of the country. For the substantial growth of commercial and intensive fish farms establishment of feed industry in private sector is indispensable and government should provide some support program in terms of technical, quality control and investment measures.

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Post Harvest Methods and Potential of Technological Intervention for Value Addition in Fish in Nepal

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ABSTRACT

Fish is a highly perishable product, especially in hot climates and sub-tropical areas of Nepal where cold preservation techniques are often not available. The problem of fish preservation is acute in hilly regions of Nepal with limited market potential and preservation facilities. In some places, especially major fish landing sites from capture fisheries and highway corridors, the fish are preserved traditionally through sun and smoke drying, and frying in oil. Preliminary assessment made on fish preservation methods in several hot places of fish selling revealed that microbial load in both fresh and preserved fish are in some cases beyond the permissible level recommended by World Health Organization. If the quality of fish products could be improved, there is high possibility that these products are sold as instant healthy and nutritious food in substantially compatible prices. This prospect has yet to be trapped for the benefit of Nepalese fish farmers, merchants and consumers. Opportunities are immense to develop the technologies of dry fish products for exotic carp, indigenous carp, catfish, and trout in Nepal.

INTRODUCTION

Fish is a very important foodstuff in developing countries due to its high protein content and nutritional value. However, fish is a highly perishable, due to its high water activity (a_w) and protein content, neutral pH and presence of autolytic enzymes, which cause fish spoilage (Liu et al 2010). The rate of fish spoilage is affected by species, fat content, fishery and slaughter method, hygienic manipulation, post mortem handling and many other factors (Huss 1995). Fish spoilage is mainly due to autolysis, bacterial contamination and rancidity (Huss 1995). In some cases, physical damages (mechanical stress, direct sunlight etc) can lower the quality considerably. The initial loss of freshness is caused by endogenously autolytic enzymes in muscle and the subsequent spoilage is usually due to microbial activities, especially for the rapid proliferation of specific spoilage organisms (SSO) (Huss 1995). Interactions between microbial metabolism and physiological reaction accelerate fish quality deterioration as amines formation, lipid oxidation, nucleotide and protein degradation and contribute to off-odors, off-flavors and texture softening (Ozogul et al 2006, Alasalvar et al 2001, Hernandez et al 2009).

Preservation methods should be applied immediately after harvest. Preservation of fish greatly slows down spoilage. Preservation methods are applied with an intention to making the fish safer and extend its shelf-life (Ghazala 1994). Fish preservation techniques currently used in the tropics include chilling, freezing, drying, salting and smoking. However, in Nepal the affordable and widely used methods of fish preservation are sun drying and smoking. Sun drying which is used for small-sized fish and smoking for all-sized fish, are traditional techniques for preservation and storage, which increase availability of fishery products to consumers.

Fat oxidation usually occurs after autolysis and bacterial spoilage. The lipid concentration in fish can contribute to the spoilage process in fish. The fats in fish are mainly unsaturated fatty acids that are

easily oxidized by oxygen from the atmosphere. High temperature or exposure to light can increase the oxidation rate. For fatty fish preserved in ice, spoilage due to rancidity is mainly caused by oxidation. This produces a bad and unpleasant odor as well as a rancid taste (Hobbs 1982).

Most outbreaks of food poisoning associated with <sh are derive from the consumption of raw or insufficiently heat-treated <sh, which may be contaminated with bacteria from water (*Vibrio* spp., *Clostridium botulinum*) or terrestrial sources (*Clostridium perfringens*, *Salmonella* spp., *Shigella* spp., *Staphylococcus* spp., *Vibrio cholera*), or <sh products re-contaminated after heat processing (Novotny et al 2004). Wound infections caused particularly by mycobacterium, *Streptococcus iniae*, *Erysipelothrix rhusiopathiae* or *Photobacterium damsela* and *Vibrio alginolyticus* are seen after injury during handling <sh or after exposure of open wounds to water environment. In the case of poor hygiene, the contamination of <sh and <sh products may increase due to unsanitary procedures, the rotation of the assigned duties of workers, and airborne microorganisms during packing of the product. Hot smoking in mild conditions at a temperature in the <sh not exceeding 65°C and a low concentration of salt does not inactivate all pathogens or inhibit bacteria during storage. Thus, the required safety can be obtained only by using very fresh <sh handled in hygienic conditions, controlling the processing and the plant hygiene at critical control points, and chilling of the product to about 2°C.

In many parts of the world, the problem of preserving fish rapidly and inexpensively still remains a major deterrent to fully utilizing local fishery resources. It is estimated that where modern facilities do not exist, 50% of the fish that is salted and/or dried is lost either to decomposition or rodent and insect infestation (Denaut 1975). Although published information on fish preservation and processing are scanty in Nepal, preliminary assessments on fish collection, transportation, processing and preservation and marketing of fish from several hot places fish landing and market have been made. Based on this assessment, the present report reviews the fish preservation and processing methods adopted by fishers/traders in Nepal. The report also looks potential prospects of fish preservation in the country and suggests some technological intervention for quality improvement of preserved fish for the benefit of all stakeholders in value chain of fish marketing.

FISH POST HARVEST MEASURES

Handling of fish

Drag net is used to harvest fish from the pond by a group of people. Fish are brought near to pond dike and dump at one place, one upon the other lot. There is no separate clean area for fish collection after harvesting. Fish are often thrown on landing site, making the fish susceptible to internal bleeding which cause rapid deterioration. Throwing of fish also bruises the fish, making prone to bacterial contamination and softening fish texture.

Toilet is taken as an essential and basic indicator of health and sanitation worldwide (ESG 2009). Every day, 16 million Nepalese (around 57% of the population) practice open defecation because they have no toilets (NMDG 2010). Access to sanitary system, garbage disposal and toilets are lowest among the poorest population and is better in the richer quintiles of the population (Karn et al 2012). In most of the village areas of Nepal, people practice open defecation near a pond dike, bank of river and cultivated area making the surroundings unhygienic. A study revealed that area contaminated by fecal matter causes favorable conditions for *Salmonella* and there was no remarkable difference in total microbial load (cell/g) of fish collected from different sites (Table 1) (Pradhan et al 2013).

Table 1. Microbial load observed in naini (*Cirrhinus mrigala*) samples collected from fish ponds at Bodhban of Bara and Jhankuti of Parsa districts

Sampling site	Sampling point	<i>Salmonella</i>	Total microbial load (cell/g)
Bodhban	Net	-ve	57.2 x10 ⁶
	Landing site	+ve	38.4 x10 ⁶
Jhankuti P-1	Net	-ve	96.4 x10 ⁶
	Landing site	-ve	93.4 x10 ⁶
Jhankuti P-2	Net	+ve	59.6 x10 ⁶
	Landing site	+ve	101.2 x10 ⁶
Nagawa, Birganj	Fish collection site	+ve	68.4 x10 ⁶

The fecal contamination in the fish is also showed by a study of microbial load in the fish sampled from different points (Table 2) (Pradhan et al 2013). *Salmonella* was absent in the fish sample collected from cast net directly to sampling bag. *Salmonella* was found in the fish sample collected from the container in the landing site as well as from container of vendor at fish market. TPC (cfu/g) and total *Coliform* (MPN/g) were also higher in these two samples than in cast net sample.

Table 2. Microbial load in fish samples collected from Koshi River

Sampling point	<i>Salmonella</i>	TPC (cfu/g)	Total <i>Coliform</i> (MPN/g)
Fish sample collected directly from cast net to plastic bag	-ve	1.5 x 10 ²	20
Sample collected at landing site in a dirty plastic bucket	+ve	1.4 x 10 ³	30
Sample collected at market nearby river from the dirty <i>handi</i> of vendor	+ve	1.6 x 10 ³	33

Processing and preservation

The fishermen sale their fish directly without washing, degutting and preserving in ice to the contractor. Contractor also keeps fish directly to the transporting vehicle without washing and degutting but preserving with ice. Bonell (1994) recommended that it should be beheaded, gutted, washed and chilled to inhibit unfavorable enzymatic and microbial processes. If the fishes are not processed immediately after they are captured, certain irreversible spoilage and deterioration reactions begin to take place (Connell 1995). Most of the processing or preservation operations are intended to reduce the rate of spoilage by reducing water activity of the fish (Eyo 1986). Degradation is fastened by poor storage during transportation from the landing and collection sites to the distribution points.

Fish marketing

Information on fish demand and consumption in Nepal is very limited. Fish is generally accepted and liked by all non-vegetarians in Kathmandu. The per capita intake of fish is a low 2 kg/person/year, which, however, does not include imported fish (DoFD 2011). As up to 75% of the fish sold in the Kathmandu valley market come from India. Rohu is available in highest quantity because it is imported from India. Pongas (*Pangasius hypothalamus*), naini (*Cirrhinus mrigala*) and *Clarias gairepinus* are other dominant fish in the market. Besides, silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyndodon idella*), buhari (*Walago attu*) are also available in the market. Hill stream fish such as *Tor* spp., *Neolissocheilus* sp., *Schizothorax* spp., *Glyptothorax* spp. and *Garra* spp.

are sold in smoked form in Kathmandu valley market, where they are brought from adjacent areas such as Trishuli, Dolalghat and Panauti (Shrestha 1994). Naini (*Cirrhinus mrigala*) popular as chhari fish is the dominant dried fish available in the market. Vacuum-packed, degutted rainbow trout (*Oncorhynchus mykiss*) is available in the department stores of Kathmandu valley stored in deep freeze. Now a days, live fish is also available in the market such as magur (*Clarias gareipinus*) and carps. Rainbow trout (*Oncorhynchus mykiss*) is available live in the farmers' fields. The channel through which fishes have been marketed to the consumers of Nepal from the production areas/producers is shown in figure 1.

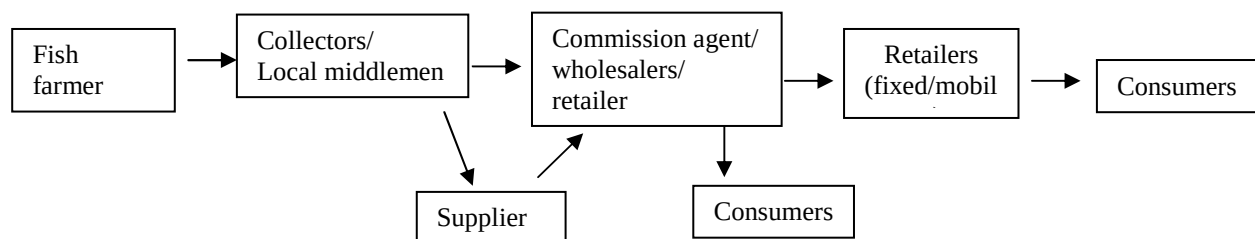


Figure 1. Fish marketing channels in Nepal

Preservation of fish

Fish being highly perishable after harvest requires proper preservation and storage to increase the shelf life (Clucas and Ward 1996). Major methods of fish preservation and processing have been identified as freezing, sun drying and smoking.

Freezing of fish is done in large cities where shopkeepers use a deep freeze for long-term storage. The ice factories are operating in big cities only and they produce limited amount of ice. There is no fish cold storage and processing factory in Nepal. The problem of fish preservation is acute in hilly regions of Nepal where there is no ice factory and poor marketing potential. Quality losses can occur very rapidly after catch. Jamin and Ayinla (2003) reported that spoilage of fish is slowed down at freezing temperatures. Using low temperature is the most frequently used measure to limit enzyme activities (Huss 1994). It is important to decrease the temperature to 0°C as soon as possible after catching. For fish in the tropical water area whereas the ambient temperature is around 25-30°C the rate of spoilage can be 25 times higher than when kept at 0°C (Aberoumand 2010).

The general practices employed for fish preservation by drying are smoking on fire place, sun drying, use of solar dryer and deep frying. These drying methods basically are similar to those employed in several other countries (Sachithanathan et al 1985 and N'jai 1985). The traditional methods of dried fish production are sun drying and smoking in Nepal (Shrestha 1995). Most fish are landed in remote fishing villages which are far from the consuming centers and which, in most cases, are not served by motorable roads. A considerable proportion of the catch will spoil and become unfit for consumption unless it is preserved by sun drying or smoke drying.

The fundamental difference of the dried fish between Nepalese products and products from other countries can be the species. For example, in hilly areas of Nepal, asala (*Shizothorax* spp) is dominant species used for smoking. Asala is exclusively collected from cold water streams and rivers as this species has not been started to cultivate commercially. The other captured species abundantly dried are sahar (*Tor* spp.), magur (*Clarias* spp.), tilapia (*Oreochromis nilotica*), bhurluk (*Puntius* spp.), bhitte (*Puntius sarana*) etc. The cultured fish used for drying are rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*), catla (*Catla catla*), silver carp (*Hypophthalmichthys nobilis*) and bighead carp etc.

Sun drying: Sun-drying of fish is an old traditional practice done in many parts of the world (Sachithananthan et al 1985 and N'jai 1985). The major problems associated with sun drying of fish are infestation of the products by the fly and insect larvae during and storage, contaminants and spoilage (Reza et al 2005). Although sun drying has several drawbacks such as slow drying rate, product contamination and overall poor quality, it is the cheapest method in terai region of Nepal. In terai during the month of Aswin and Kartik, fish are dried under the sun spreading over the mat for 3-4 days depending upon the weather conditions and size of the fish. Among fish species used for drying, sidra (*Puntius* spp.) comprises 75% and hile (*Channa* spp.), *Oxygaster*, *Anabas*, *Nandus* and chuchche bam (*Xenentodon* spp.) collectively comprised of 25%. These dried fish, locally known as sidra, have a nice taste and are used for pickles.

Smoking on fire place: Smoking of fish on fire place was one of the most popularly practiced methods among all. Chhari fish (90% naini and 10% rohu) is smoked for commercial marketing purpose. In this method, fish are smoked over a big *chulho* made up of mud, either built by digging under the ground or over the ground. Fishes are smoked without washing and degutting over the fire. The fish are arranged properly one upon the other and covered with thick paper in the iron mesh and kept over big *chulho*. During smoking belly of fish is burst out. This type of smoking is practiced in Bara and Rautahat districts.

Smoking over chulho: Fish captured from rivers and streams in hill regions are dried by smoking over *chulho*. In Chisapani of Karnali River side, captured fish are transported in *handi* and sold to the nearby hotels. Field observations revealed that fish are gutted, washed and preserved in refrigerator by the hoteliers in order to inhibit unfavorable enzymatic and microbial processes. Sometimes, turmeric powder (0.5-1.0%) and local *chuk* (concentrated citrus juice) is dressed over the fish. Then the fish are either fastens with a skewer using a long metal or wooden pin and hang in the air to drip water so that it will take less time to dry. After air drying the fish are taken out and dried upon the fire place by keeping over iron mesh. It takes 2-3 days for completion of drying depending upon size of fish and weather. The dripping of water from the fish causes loss of water soluble nutrients during hanging in air. The fish usually used for drying in major fish catch and collection sites is given in table 3.

Table 3. List of fishes commonly used for drying in major fish catch and collection sites

Local name	Scientific name	Local name	Scientific name
Sahar	<i>Tor putitora</i>	Kabre	<i>Glyptothorax annandalei</i>
Asala	<i>Schizothorax</i> sp.	Lohari	<i>Crossocheilus latius</i>
Katle	<i>Neolissocheilus hexagonolepis</i>	Bhurluk	<i>Puntius</i> spp.
Thend	<i>Labeo angra</i>	Chuchche bam	<i>Xenentodon cancila</i>
Gardi	<i>Labeo dero</i>	Karange	<i>Puntius chilinoids</i>
Kulnch	<i>Labeo calbasu</i>	Buduna	<i>Garra gotyla</i>
Rajabam	<i>Anguilla bengalensis</i>	Bhitte	<i>Puntius sarana</i>
Rohu	<i>Labeo rohita</i>	Rewa	<i>Cirrhinus rewa</i>
Naini	<i>Cirrhinus mrigala</i>	Magur	<i>Clarias batrachus</i>
Bhakur	<i>Catla catla</i>	Baghi	<i>Botia almorhae</i>
Bhoti	<i>Channa gachua</i>	Faketa	<i>Barilius</i> sp
Hile	<i>Channa punctatus</i>	Tilapia	<i>Oreochromis nilotica</i>
Chelwa	<i>Clupisoma garua</i>	Silver carp	<i>Hypophthalmichthys molitrix</i>
Tengra	<i>Mystus seengala</i>	Bighead carp	<i>Aristichthys nobillis</i>

Fish smoking in a chamber: The drying chamber is a special device used to dry fish. The chamber is a multistory partitioned by mesh nets where fire wood produced the heat in lowest chamber, and then fish fillet or pieces placed above the fire. The fish are cleaned, split into two equal halves from back with sharp knife, and dried. It takes 6-18 hours depending upon the size and volume of fish in the chamber. This practice is used limitedly because of shortage of firewood.

Deep frying: Deep frying is a preferred method of preservation in highway corridor, Malekhu and Karnali Chisapani. Deep fried fish can be stored for a week or more. In Begnas lake, Phewa lake (Khapaudi), Modi river, Mardi river, Dolalghat, Malekhu, Karnali Chisapani fishes are deep fried. Fishes like bhitte, bhurluk, naini, rohu, kalanch and asala are the fish mostly used for deep frying. For deep frying, the fish is first split open, viscera is removed and washed properly. Then the fish is cut into cubes, marinated with salt and turmeric and fried in a frying pan.

Solar dryer: Traditional drying process consumes more firewood. However, the sun drying and smoking methods can be diverted towards the use of solar energy. Solar drying and its improved processes minimize or stop some of the limitations of open sun drying. Drying in solar dryer is different from open sun drying because the solar dryer is an enclosed structure that traps heat inside the drier and make effective use of the heat. Several solar dryer designs have been constructed and tested for different fish species (Ogbonnaya 2009 and Sachithanathan et al 1985). The potential advantages of solar drying techniques compared with sun drying are summarized earlier by Sachithanathan et al (1985). Due to the high temperature maintained in the dryer, drying time, insect infestation and microbial spoilage can be reduced considerably. Effect of two drying methods using smoking kiln and electric oven on the nutritional properties of tilapia fish (*Oreochromis niloticus*) and cat fish (*Clarias gariepinus*) were studied and reported high quality in electric oven dried fishes (Ogbonnaya 2009 and Ogbonnaya and Ibrahim 2009). Towards this direction considerable works have been carried out for development of solar driers in recent years in Nepal. In Pokhara valley, solar dryer is used to dry fish by some farmers. These solar dryer are available in market readymade.

Hybrid solar dryer: Solar dryer can be used only during sunny day and day time. To resolve this, a hybrid solar dryer is designed by Engineering Division of Nepal Agricultural Research Council (NARC) to undertake drying of perishable commodities even in the case when there is no solar radiation (in night time) or in the rainy days. The dryer uses fuel wood or agricultural residues such as corncob as a fuel along with the solar radiation. The dryer consists of fire chamber with a grate and gate for controlling the air inlet. There are 7 fuel gas pipes passing through the drying chamber to exchange heat. It also consists of the air inlet and exhaust chimney with valve connected to the chamber as in the case of normal solar dryer. It consists of 5 trays with steel nets to hold the products for drying.

Hybrid solar dryer can be operated by solar energy and wood fire. In the absence of solar energy wood can be used to dry the fish. There was no dust contamination and insect infestation in this method. It can be used at any time. A hybrid solar dryer was provided to the fish processor by NARDF project at Khapaudi, Pokhara of Kaski district.

Nutritional status of post harvest fish

Post-harvest losses in fish are represented by a net reduction in the amounts of nutrients potentially available to the consumer either by direct physical loss or nutritional loss. These factors have effect on consumer acceptability, commercial value and income of fish farmers/traders. Also, the health implication of consuming spoilt fish cannot be quantified. The short shelf-life of dead fish is due to

changes in the chemical constituents of fish after death. Smoking enhances flavor and increase utilization of the fish. Nonetheless, deterioration and spoilage still occur in smoked fish during storage. Proximate analysis (moisture, protein, fats, total ash and carbohydrate) was made to determine the nutritional status of fresh fish, hybrid solar dried fish, smoked dried fish and commercially fried flesh of naini (Pradhan et al 2012). Highest protein content ($58.3 \pm 2.6\%$) was found in commercially smoked dried fish while the least ($17.6 \pm 0.3\%$) was observed in fresh fish samples from the village fish pond (Table 4). Proximate composition of commercially dried and hybrid solar dryer dried fish were not significantly different ($P > 0.05$) but differed with fresh and commercially fried fish.

Table 4. Proximate composition (%) of fresh, commercially dried, commercially fried and experimentally dried fish in hybrid solar

Treatment	Moisture	Total ash	Total fat	Crude protein	Carbohydrate
Commercially dried fish	12.6 ± 3.0^a	12.5 ± 0.4^c	15.7 ± 0.3^b	58.4 ± 3^c	1.0 ± 0.4^a
Commercially fried fish	44 ± 0^b	6.1 ± 0.6^b	21.4 ± 4^c	22.53 ± 1^b	$6. \pm 3^b$
Fresh fish	78.4 ± 0.6^c	2.4 ± 0.3^a	0.4 ± 0.1^a	17.6 ± 0.3^a	1.3 ± 1.0^a
Hybrid solar dried fish	11.6 ± 0.8^a	13.3 ± 0.6^c	16.83 ± 0.4^b	57.5 ± 0.7^c	0.6 ± 0.1^a

Microbial load in fish

The quality of fresh fish depends on the characteristics and conditions, as well as factors such as hygiene and handling, during pre- and post-processing (from catch to on shore processing). Bacterial growth, enzyme activity, physical damage, dehydration, chemical reactions and contamination are the main causes of quality loss in fish. Food-spoilage and pathogenic organisms such as mold, *Coliform*, *E. coli*, *Staphylococcus*, *Salmonella* and total plate count (TPC) were screened in fresh fish, experimentally hybrid solar dried fish, smoked dried fish and commercially fried flesh of naini (Pradhan et al 2012). The analysis suggests that fresh fish from pond and commercially dried fish which is marketed in highway corridor are less hygienic at current state of drying since mold, *Coliform*, *E. coli*, *Staphylococcus* were detected at concentration above recommended norms (Table 5) (Pradhan et al 2012).

Table 5. Microbial load (cfu per gram) in raw, commercially dried, commercially fried and experimentally hybrid solar dried fish

Treatment	Mold	<i>Coliform</i>	<i>E. coli</i>	<i>Staphylococcus</i>	<i>Salmonella</i>	TPC
Commercially dried fish	2253 ± 3108^a	236.6 $\pm 225^b$	80 $\pm 138.5^a$	TNTC ^c	0.0 ^a	2506670 $\pm 496622^b$
Commercially fried fish	3.0 ± 6^a	0.0 ^a	0.0 ^a	1444 ± 1308^b	0.0 ^a	4200 ± 1539^a
Fresh fish	2611 ± 1230^a	$> 2400^c$	$> 2400^b$	TNTC ^c	11600^b	TNTC ^a
Hybrid solar dried fish	0.0 ^a	0.0 ^a	0.0 ^a	$62. \pm 9^a$	0.0 ^a	2615 ± 124^a
ICMSF, 1978	10000 cfu/g	None	< 10 cfu/g	< 100 cfu/g	Not to be detected	Not to exceed 1000,000 cfu/g

The International Commission on Microbiological Specifications for Foods (ICMSF 1982) indicated a limit of acceptability as less than 1.0×10^6 cfu/g for the total viable count in any food to be safe for consumption. Such counts were found in the commercially fried fish and experimentally hybrid solar dried fish. Except *Salmonella* the microbial loads in commercially dried fish are above the permissible level. Mould counts were 3.0 ± 6 cfu/g in commercially fried fish (Table 6), indicating the commercially fried fish met the specified standard requirement for safe food. While commercially dried fish exceeded the permissible standard. In fresh fish, all microbial loads were above the permissible level. Hence, these two items (fresh fish and commercially dried fish) were poor in terms

of microbial content. Indeed fish and other free-swimming aquatic animals do not usually carry those organisms generally considered to be typical of the mammalian microflora, including *E. coli*, the faecal *coliforms*. The presence of human enteric organisms on aquatic food products is clear evidence of contamination from a terrigenous source. Fish and shellfish products are a minor source of bacterial food borne disease in North America, the United Kingdom, and Australia (Todd 1978), but there is a continuing high relative incidence of bacterial food borne disease from fish products in Japan and probably in Southeast Asian countries where fish are commonly eaten raw or with little cooking (Sakazaki 1979). Raw or processed aquatic foods are in general excellent substrates for the growth of most common bacterial agents of food borne disease if held at improper temperatures. It is important therefore to avoid contamination of these foods during preparation and storage and to hold them at chill temperatures. *Coliforms* and *E. coli* were also not detected in the commercially fried and experimentally hybrid solar dried fish sample. ICMSF (1982) specified the levels of *E. coli* to be less than 1.0×10^1 cfu/g. The non-detection of these food poisoning organisms indicated that the fish was safe for consumption. *Salmonella* species were not detected in any samples (Table 7) except fresh fish. ICMSF (1982) stipulated levels of zero cfu/g of these organisms in the food to be considered safe for human consumption. The cured fish are liable to deteriorate during storage due to mould growth. Experimentally hybrid solar dried fish was properly handled and well treated with heat and it dried quickly and the end product was clean and hygienic.

Storage and post harvest loss of dried fish

Dried fish are stored differently at different places for example, in bamboo basket, paper box, mesh net, polythene bag, jute bag etc. For example, in Karnali Chisapani and Modi Khola, dried fish is stored in bamboo basket, wooden cupboard and hung over fireplace until sold. In Malekhu, the hoteliers hang the dried fish near the fire place by hanging in rope in air. Fish processing using sun drying and smoking, though less costly, result in losses of up to 30% (FAO 1992b) especially during the rainy season, which in Nepal is from June to October, when fish drying and smoking is difficult due to prolonged periods of cloud cover, high humidity (FAO 1992a) and continuous rains in some areas. A considerable amount of fish becomes spoiled due to rancidity, and microbial and insect attacks. However, the quality and nutritional value of dried and smoked fish is compromised if the fish is not stored properly. For example, water soluble vitamins found in fish may be lost due to heating which reduces the moisture (FAO 1992c). Processed fish sold locally fetches a low price (FAO 1992b), resulting in marginal profits to fish processors and traders.

There is a great chance of microbial attack, fungal development and insect infestation in whole smoked fish because the outer surface of fish dried earlier but the inner area remains moist. However, it will happen occasionally as there were less chance of post harvest loss of smoked fish because of high demand and less chance to remain the fish to be unsold. A study carried out by Pradhan et al (2012) to determine the microbial load in smoke dried fish at Karnali Chisapani (*L. calbasu* and *T. putitora*) showed presence of harmful microorganism such as mold, *Coliform*, *E. coli*, *Staphylococcus* and TPC (Table 6).

Table 6. Mold and bacterial level in smoked fish obtained from Karnali Chisapani and Malekhu, Dhading

Fish species	Mold/g	Coliform/g	Total plate count/g (cfu/ml)	<i>E. coli</i> /g (mpn value)	<i>Staphylococcus</i> spp.
<i>L. calbasu</i>	37×10^{10} TNTC ¹	-ve to 15	22.70×10^{610} TNTC*	-ve	TNTC
<i>T. putitora</i>	16×10^1 to 77×10^1	-ve to 240	24.56×10^3 to TNTC	-ve to 93	75×10^2 to TNTC
<i>C. mrigala</i>	-ve to 58.50×10^2	10 to 460	-ve	-ve to 240	TNTC

TNTC, too numerous to count; cfu, colony forming unit

The fungal problem is a common problem and it adversely affects the quality of cured fish. The presence of these fungi in smoked fishes is acquiring importance in view of safety and quality of fish. The total mold count was also high in all samples except in one sample of naini. The high mold count may be due to high moisture content and humidity. The existence of *Coliform* indicates that a product was processed under insufficient hygiene conditions (ICMSF 1978). The presence total plate count (TPC, bacterial number) might be due to environmental contamination during smoking. These results showed the low quality of smoked fish in Chisapani. Less than 10^4 - 10^6 cfu/g for the total number of total microorganisms that grow at 35-37°C and 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). *E. coli* is a well known recognized indicator for quality assurance of municipal water (Perry-O'Kefe et al 2001). *E. coli* is considered to be one of the most hazardous food borne pathogens. The highest count of TPC and *E. coli* in dried fish samples revealed the unhygienic conditions prevailed during the drying process. *Salmonella* spp. was not detected in all the six dried fish samples.

Proper handling of fish between capture and delivery to the consumer is a crucial element in assuring final product quality. Standards of sanitation, method of handling and the time/temperature of holding fish are all significant quality factors. With a few exceptions, fish are considered free of pathogenic bacteria of public health significance when first caught. The presence of bacteria harmful to human generally indicates poor sanitation in handling and processing and the contamination is almost always of human or animal origin. A survey of several types of processed food items including dried, smoked and steamed fish in the Philippines revealed a high incidence of *Staphylococcus aureus*, coliforms, *Salmonella* and yeasts and moulds. The occurrence of these pathogens was thought to have resulted from poor handling, processing, storage and distribution practices. During the rainy summer months (April to August), the temperature and relative humidity can be as high as 34°C and 92%, respectively. These climatic conditions favor microbial growth and enterotoxin production in local foodstuffs which could have been responsible for sporadic local outbreaks of food-borne disease.

Value-added fish products

Value addition is the need of the hour, to satisfy the ever changing and diverse demands from the importing countries as well as urban consumers at home. The technology up-gradation and value addition has resulted in adoption of modern technology in processing of several value-added products out of low cost fish and shell fish, which have both export and domestic markets. Some of the important value-added fish products are fried fish, fish sauce, fish curry, fish salads, fish pickles, dehydrated fish products, fish sausage, etc. Developing a suitable pack, to provide these products adequate protection and shelf-life as well as consumer appeal is an important task. There is need of studies in this field to identify and determine the most suitable packaging materials for these products.

CONSTRAINTS

Fishermen, local fish processors and fish traders (middle men) have little knowledge of fish quality, processing, preservation and handling. Landing sites are often remote, and it is not economic to provide the infrastructure needed to preserve fresh fish either on board or immediately on landing. Even when landing sites and roads exist, it is often not economic to transport the catch. This is compounded by poor road conditions and vehicles that are not designed for transportation of fresh fish. There is also a lack of fresh fish facilities and services such as availability of ice, refrigerators etc in the retail markets due to lack of electricity and inadequate ice production machines. As a result, fresh fish without ice is sold in areas closer to the lake and river. The conditions on most fishing boats are not conducive to fresh fish preservation, e.g., lack of ice and refrigeration on boats and poor and/or unclean fish handling materials such as boxes and shovel.

Several challenges have been reported (FAO 1992b). Use of local packaging materials such as bamboo baskets, plastic tray and Styrofoam compromise the quality of the fish during transportation. Market facilities also lack coolers and ice. The poor means of fish transportation ranging from use of *riksha*, *tanga* to unrefrigerated vehicles coupled with poor roads increases the rate of fish spoilage. When fish arrives at the markets, consumers buy irrespective of the condition. It is apparently due to the high demand for the product. Most consumers lack basic fresh fish sensory knowledge such as fresh fish flesh condition.

WAY FORWARD

There is a need to develop fisheries infrastructure and quality assurance by developing landing sites at potential areas, installation of ice plants and chilling room, construction of fish market stalls at different potential areas. A fish quality laboratory should be established to control the quality of fish for both the export and domestic markets. Improved containers, smokers and drying equipment are all needed, in a range of sizes suitable for the quantities of fish in particular places.

There should be capacity building initiatives program from public sector by organizing in-country training staff in the fisheries and study tours for fish farmers and technical staff. Research should focus on development of appropriate preservation technologies for fisher community of remote areas. Many fish by-products can be processed into pet food/animal feed products or for non-food products such as gelatin, leather and fertilizer. All of the solid waste from various cleaning operations or unused by-products should be disposed properly.

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Organic Agriculture in Coping Climate Change- A Review of Emerging Evidences

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ABSTRACT

This review paper attempts to bring together the contribution of organic agriculture to climate change. The paper also focuses on the utilization of local knowledge and traditional skills to adapt to the key consequences of climate change and further raising the issue for future development and research requirements. The research results from various parts of the globe on organic farming and its adaptation and mitigation potential against climate change transitions have been presented. The potential of organic farming, especially on adaptation and mitigation strategy for climate change has been discussed. It has been argued that organic farming has potential to reduce the green house gases, but there is a need for more researches to better understand the organic agriculture approach in climate change management and implementing strategies that addresses the emerging risks associated with climate change.

INTRODUCTION

Climate change is now emerging as a huge challenge in conservation and management of agriculture, biodiversity, ecosystem services, and natural resources throughout the world. It has a direct impact on agriculture production due to its climate dependent nature, more significantly in developing countries where agriculture is a source of income and employment for a larger population. However, agriculture is not only affected by climate change but also contributes to it. Conventional intensive agriculture practiced over the last century has been a major contributor to climate change, second only to energy sector (World Bank 2008). The land use changes caused by deforestations, overgrazing by animals and different practices leading to soil degradation are the major causes of green house gases (GHGs) emissions. According to the Intergovernmental Panel on Climate change (IPPC), the annual amount of GHGs emitted by the agriculture sector is estimated between 5.1 and 6.1 giga tones Co₂ equivalents in 2005 (Barker et al 2007). This represents approximately 10-12% of total GHGs emissions. The Nepalese GHGs emission from the agriculture sector is very low in comparison to global terms. However, there is greater challenge of responding to the impacts of climate change, especially when food security is another major issue. Like many other emerging economies Nepal is also developing its National Adaptation Plan of Action under the UN framework, but its implementation still has a long way to go. Therefore, a strategic agriculture approach should be adopted that seek to make the best use of local resources, which can be managed by the small holder farmers, ensure food security, sustainable livelihood and at the same time supported by government policies and programmes. The organic agricultural system successfully integrates all of it and is believed to be the most sustainable approach to climate change adaptation and mitigation.

In this paper an attempt has been made to bring the issue whether or not organic agriculture contributes to reduce GHG releases and sequester carbon? Furthermore, it also discusses the current issues related to organic farming, food security and climate change issue in the light of recent

developments at global and national level. Paper further discusses how important is traditional skills and knowledge for the management of the change and increasing climate resilience. The objective of the study is aimed at promoting understanding how organic agriculture practices are supportive for climate change management. It examines the importance of traditional skills and knowledge for adaptation to and mitigation of climate change. One modest purpose is also to initiate positive policy implications towards organic agriculture and identify research areas for future development.

METHODOLOGY

This study is based on the desk review and web search of the scientific literatures. A total of 30 published and online papers relevant to the subject matter were reviewed and analyzed. The research result and case studies from various parts of the globe on organic farming and its adaptation and mitigation potential against climate change transitions have been presented. It is not meant to be an exhaustive study, but include key recent findings in the backdrop of climate change.

RESULTS AND DISCUSSION

Elements of organic agriculture

Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. Organic production systems are based on specific standards precisely formulated for food production and aim at achieving agro-ecosystems, which are socially and ecologically sustainable. It is based on minimizing the use of external inputs through use of on-farm resources efficiently compared to industrial agriculture. Thus the use of synthetic fertilizers and pesticides is avoided. According to the codex alimentarius commission *"Organic Agriculture is a holistic production system that avoids the use of synthetic fertilizers, pesticides and genetically modified organism, minimizes pollution of air and water, and optimizes the health and productivity of interdependent communities of plants animals and people."* Organic agriculture is claimed to be one of the most sustainable approach in food production (Niggli et al 2008). One goal of organic agriculture is to reduce dependency of agriculture production on external inputs and provide environmental benefits. As stated in the 2002 report of the United Nations Food and Agriculture Organization (FAO), organic agriculture enables ecosystems to better adjust to the effects of climate change and has major potential for reducing agricultural greenhouse gas emissions. It has particular sequestration potential as it follows the key principle of tight nutrient and energy cycles through organic matter management in soil. Organic systems promote shifts in soil microbial functional diversity, with benefits in carbon utilization efficiency (Mader et al 2002). Positive effects of organic farming on soil carbon have been reported repeatedly (Scialabba and Lindenlauf 2010). Organic agriculture is a most resilient adaptation strategy to climate change (Sherief and Shreejith 2010) as it uses crop rotation, green manuring, compost, biological pest control and mechanical cultivation to maintain soil productivity and control for pest.

Organic agriculture: the historical perspective

Organic agriculture has a long tradition as a farming system and it has been adapted for many climate zones and local conditions. Organic farming also known as natural farming is originated from Asian countries where agriculture has been the mainstay of the people for their livelihoods and survival since generations (Reddy 2009). Organic agriculture is based upon traditional sustainable agriculture, farmers' innovations and the results of scientific research. Organic farming practices are embedded in local cultures and their ethical values and beliefs. Therefore, organic farming movements around the globe are diverse and colorful. In many developing countries, traditional sustainable agriculture has

been applied for centuries and still today provides a pool of locally adapted solutions for agriculture. Organic farming was and is constantly being developed by farmers, scientists and concerned people all over the world. A central element of the organic farming method is the efficient use of on-farm and local resources like farmyard manure, indirect crop protection and local seed. Therefore, organic agriculture is not just a solution for more well-off countries but applied in country like Nepal as well (Aryal et al 2009).

International Federation of Organic Agriculture Movement (IFOAM) was established in 1972 in France for the promotion of organic agriculture and its movement in the world. This organisation is dedicated mainly to disseminate the information on the principles and practices of organic agriculture across the world. Basically, IFOAM is an umbrella organisation for organic agriculture promotion in and around the globe.

The context of organic farming

Globally, organic agriculture is developing rapidly and currently at least 141 countries produce organic food commercially (Reddy 2009). Among the countries involved in the organic farming around 65% are developing countries. Organic food production is gaining wider recognition due to negative effects of chemical inputs in the health of mankind and environment. As per the estimation of its production in 2007, about 1.2 millions of producers growing organic production in around 32.2 million hectares of land (Reddy 2009). In a succeeding year, the area under organic farming has increased by almost 1.5 million hectares. When compared with the regions of highest growing areas, the largest areas of organically managed agriculture land are Oceania, Europe and Latin America. When it comes in country-wise Australia, Argentina and Brazil have the largest organically managed land areas. When it comes to developing countries about 11 million hectares i.e., one third of world's organically managed land is located in these countries (Willer and Klicher 2009).

In Nepal, organic farming is not a new concept and practice of agriculture. From the ancient times farmers are exercising niche-based integrated farming making the best use of the diverse local resources (plants and animals) to fulfill their basic needs of food, fiber and shelters. Nepal has a history of about 50 years of chemical fertilizers and pesticides use aiming at higher agricultural production. Until then, Nepalese farmers did not know any chemicals in agriculture and the farming systems were completely organic. Successful introduction of green revolution in South Asia made Nepal to follow it and the use of agrochemicals became pervasive. The immense use of chemical fertilizers and pesticides has been the usual practice of modern farming in most of the countries in the world for increasing agricultural production and Nepal is no exception. This practice has also been a compulsion for us to increase the production and feed our ever increasing population. However, though this seems to solve the current problem of low production to some extent, it has proven that it does not bode well for the future with the point of view of the health of human being, natural resources and of the whole eco-system.

Organic farming is gaining wider recognition in Nepal day by day due to its high demand of organic products (Aryal 2008). Despite growing demands for organic products both in national and international markets, organic agriculture face numerous challenges associated with lack of awareness, poor product marketing mechanism, inadequate technical services, unavailability of quality inputs and inadequate policy support (Aryal et al 2009). The endorsement of the national policy guidelines on organic agriculture by the Ministry of Agriculture and Cooperatives (MoAC) has broadened the scope of organic agriculture in Nepal (Pokhrel et al 2008). However, the emphasis on development and/or promotion of organic agriculture at the programme level looks shy. There is virtual lack of government support to the organic growers and marketers and vacuity of policy.

Farmers in various parts of Nepal now are aware of the negative impacts of modern agriculture (Bhusal 2005), and are developing/practicing organic agriculture independently in different parts of the country to carry both ecology and economy together (Adhikari 2005). Though it may take a while to embrace the organic farming and make it popular among the farmers because of technological and policy constraints, among others, we must surely move in the direction of its promotion and wider adoption. The move has slowly begun with some innovative farmers opting organic farming as a profitable enterprise, as encouraged by the market in the vicinity of the big cities, and with I/NGOs who have taken it as a means of food security among the marginal farmers in the rural areas. Similarly, in recent years, organic agriculture has received due attention in most of the academic and developmental forum in the country. Political commitments such as avoiding conflicting drive to maximize production, hammering proactive policy, providing market incentives and institutionalization of Nepalese organic movement are imperative to further enhance organic sector in Nepal (Bhatta et al 2008).

Organic agriculture, food security and climate change

Worldwide a common question asked these days is can organic agriculture is able to fulfill the food requirement of the global people? Here, most often the common question raised by the people is about its yield (Trewavas 2004). To answer this question, one may ask, is the modern agriculture successfully feeding the world's population at present? What we can argue here is that since even the high-input conventional agriculture systems have also failed to feed the growing population, why then not to move towards eco-friendly agriculture farming. In this context, the agriculture approach that comprises of highly diversified farming practices and thus increases the diversity of income sources and at the same time has the flexibility to cope with the adverse impacts of climate change and variability such as changed rainfall patterns can be organic agriculture.

The various literatures showed that the potential of organic farming to produce enough food to feed the world's current population, despite the limited research and development has received attention over the last 60 years. Examples include studies like (Badgley et al 2007), which, while limited in scope, did indicate that organic agriculture has the potential to contribute "substantially to the global food supply. Studies done by (Halberg et al 2007), which deal with additional concerns other than simple yield comparisons, are also useful in pointing out the failure of food distribution under the current system and note the environmental sustainability problems of non-organic farming compared to organic systems. Current evidences suggests that it is possible to massively cut the amount of chemical inputs used worldwide right now without a drop in food availability, through low-input farming methods that use organic techniques.

One of the concerns in climate change and food systems is to enhance adaptive capacity of systems and people. Folke et al (2003) proposed four dimensions to enhance adaptive capacity in relation to climate change and they are also pertinent to food systems. So, it is highly imperative to adjust our food systems policies and practices to 'learning to live' in the changing context of uncertainty and change; create diversity within food systems; and also use our own knowledge and knowledge systems to address unprecedented rising food insecurity situations. Enhancing capacity of people through knowledge, technology transfer and appropriate safety net mechanisms, besides other, are vital hence these need to be well reflected in our national and local agricultural plans and program.

Organic agriculture as an adaptation and mitigation strategy

It is very much clear that the agricultural sector is highly impacted by climate change. Various researches indicate that current agricultural activities are a significant source of GHGs that aggravate climate disruption. To cope with such condition it is important to look for the adaptation and mitigation potential of the farming system. Sustainable and organic agricultural systems can help reduce agricultural GHG emissions through energy conservation, lower levels of carbon-based inputs,

lower use of synthetic fertilizers and other features that minimize GHG emissions and sequester carbon in the soil.

Here, we need to know what is adaptation and mitigation. To simply understand it, adaptation is mainly about warning people about certain events in advance and preparing them to deal with vulnerability and uncertainty. Effective predictability, awareness, provision of certain support systems and better planning are some of important things to consider in local preparedness for reducing vulnerability and enhancing resilience (Chaudhary and Aryal 2009). Some of the adaptation strategies that farmers across the region are selection of certain technologies over others such as small hydropower, drought tolerant crop varieties, mixed cropping, sloping agriculture land technology (SALT).

On the other hand, mitigation refers to efforts to reduce or prevent emission of GHGs. It can be by introducing new technologies and renewable energies, changing management practices. Examples include better agricultural technologies, including introduction of drought tolerant (water- stress) cultivars that perform well in low external input (chemical fertilizer, pesticides).

A large proportion of the mitigation potential of agriculture (excluding bio-energy) arises from soil carbon sequestration, which has strong synergies with sustainable agriculture and generally reduces vulnerability to climate change (IPCC 2007). Scientists have recently shown that with improved management practices, carbon stocks in the soil that are traditionally lost through land cultivation can be restored, thus removing CO₂ from the atmosphere. Optimizing agricultural management for accumulation of soil organic carbon (SOC) can result in the sequestration of atmospheric CO₂ thereby partially mitigating the current increase in atmospheric CO₂ (IPCC 2005, Sampson and Scholes 2000). There are various interesting research findings coming from the long research on organic matter in Switzerland. The study carried out by Fliebach et al (2006) shows that the organic farming with composted manure is the only agricultural practice that limits the decrease of carbon content in the soil. They have done 21 year long experiment on this and the result was that the soil organic nitrogen and carbon content are 5% to 12% higher at normal manure intensity (i.e., 1.4 livestock units/ha) compared to reduced intensity (0.7 livestock units/ha). Compared to no manure use, the organic carbon content in soil is 26% higher under normal manure use in organic farming. In addition, organic matter content is up to 12% higher under composted farmyard manure use compared to rotted and stacked manure

The Rodale Institute's farming systems trial, to compare the carbon sequestration ability of organic and conventional systems is one of the longest running studies that took 27 years to find that organic systems showed an increase of almost 30% in soil carbon while the conventional system showed no significant increase in soil carbon. Agriculture is the main emitter of nitrous oxides and methane according to current practice and knowledge. Between 1960 and 2000, while agricultural productivity increased substantially with increased utilization of fertilizers, the global efficiency of nitrogen use for cereal production decreased from 80 to 30%, while the risk of nitrogen emissions increased (Erisman et al 2008). According to IPCC, 1.6% of nitrogen fertilizer applied is emitted as nitrous oxide. An important potential contribution of organically managed systems is the careful management of nutrients, and hence the reduction of N₂O emissions from soils, which are the most relevant single source of direct GHG emissions from agriculture (Scialabba and Lindenlauf 2010). In organic agriculture, the ban of mineral nitrogen and the reduced livestock units per hectare considerably reduce the concentration of easily available mineral nitrogen in soils and thus N₂O emissions (Niggli et al 2008). The findings of the year long research on emission rates in organic versus conventional farming by Petersen et al (2006) in five European countries on N₂O emission shows that the emission rates of N₂O was found reduced in organic farm compared with conventional.

To conclude this section additional research is needed to verify on the current research findings as well as we need to put efforts in improving carbon sink and reduction of carbon emission (mitigation). As well as ability to cope with climate change or deal with vulnerability and uncertainty needs to be strengthened (adaptation).

How important is the local knowledge in climate change adaptation?

Climate change is a global phenomenon as it is widespread throughout the world, but it is taking place locally. Scientists have in past failed to keep their eyes in every corner to observe changes occurring at local level (Chaudhary and Aryal 2009). As a result, we lack historical data on climate change, particularly for developing countries. On the contrary, local people perceive changes occurring in their locality, neighboring regions, farms and forests. They are knowledgeable about changes occurring in their localities because they have lived long enough to discern local climate and its effects; and they plan their activities accordingly to changes in local weather and climate.

We can validate scientific findings by comparing them with local knowledge and practices. We can also test theories and hypotheses by examining concurrence between scientific and local knowledge. Besides, local knowledge can be combined with scientific knowledge to understand change and make strategies in climate change adaptation and mitigation. Local knowledge thus can play complementary, supplementary and surrogate role to scientific knowledge in understanding climate change and planning for adaptation and mitigation. Local people at various parts of Nepal are practicing their local management system to adapt with the changing climate. Some of the examples like mulching helps increase soil moisture for those farming vegetables, and bio-fertilizers and bio-pesticides help improve soil fertility. Fodder trees planted on grasslands help tackle the invasion of new grass species, and growing potatoes in rows requires less water helping farmers to cope with drought. Farmers in the Gorkha and Tanahun districts are developing modified hedgerows in their slopping lands to reduce the soil erosion as well as retain the nutrients into soil for the fertility management.

As climate change will disproportionately affect the most vulnerable, its adaptation has become a key issue for many developing countries. The farming community therefore will need to adapt their practices to deal with changing temperatures and more frequent extreme weather events.

Can organic agriculture reduce the carbon emission?

Organic agriculture has significant potential to reduce carbon dioxide emissions. The research on carbon deposition on soil shows that about 20% increase in soil organic matter due to organic agriculture results in deposition of an estimated amount of 9 ton carbon/ha, which is in line with the results over a 15-year period (Drinkwater et al 1998). Furthermore, the study carried out by Smith et al (1997) calculated a considerable potential increase of soil carbon when manure, straw-recycling, minimal tillage, reforestation and energy-saving plant production are combined.

Soil carbon sequestration is enhanced through agricultural management practices (such as increased application of organic manures, use of intercrops and green manures, higher shares of perennial grasslands and trees or hedges, etc.), which promote greater soil organic matter (and thus soil organic carbon) content and improve soil structure (Niggli et al 2008).

CONCLUSION

The review of literatures has shown that organic agriculture could contribute significantly to reduce the GHG releases and to sequester carbon in soils and biomass. Furthermore, various researches and studies provide sufficient evidences on how communities have been using traditional knowledge,

practices and technologies to cope with adverse climatic stresses. Adaptation and coping mechanisms include conservation and sustainable use of local genetic resources, changing the cropping system and crop species, use of different soil and water conservation methods such as mulching, drip irrigation and cover cropping etc. As opposed to the focus of conservation agriculture on a single technology, organic agriculture follows a site-specific and systematic approach that includes a comprehensive set of integrated technologies. Organic agriculture has been neglected in many governments agricultural and natural resources management policies and therefore there is less government assistance for the promotion of this sector. Besides, there is a need for more researches to better understand the organic agriculture approach in climate change management and implementing strategies that addresses the emerging risks associated with climate change.

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Response of Organic Fertilizers for Potato Production in the Hills of Nepal

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ABSTRACT

The field experiment was conducted during the summer season of 2008/09 at Lakuri Bhanjyang in Lalitpur district and 2009/10 and 2010/11 at Muralikhola (1400 masl) in Kavre district to investigate the response of organic fertilizers on different varieties potato. The experiment was planted at four farmers' fields as four replications in RCB design. The treatment combinations were: three organic fertilizers (Biozyme, Nitrobenzene and Kwian Thong) and three potato varieties (Kufri Jyoti, Janakdev and Khumal Seto-1) along with the farmers' variety and fertilizer practices. The crop was planted in 3 m × 2 m plot size at a spacing of 60 and 25 cm. Farm yard manure at the rate of 10 tones/ha was applied in each treatment before planting. As per the treatments, half doses of Nitrobenzene at the rate of 50 kg/ha, Biozyme 20 kg/ha and Kwian Thong 150 kg/ha were applied as basal doses and remaining half doses were top-dressed at the time of first earthing up along with FYM. The pooled analysis of three years' data revealed that there was a significant difference among the treatments on potato yield. The highest mean tuber yield (19.26 t/ha) was recorded on the combination of potato variety Janakdev and organic fertilizers Kwian Thong and it was found at par with variety Kufri Jyoti and Kwian Thong (16.62 t/ha); whereas the lowest tuber yield (10.08 t/ha) was recorded on variety Kufri Jyoti and Nitrobenzene and it was at par with 10 t/ha compost and farmers' variety. The mean economic analysis over years showed that there was an extra income of NRs. 143,100÷ha (US\$ 1,789/ha) on combination of potato variety Janakdev with Kwian Thong organic fertilizer followed by NRs 84,240÷ha (US\$ 1,053/ha) on combination of potato variety Kufri Jyoti and Kwian Thong. But the combination of potato varieties Kufri Jyoti and Khumal Seto-1 with Nitrobenzene showed the loss of NRs. 22,460÷ha (US\$ 281/ha) and 19,460÷ha (US\$ 243/ha), respectively over the farmers' variety and fertilizer practices.

INTRODUCTION

The intensification of agriculture with increasing use of pesticides and agro-chemicals has resulted in several problems like, pest resistance to pesticides, pesticide residues in soil, water and foods, reduction in natural enemies of pest and ultimately degradation of soil environment and ecosystem. The use of agro-chemicals (fertilizers, insecticides and pesticides) is very high in commercial potato production areas. Realizing these facts, some of the researches were initiated for sustainable potato production with the use of organic measures. Organic potato production is a production system that avoids or largely excludes the use of synthetic fertilizers, pesticides and growth regulators. This system sustains the health of soils, ecosystems and people. It combines both traditional and improved technology to conserve natural resources and promote good relationships on natural resources and quality of life. The basic requirements for organic production are: a) the environment should not be polluted (water, air and arable lands), b) no synthetic materials should be used during the production; c) pollution is avoided during storage, processing, transportation, and distribution; and e) there should be system of supervision and certification of organic products by government agencies.

The present scenario on global organic research and farming is encouraging in the world. However, there is limited research and production of organic products in Nepal. It is due to the limited awareness of organic farming both in consumers and producers, lack of marketing and infrastructure and inability to capture marketing economies. The production cost of organic products is higher and yield is lower than inorganic production system. It is reported that the cost of organic foods is about 30 percent higher than that of the common food in developed countries (Xie 2008). The local market for organic food is increasing by 20 to 30 percent every year.

The world organic market, estimated over US\$ 52 billion with compounded growth of 23% per annum (Newa 2011). The total Indian organic farming industry was estimated at around US\$ 20 million in 2002. Although, there is no authentic data compiled yet in Nepal, assumption is worth at least of US\$ 7 million (NRs. 520,000,000.00) per annum including export. Till now, only 10,000 ha land is certified for organic production in Nepal. There is high demand of organic product for export and within country due to increased awareness of consumers about organic products. Newa (2011) reported that at present 25 companies and 16 cooperatives are actively involved in organic business in Nepal. He further reported that about 13,500 families require organic foods in Katmandu i.e., 180 tones/day. For the production of organic potato in India, bio-fertilizers, Azotobactor and Arbuscular mycorrhizal fungi are used to improve soil and productivity of potato (Vignes et al 2005). Among the bio-pesticides, Asuro, Khirro, Sisnu, Bakaino, Banmara etc. are valuable botanicals, which can be used for managing pests and diseases in Nepal (Ranabhat and G.C. 2003). Neem oil contains high amount of pesticidal compounds and can be used to treat the seeds of various crops (at 2-5 ml/kg of seeds) (Neupane 2003). However, uses of many organic fertilizers and their quantity have not been tested so far. Similarly, there is no fully recommended technology, policy and certified agencies for organic certification, also. Considering these facts, this research was conducted in Latitpur and Kavre districts during the years 2008/09 to 2010/11 to identify the suitable varieties of potato and organic fertilizers for organic potato production.

MATERIALS AND METHODS

The field experiment was conducted during summer season of 2008/09 at Lakuri Bhanjyang in Lalitpur district and during 2009/10 - 2010/11 at Muralikhola (1400 masl) in Kavre district. Three potato varieties namely 'Kufri Jyoti', 'Janakdev' and 'Khumal Seto-1' along with three non-chemical fertilizers namely Biozyme, Nitrobenzene (Indian products) and Kwian Thong (Thailand product) were used in the study (Table 1). The Kufri Jyoti and Khumal Seto-1, white colored varieties, along with Janakdev, a red colored one, were used in the trials. The 'Nitrobenzene' contained 15 percent nitrogen while Biozyme was a mixture of several elements and Kwian Thong, contain NPK and other several micronutrients. The 'Kwian Thong' also contained two bacteria (*Lactobacillus* and *Bacillus subtilis*) which were active for fertilizer decomposition.

All together there were ten treatments constituted with three varieties of potato, three types of fertilizers and an additional treatment of farmer's variety and farm yard manure combination as a check. The experiment was laid out in randomized complete block design with four replications. The individual experimental plots of 3 m × 2 m size were planted with five rows of potato at 60 and 25 cm row and plant spacing, respectively. Farm yard manure at the rate of 10 tones/ha was well mixed in each plot before planting. Along with FYM the half dose of Nitrobenzene at the rate of 50 kg/ha, Biozyme 20 kg/ha and Kwian Thong 150 kg/ha was applied as a basal dose based on the treatments. The remaining half doses were top-dressed at the time of first earthing-up. Observations were recorded on growth and yield parameters. Analyses of variance were computed to determine significance among treatments using Genstat and MSTATC was used for mean separation.

Table 1. Description of treatment combinations

Treatment No.	Variety	Non-chemical fertilizers
1	Kufri Jyoti	Nitrobenzene @ 100 kg/ha
2	Kufri Jyoti	Biozyme @ 40 kg/ha
3	Kufri Jyoti	Kwian Thong @ 300kg/ha
4	Janakdev	Nitrobenzene @ 100 kg/ha
5	Janakdev	Biozyme @ 40 kg/ha
6	Janakdev	Kwian Thong @ 300kg/ha
7	Khumal Seto-1	Nitrobenzene @ 100 kg/ha
8	Khumal Seto-1	Biozyme @ 40 kg/ha
9	Khumal Seto-1	Kwian Thong @ 300kg/ha
10	Farmers Variety	Farmer's practice (FYM @ 10t/ha)

RESULTS AND DISCUSSION

Plant height

There was significant difference among the treatments on plant height at 75 days after planting in all 3 years. The highest plant height (28.3 cm, 54.6 cm and 31.0 cm) was recorded on the combination of variety Janakdev and organic fertilizer Kwian Thong, in 2008/09, 2009/10 and 2010/11, respectively. However, their pooled analysis did not show any significant differences on plant height at 75 days after planting. This could be due to the great variation of plant height in different years; it might be due to the climatic conditions. The detail effect of combination of varieties and organic fertilizers on plant height in different years and pooled analysis data is presented in Table 2.

Table 2. Effect of organic fertilizers and varieties on plant height at 75 days after planting at Lalitpur and Kavre districts, 2008/09 - 2010/11

Treatment combinations	2008/9	2009/10	2010/11	Mean
Kufri Jyoti + Nitrobenze	24.00ab	25.0b	26.3ab	25.1
Kufri Jyoti + Biozyme	24.3 ab	22.3b	27.0ab	24.5
Kufri Jyoti + Kwian Thong	24.8 ab	22.9b	26.8ab	24.8
Janakdev + Nitrobenze	23.5ab	56.00a	25.8b	35.1
Janakdev + Biozyme	25.5ab	49.9a	27.5ab	34.3
Janakdev + Kwian Thong	28.3a	54.6a	31.0a	38.0
Khumal Seto 1 + Nitrobenze	28.0 a	23.1b	24.5b	25.2
Khumal Seto 1 + Biozyme	17.5 c	24.4b	23.8b	21.9
Khumal Seto 1 + Kwian Thong	22.0 bc	22.8b	25.5b	23.4
Farmers' variety + FYM	23.5 ab	24.4b	24.0b	24.0
F-test	*	**	*	ns
LSD (0.05)	5.565	6.352	3.933	-
CV (%)	15.9	13.5	10.3	28.7

*, significant; **, highly significant; ns, not significant

Ground coverage percentage

There was a insignificant difference among the treatments on ground coverage percentage at 75 days after planting in all the years. The ground cover percentage was found more or less similar in first and second years but found very high in third years. It may be due to planting of more sprouted tubers and good rain fall in the third years (Table 3). These data indicated that planting distance need to be tested for organic potato production, since the recommended distance with chemicals fertilizers may not be appropriate with organic potato production under such soil and climatic conditions.

Table 3. Effect of organic fertilizers and varieties on ground cover percentage at 75 days after planting at Lalitpur and Kavre districts, 2008/09- 2010/11

Treatment combinations	Ground coverage (%; days after planting)			
	2008/9	2009/10	2010/11	Mean
Kufri Jyoti + Nitrobenze	53.7	53.7	71.2	59.5
Kufri Jyoti + Biozyme	55.0	55.0	68.7	59.6
Kufri Jyoti + Kwian Thong	55.2	55.2	72.5	61.0
Janakdev + Nitrobenze	57.5	57.5	65.0	60.0
Janakdev + Biozyme	58.7	58.7	70.0	62.5
Janakdev + Kwian Thong	57.5	57.5	53.7	56.2
Khumal Seto 1 + Nitrobenze	55.0	55.0	71.2	60.4
Khumal Seto 1 + Biozyme	53.7	53.7	72.5	60.0
Khumal Seto 1 + Kwian Thong	50.0	50.0	75.0	58.3
Farmers' variety + FYM	43.7	43.7	70.0	52.5
F-test	ns	ns	ns	ns
LSD (0.05)	-	-	-	-
CV (%)	13.4	13.4	14.5	8.5

ns, not significant

Tuber yield

There was a significant difference among treatments on tuber yield of potato in different years and combined analysis over the years. In the first year, the highest tuber yield (17.71 t/ha) was recorded on combination of Kufri Jyoti variety with Kwian Thong organic fertilizer followed by combination of Janakdev with Kwian Thong fertilizers (17.21 t/ha). In 2009/10 and 2010/11, the highest tuber yield (23.83 t/ha and 16.75 t/ha) was recorded on combination of Janakdev with Kwian Thong fertilizer, respectively. In the first year, the lowest tuber yield (8.9 t/ha) was recorded on the treatment having Kufri Jyoti and Nitrobenzene fertilizer and it was found at par with farmers practices (Farmers' variety + FYM @ 10t/ha). In the second and third years and combined analysis, the lowest tuber yield (11.93 t/ha, 8.85 t/ha and 10.11 t/ha) was recorded on farmers' practices (Table 4). Based on three years' record, Kwian Thong organic fertilizer was found effective in increasing the production of potato. The increased in production due to application of Kwian Thong organic fertilizers could be due to present of major and minor nutrients. Asia Agro Tech Co. LTD reported that Kwian Thong contain 1-3% N, 1-2% P₂O₅, 1.3-3% K₂O, 7.4% Ca, 4.09% Mg, 1.03% Fe, 0.003% Cu, 0.05% Mn, 0.0075% Zn, 0.0035% B, 0.06% Mo, 1.88% S, 10-15% OM, 0.18% humic acid and 0.17% Na. The analysis report of Soil Management Directorate of MOAC reported that Kwian Thong organic fertilizer contains 1.02% nitrogen, 4% phosphorus, 0.32% potash, 145.7 ppm zinc, 1670.9 ppm manganese, 47.6 ppm copper and 162.5 ppm boron. The increment in production due to application of Kwian Thong was reported on rice and wheat in Kathmandu, Bhaktapur and many other places.

Economic analysis

The economic analysis showed that the application of Biozyme and Kwian Thong was found effective than farmers' practices, while the application of Nitrobenzene showed negative result for benefit. Based on 3 years' pooled result, the maximum total extra benefit NRs. 7155/ropani was recorded by using Janakdev variety and Kwian Thong organic fertilizer @ 15 kg/ropani and it was followed by NRs. 4212/ropani with combination of Kufri Jyoti and Kwian (Table 5).

Table 4. Effect of organic fertilizers and varieties on tuber yields of potato at Lalitpur and Kavre districts, 2008/09 - 2010/11

Treatment combinations	2008/9	2009/10	2010/11	Mean
Kufri Jyoti + Nitrobenze	8.9d	13.26de	11.04cd	11.08d
Kufri Jyoti + Biozyme	11.88bcd	18.79b	9.66cd	13.44bcd
Kufri Jyoti + Kwian Thong	17.71a	19.94b	12.22bc	16.62ab
Janakdev + Nitrobenze	11.67cd	11.56e	14.79ab	12.67cd
Janakdev + Biozyme	11.63cd	13.56de	12.59bc	12.59cd
Janakdev + Kwian Thong	17.21ab	23.83a	16.75a	19.26a
Khumal Seto 1 + Nitrobenze	10.94cd	12.16e	10.73cd	11.28d
Khumal Seto 1 + Biozyme	11.17cd	15.33cd	12.21bc	12.90bcd
Khumal Seto 1 + Kwian Thong	15.48abc	17.71bc	12.74bc	15.31bc
Farmers' variety+FYM	9.54d	11.93e	8.85d	10.11d
F-test	*	**	**	**
LSD (0.05)	5.538	2.799	2.991	3.513
CV (%)	30.2	12.2	16.9	15.1

*, significant; **, highly significant

Table 5. Economic analysis of variety and fertilizer trial of potato at Lalitpur and Kavre districts, 2008/09 - 2010/11

Treatment Combination	Yield (t/ha.)*	Total profit (NRs./ha)	Extra organic fertilizer (kg/ha) +	Extra org. fert. cost (NRs/ha)	Extra total cost (Fert. + labors)	Total profit (NRs/ha)	Economic benefit over farmers practices (NRs/ha)
Kufri Jyoti + Nitrobenzene	11.08	166200	100	35000	37000	129,200	-22,460
Kufri Jyoti + Biozyme	13.44	1201600	40	2000	4000	197,600	45,940
Kuf Jyoti + Kwian Thong	16.62	249300	300	11200	13400	235,900	84,240
Janakdev + Nitrobenzene	12.68	202720	100	3500	37000	165,720	14,060
Janakdev + Biozyme	12.60	200240	40	2000	4000	196,240	44,600
Janakdev + Kwian Thong	19.26	308160	300	11200	13400	294,760	143,100
Khu.Seto 1 +Nitrobenzene	11.28	169200	100	35000	37000	132,200	-19,460
Khumal Seto 1 + Biozyme	12.90	193500	40	2000	4000	189,500	37,840
Kh. Seto 1 + Kwian Thong	15.38	230860	300	11200	13400	217,460	65,800
Farmers' variety + FYM	10.10	157660	-	-	-	151,660	-

*, Price of Potato /kg: Rs 15 for white and Rs. 16 for red potato; +, price of organic fertilizers/kg = Rs. 350 for Nitrobenzene, Rs. 50 for Biozyme and Rs. 38 for Kwian Thong

The combination of variety 'Janakdev' and 'Kwian Thong' (non-chemical fertilizer) increased the yield up to 90.5% more than the farmers' practices (farmers' variety and farmers fertilizes practices, i.e., application of 10 tones FYM/ha) under Lakuri Bhanjyang, Lalitpur and Muralikhola, Kavre conditions during the summer season planting. In economic term, the combination of Janakdev potato variety with 300 kg Kwian Thong/ha gave extra income of NRs.143,100 (US\$ 1,789) followed by the combination of Kufri Jyoti variety with 300 kg Kwian Thong NRs. 84,240/ha (US\$ 1,053). Up-scaling and dissemination of this technology is recommended in the hills of Nepal.

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Locally Made Bio-pesticides Use in the Mid Hills of Nepal - A Case Study of Baglung District

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ABSTRACT

An attempt was made to explore the status of using locally made bio-pesticides to manage insect pests in crops in three Village Development Committees (VDCs), Hatiya, Amalachur and Amarbhumi, of Baglung district in Nepal from July to September 2010. A total of randomly selected 75 farmers, comprising of 25 households from each VDC, were purposively interviewed using questionnaires. Informal group discussion, expert interview and field observation were also conducted to collect necessary information. Survey results showed that crop pests were the main problem of crop production as expressed by about 53% respondents. Aphids (*Brevicoryne brassicae*) and cabbage butterflies (*Pieris* spp.) in cauliflower and tomato fruit worm (*Helicoverpa armigera*) and white fly (*Bemisia tabaci*) in tomato were considered to be major insect pests in the area. Use of home-made bio-pesticides (*Gitimal*) was very common in vegetable crops as expressed by 88% of the respondents. The farmers are using different forms of botanical products to control the pests. The commonly used botanicals in crude form against the storage insect pests were *Zanthoxylum alatum*, *Artemisia vulgaris*, *Justicia adhatoda* and *Acorus calamus* as expressed by about 21% of the farmers. Wood ash and mustard oil were also used by some farmers. Majority of the respondents (93%) reported that the use of botanicals having pest killing properties such as *J. adhatoda*, *A. vulgaris*, *E. adenophorum* is becoming a common practice as they are easily available locally, their preparation is simple, and they are less harmful to human health and environment. The dose, frequency and application methods of using such botanical products against crop pests are to be studied scientifically.

INTRODUCTION

Huge quantity of chemical pesticides are being used by commercial farmers near by road and market centres to manage insect pests on crops. Due to pesticide exposure, farmers are having health-related problems such as headache, dizziness, muscular twitching, skin irritation, respiratory discomfort etc (Dung and Dung 1999, Murphy et al 1999, Yassin et al 2002, Maumbe and Swinton 2003). More than 13 acute systems related to use of chemical pesticides have been reported in the major vegetable growing areas in the mid hills of Nepal (Atreya 2005). The regular and indiscriminate application of chemical pesticides in agriculture has not only led to the development of pesticide resistant strains of insects, but also the presence of toxic residue on food grains creating problems on human health and environment. Farmers have preference for highly toxic insecticides with broad spectrum activity, which result in immediate kill of pests (Neupane 1995). Farmers are abusing chemical pesticide in commercial vegetable production (Palikhe 2002).

Botanical pesticides have low toxicity as compared to the chemical pesticides. It is growing and gaining the farmer's interest to use as an alternative to minimize the use of chemical pesticides. Locally available plants with pesticidal properties, animal urine and ash are commonly used as home made bio-pesticides. Plants suitable for botanical pesticide can easily be grown with minimal cost or free of cost. Botanical pesticide can be prepared in household level using locally available plants and

their extracts. Farmers have been applying such traditional technologies for pest management since long time. Bio-pesticides are less toxic to human health and have no detrimental negative side effects.

Globally, 2,400 plant species have been reported to be toxic and pesticidal properties, among them 324 plant species are found in Nepal. Of the 24,00 toxic plant species, 41 plant species are known to have high level of toxic elements, and among them 23 plants species are found in Nepal (Neupane 2005). So, Nepal posses high prospect of using home made bio-pesticides. But the knowledge regarding types of botanical pesticides, their mode of actions and the application techniques are lacking which are essential for their promotion and management. So this study was conducted with the objective to find out major pests of tomato and cauliflower production and the use of locally made biopesticides to manage them.

MATERIALS AND METHODS

This study was carried out in three Village Development Committees (VDCs), Hatiya, Narethanti and Amarbhumi, of Baglung district of Nepal. These VDCs were potential for commercial and semi-commercial vegetable production. The survey was conducted from July to September 2010. In total, 75 households, 25 households from each VDC, were propoosively selected for the survey. The farmers were interviewed by using pre-tested questionnaires. The informal secondary data were collected from different published and unpublished literatures, reports and web pages. In addition, group discussion as well as field observations were also done to get more insight information.

RESULTS AND DISCUSSION

About 88% of the respondents were involved in cauliflower production. They reported that aphids (*Brevicoryne brassicae*) and cabbage butterflies (*Pieris* spp.) were the major insect pests of cauliflower, and tomato fruit worm (*Helicoverpa armigera*), white fly (*Bemisia tabaci*), root knot nematodes (*Meloidogyne* spp.), and white grubs are the major pests of tomato. Among them, *H. armigera*, *B. tabaci* and *Meloidogyne* spp. were the most damaging pests in tomato and *B. brassicae* in cauliflower. Anonymous (1999) and Sachan and Gangwar (1990) also considered *B. brassicae* as the most important pest of crucifer family and had mentioned *H. armigera* as an economically important pest of tomato. Burgess et al (2002) also explained *B. tabaci* and *Meloidogyne* spp. causes serious damage in tomato production. *B. tabaci* is also the major pest under greenhouse production of tomato, pepper, beans, eggplant and cucumber (Cock 1986).

Farmers were found using all kinds of available pest management methods such as cultural, mechanical, chemical, biological, botanical and others to reduce damage from crop pests. *Gitimal*, cattle urine, ash, kerosene, tobacco, chilli, *sisnoo* and soap were the common ones used by the farmers. Almost all farmers (96% of respondents) were using home-made bio-pesticides in managing insect pests and diseases of vegetable crops. Of biopesticides, *Gitimal* was popular among the farmers in survey sites. Panthi et al (2008) and Mandal (2008) had also mentioned that farmers prefer *Gitimal*. According to Panthi et al (2008) *Gitimal* has allomones compound in the mixture which helps to manage crop pests.

Gitimal is prepared by fermentation of the plant materials having pesticidal properties, like *E. adenophorum*, *J. adhatoda*, *A. vulgaris*, *Z. armatum*, *U. dioica*, *A. sativum*, and *S. insigne* with cattle urine and cattle dung.

Farmers reported the use of different types/parts of botanicals for different purposes, including pest control in different stages of crops. Approximately, 41% respondents were found using plant parts of *J. adhatoda*, *A. vulgaris*, *E. adenophorum*, *S. insigne*, *Toona ciliata*, *Madhuca indica*, *A. sativum* and mustard cake during field preparation time. They used to incorporate these plants and plant parts into soil for the purpose of supplying organic matters and plant nutrients, and also to minimize infestation by soil inhabiting pests. Farmers also use other botanicals, cattle urine, wood ash, kerosene, soap, mustard oil, cow dung and milk against insect pests and plant diseases. They apply sole cattle urine mainly during vegetative growth stage of crops against soft-bodied insect pests such as aphids. Poudel et al (2004) also reported that soft-bodied insect pests like aphids and red ants are the main target pests for using cattle urine.

Farmers also expressed some limitations of home-made bio-pesticides. The bio-pesticides produce strong odor during their preparation and cause headache and allergies to the person who is involved in preparation and application of biopesticides. Maniania et al (2003) reported that the pesticidal plants produce strong odor causing headache when applied in the field. Moreover, Belmain and Stevenson (2001) explained that the botanical pesticides derived from plants do not guarantee safety to human and environment. So, it is advisable to farmers to use safety measures, as mostly they do not wear particular dress, mask, gloves, shoes etc. during bio-pesticide preparation and use. Usually, Nepalese farmers do not use any appropriate safety measures during botanical pesticide preparation and application.

Botanical pesticides preparation is time consuming and laborous. *Gitimal* takes 35-45 days depending upon the season to be ready to apply fermented product in the field. And bio-pesticides remain effective for a short period of time in field as compared to that of chemical pesticides so it demands frequent application and some of them are effective only for certain development stages of the pests. Rodgers (1993) argued that many potential bio-pesticides are only effective against particular development stage of pest or disease organism.

Gitimal was the most popular one among several locally prepared bio-pesticides, and farmers seems to be satisfied with the use of bio-pesticides in controlling crop pests. However, they were not confident about dose and frequency of biopesticide application, and also method of application was lacking for efficient use of the product. So detail scientific studies are needed to explore the mode of action of the bio-pesticides and validate the effectiveness of *Gitimal* and other bio-pesticides so as to determine their efficiency and their application procedures for recommendation of the product to use by the farmers.

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Verification of Resistant Rootstocks against Root-knot Nematodes and Grafting Technology on Tomato

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ABSTRACT

Nematode infestation in tomato grown under plastic house conditions year after year is appearing as a major limiting factor in western hills of Nepal. The two different types of experiments were carried out in two consecutive years, 2009 and 2010 at Agriculture Research Station (ARS), Malepatan, Pokhara and farmers' field of Arukharka, Syangja. The objectives of the experiments were to find out the reaction of available rootstocks to root-knot nematode and to verify the fruit yield of grafted tomato. Chilli pp02337-7502, wild eggplant (*Solanum sisymbriifolium*), Bihi (*Solanum torvum*) were found resistant to root knot nematodes under inoculated conditions. The fruit yield increased by 22 to 38% in grafted tomato plants over non-grafted plants. The wild eggplant *S. sisymbriifolium* was found the promising resistant rootstock to adopt grafting practice for the control of root knot nematodes (RKN). However, local Bihi (*S. torvum*) could be another alternative root stock against RKN and grafting technology might be the best alternative measure to grow tomatoes in nematode prone areas.

INTRODUCTION

Tomato and eggplant are the two important solanaceous vegetables widely grown in Nepal. Tomato ranked fifth among vegetables with area coverage of 16,702 ha and the productivity of 15.52 t/ha (VDD 2010/11). At present, tomato cultivation under plastic house is in increasing trend in the mid hills of Nepal. Only in western development region there are more than 6000 plastic houses (RAD 2067/68). Lack of technical knowledge and growing tomato in same field for long period, incidence of soil borne diseases like bacterial wilt, bacterial soft rot and root-knot disease are increasing. Among them, root-knot disease (*Meloidogyne* spp.) is a major biotic factor responsible for low yield of tomato under plastic tunnel (Baidya 2009). Use of plants grafted in resistant rootstocks is one of the techniques for managing soil borne diseases including root-knot nematodes.

Japanese scientists were the first to innovate the technique of cleft grafting in eggplant for controlling bacterial wilt in eggplant and tomato (Rashid et al 2007). Rootstocks of wild eggplant (*Solanum sysimbriifolium*) are widely used for the grafting for scion of tomato and eggplant in South Asia region. In addition, grafting allows the production earlier with higher yields. Root of the rootstocks are strong and healthy and help grafted plants take up adequate amounts of nutrients and moisture from the soil, resulting much more yield and also provide longer harvesting period than the non grafted plants. In Nepal, grafting technology was introduced in tomato for the control of root knot nematode and bacterial wilt diseases from Bangladesh through Plant Pathology Division, Khumaltar (PPD) in 2007. After receiving training at PPD, Khumaltar in 2007, the technology has been introduced at Agriculture Research Station (Horticulture), Malepatan, Pokhara and providing training to the farmers as well as to nursery men since 2009. Some locally collected and exotic solanaceous species that were introduced from AVRDC through IPM/CRSP have also been evaluated for resistance at ARS Malepatan. Field verification of grafted tomato plants were carried out in the farmers' infested fields for their reaction to root knot infection as well as for yield.

Grafted tomato plants were completely free from root knot compared to gall index (6 in 0-10 scale) in non-grafted plants and the fruit yield increased by 33% over non-grafted plants (Timila et al 2009).

MATERIALS AND METHODS

Rootstocks testing

The experiment was conducted at ARS, Malepatan. Potting mixtures containing 2.5 kg of sterilized sandy loam soil plus well decomposed farm yard manure (at 1:1 ratio) were filled in the earthen pots. One month old seedlings of different crops such as eggplant (EG 195, EG 203, Pokhara, Lurki), tomato (Hawai 7996, Srijana), Chilli (pp02337-7502), Kantakari (Bihi, wild eggplant) were transplanted and kept under shade house. Each pot contained two plants and replicated five times. The pots were artificially inoculated with ten galls (0.5-1.0 gm) of nematode from tomato roots. The galls were placed near root zone seven days after transplanting. Observations were taken at 45 and 90 days after transplanting by up-rooting the plants. Root galls were scored in 0-10 galling index (Bridge and Page 1980).

Grafted plants performance and production verification

Cleft grafting technique was adopted in grafting procedure. A one cm deep longitudinal opening on rootstock was made after removing top portion of the rootstock above 5-6 cm with sharp razor blade. The root stock of wild eggplant and scion of Srijana hybrid tomato was used. The scion of 4-5 cm from the top and made two angular cuts about one cm long in both sides that gives 'V' shaped end of the scion. The V-shaped portion of the scion was inserted in the opening of the rootstock and tied with parafilm or clipped with plastic clip. The grafted plants were kept under humid conditions not less than 85% humidity (under grafting house). As the new leaves started to develop, the plants were shifted in shade house for hardening for about 1-2 weeks. Grafted and non-grafted plants were transplanted under plastic tunnels. During transplanting care was taken to keep grafted point above soil level (approximately 4 inch above soil level). Fertilizers, irrigation and other agronomical practices were given as for normal cultivation of tomato of Srijana variety under plastic tunnel. Suckers were removed as and when appeared. Scoring of Root galling was noted after final harvest.

RESULTS AND DISCUSSION

Rootstocks testing

The highest root gall index was observed in tomato, Hawai 7996 at 45 days after transplanting. Other infected plants were 'EG 195, EG 203 and Pokhara Lurki varieties of eggplant and hybrid tomato variety 'Srijana'. Very little infection was observed in 'Kantakari'. In 90 days, the highest gall index was observed in 'Pokhara Lurki', 'Hawai 7996' and 'Shrijana' whereas, EG 195' 'EG 203' and 'Kantakari' showed moderate type of infection. Chilli genotype 'pp 02337-7502' and wild brinjals were found free from root gall formation. Similar type of reaction of different rootstock plants were found in the second season, also (Table 1).

Performance of grafted plants and production verification

Results clearly indicated that under both on-station and on-farm conditions, higher fruit yields were obtained from grafted plants. The fruit yield increased by 22-37% in grafted plants over non-grafted plants. Tomato hybrid, Srijana, is highly susceptible to root knot nematodes. The galling index of the grafted and non-grafted plants is presented in table 2. The yield increase could be due to healthy and strong root system of grafted plants and also longer period of fruit harvests as well as free from nematode gall in the root system. However, yield increment percent may differ in grafted plant with the variation in inoculum density in the field.

Table 1. Reaction of various rootstock plants to root knot nematode, 2009

Crop	Variety	Root gall index score during first season		Root gall index score during second season		Source
		45 DAI	90 DAI	45 DAI	90 DAI	
Brinjal	EG 195	3	5	2	5	AVRDC
	EG 203	3	5	2	5	AVRDC
	Pokhara lurki	3	6	3	6	ARS, Malepattan
Tomato	Hawai 7996	4	6	3	6	AVRDC
Tomato	'Srijana'	3	6	3	7	ARS, Malepattan
Chilli	pp02337-7502	0	0	0	0	AVRDC
Wild brinjal	<i>Solanum sisymbriifolium</i>	0	0	0	0	Bangladesh
Bihi	<i>Solanum torvum</i>	0	0	0	0	ARS, Malepattan
Kantakari	<i>Solanum viarum</i>	2	5	2	4	ARS, Malepattan

⁺ DAI= Days after inoculation

Chilli pp02337-7502 and wild eggplant (*Solanum sisymbriifolium*) were found resistant to root- knot nematode. These could be used as the sources of resistance for root stock for desirable scion that are to be cultivated in nematode prone areas. Exploration of local Bihi (*Solanum torvum*) could be the alternative source of rootstock against root knot nematodes. Grafting technology might be the best practice to grow tomato where nematode problem is severe and useful management tool for cultivation of tomato susceptible to root-knot nematodes.

Table 2. Yield performance of grafted tomato plants at the station and in the farmer's field, 2009

Tomato	At the Station, 2009				In farmers field, Arukharka, Syangja		
	Root gall index	Mean no. fruits/plant	Mean fruit wt, kg/plant	% yield increase	Root gall index	Mean fruit wt, g/plant	% yield increase
Grafted	0	151	4.62	21.89	0	9.26	36.77
Non-grafted	4.3	112	3.79	-	5.3	6.77	-

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Effect of Different Organic Manures and Bio-fertilizers on Yield of Bush-type French Bean (*Phaseolus vulgaris* L.) Genotypes

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ABSTRACT

A study was conducted to find out the effect of different organic manures and bio-fertilizers on bush type French bean (*Phaseolus vulgaris* L.) variety Arka Suvidha during autumn seasons of 2010 and 2011 at the Agriculture Research Station, Malepatan, Pokhara (848 masl) to assess the effects on yield and yield attributes. The treatments composed of different types of organic manures (Cattle manure, Vermen-compost, Bokashi and Poultry manure) and bio-fertilizer (Effective micro-organism and *Rhizobium*). The experiment was arranged in randomized complete block design with three replications. The temperature during the growth period ranged from 14°C to 32°C. The results showed significant variations in different growth parameters and fresh pod yield. Application of poultry manure in combination with EM produced the highest number of branches (6.3), nodes (30.0) and plant height (29.2 cm) flower buds per inflorescence (5.3), longest (11.5 cm) and widest (10.5 mm) pods. Highest fresh pod yield (13.3 t/ha) was also produced by the application of poultry manure in combination with EM and was followed by cattle manure (11.3 t/ha). In general application of bio-fertilizers in combinations with organic fertilizers produced higher fresh pod yield.

INTRODUCTION

The trend of soil depletion in the hills has been the major constraint for crop production and productivity. Low productivity is mainly attributed due to low yielding potential varieties, poor management practices, low inputs such as fertilizers and compost and poor inherent soil fertility (Bhattarai et al 2009). Due to the continuous application of chemical fertilizers, the soil has become highly acidic in the hilly areas. The price of chemical fertilizers is increasing every year and the cost of production has increased tremendously (Budathoki, 2006). Inoculation with *Rhizobium* results in greater nodulation and nitrogen fixation by French bean. Cuautle et al (1981) obtained larger number of nodules per plant, when grown in fumigated soil inoculated with *Rhizobium* strain and the seed yield from these plants was also highest. Yadav and Vijayumari (2003) found better yield in vermi-compost treatment. Overall growth and yield record from the vermi-compost treatment and admixed with FYM. Higher production per plot, germination percent, height of plant, number of leaves, length of leaves, number of pods per plant, length of root and number of nodules was obtained by FYM than the N:P:K treatment (Rameshwar 2006).

Singh and Chauhan (2009) investigated the effect of organic sources of nutrients viz., vermi-compost, FYM and along with inorganic fertilizers in French bean under irrigated conditions. Vermi-compost treatment recorded the highest in all observations except biomass of whole plant (above and ground biomass) which was recorded highest in N:P:K treatment. The results of the vermi-compost treatment was found best than the farmyard manure, inorganic fertilizers and mixed treatments. Finally, they concluded that French bean was most responsive to vermi-compost treatment on growth and yield in comparison to farmyard manure, chemical fertilizers and mixed treatments under irrigated conditions of Srinagar valley, India. It also concluded that vermi-compost is particularly good for farmers,

consumers and ultimately for soil as it can be used as resource for maximum crop productivity with more financial output in comparison to chemical fertilizers. The highest productivity by vermi-compost treatment might be due to the improvement of physico-chemical properties of the soil.

French bean (*Phaseolus vulgaris* L.) is one of the important vegetable crops for year round production and consumption in Nepal. The area, production and productivity of vegetables since more than 30 years are in increasing trend. In 2010/11 the area, production and productivity of vegetable crops were 244,102 hectares, 3,203,563 metric tons and 13,124 t/ha respectively (VDD 2011). A study was conducted at Malepatan, Kaski during the year 2010 to evaluate 19 exotic and indigenous French bean genotypes in spring season. Among the tested genotypes Arka Komal, Arka Suvidha and Mallika showed best performance (Pandey et al 2011). The experiment was conducted to assess the effect of different compost materials and bio-fertilizers on fresh pod yield and yield attributes in bush type French bean.

MATERIALS AND METHODS

The experiment was conducted at the Agriculture Research Station (Horticulture), Malepatan, Pokhara. The station is situated at a latitude of 28°13'6.18" N and a longitude of 83°58'27.72" E at an elevation of 848 m asl and is characterized by a sub-tropical climate. The experiment was conducted in two consecutive years 2010 and 2011 in two factors as factorial randomized complete block design (RCBD) and each treatment combination was replicated three times. The temperature during the growing period ranged from 14° to 32°C. Arka Suvidha was used for the experiment. Factor A was different compost materials and factor B as bio-fertilizers. Compost materials were cattle manure, vermi-compost, improved bokashi and poultry manure. Bio-fertilizers were *Rhizobium*, effective microorganism (EM) and no bio-fertilizer application. All compost materials were analyzed for nutrient contents before application and all these materials were applied equal to 10 tons compost plus 40 kg nitrogen per hectare.

Spacing was maintained at 60 × 30 cm and experimental plot size was 2.4 × 1.5 m. The crop was planted on 26 August in 2010 and 2011. Scoring of agro-morphological characters was done following descriptors for *Phaseolus vulgaris* (IBPGR 1982). The data were analyzed using Genstat software (version 12.1 VSN International, Hemel Hempstead, UK). Plant height was measured in five randomly selected plants at the green pod maturity stage from the cotyledon scar to the highest tip of the plant. Pod length and pod width were measured on the largest, fully expanded, immature, green pod and measurements were averaged from 10 randomly selected plants (followed descriptors). Fresh pods were harvested four times (harvestings) at 10 days interval when they were fully expanded, immature and green stage.

Rhizobium

Paste of 100 gram *Rhizobium* + 100 gram Gur (Sakhkhar) + 250 ml water was made mixed with seed and kept in shade for 20 minutes and then the seed was sown immediately. The amount was sufficient for 5 kg seed.

EM

One liter EM + 1 kg Gur (Sakhkhar) + 18 liters water were mixed and kept in a drum for 10 days. After 10 days the liquid was diluted (5 times more water added). 100 liters of this diluted EM was mixed in 1000 kg compost and this was applied when sowing the crop. This amount was sufficient for a ropani (500 m²).

Vermi-compost

Nutrient content was analyzed and applied equal to 10 tons compost plus 40 kg nitrogen per hectare in the soil before sowing the crop.

Compost

FYM, poultry manure and bokashi analyzed for nutrient content and applied 10 t/ha plus equal to 40 kg nitrogen per hectare in the soil before sowing the crop.

Bokashi

Mixed 150 ml EM and 10 g gur in 35 lit water and stored for 24 hours. Mixed the liquid with 100 kg milled rice husk, 10 kg bone meal, and 10 kg oil cake and covered with polythene and stored in shade for 20 days. Applied equal to 10 tons compost plus 40 kg N/ha while preparing the land.

Nutrient content	Nitrogen %	Phosphorus %	Potash %
Cattle manure	1.65	0.81	1.27
Poultry manure	2.33	0.92	1.73
Vermi compost	1.82	0.97	1.99
Bokashi	1.71	0.80	1.63

RESULTS AND DISCUSSION**Branches**

Plant growth including the number of branches is the result of a variety's genetic potential interacting with the environment and farming practices. The number of branches per plant among the different compost materials and bio-fertilizers application differed significantly but the interaction among the compost materials and bio-fertilizers was not significant (Table 1). The highest number of branches was produced by the application of poultry manure with an average of 6.07 branches per plant, whereas the lowest number of branches was produced by the application of Bokashi with an average of 4.14 branches per plant. Similarly, the highest number of branches was produced by the application of EM and *Rhizobium* with an average of 5.12 branches per plant, whereas the lowest number of branches was produced by without application of bio-fertilizers with an average of 4.65 branches per plant. The results indicated that the combination of poultry manure and either *Rhizobium* or EM increased the number of branches.

Node number

The number of nodes per plant produced by the application of different compost materials was found significantly different but the application of bio-fertilizers did not differed significantly and the interaction was also not significant (Table 2). The highest number of nodes was produced by the application of poultry manure with an average of 28.4 nodes per plant, whereas the lowest number of nodes was produced by the application of vermi-compost with an average of 22.30 nodes per plant. The results indicated that the poultry manure enhances the plant growth as compared to other compost materials and bio-fertilizers did not show the effect on nodes number.

Table 1. Effect of different compost materials and bio-fertilizers application on number of branches in bush bean during autumn seasons of 2010 and 2011

Compost materials	Bio-fertilizer			Mean of organic manure	F value of organic manures	LSD of organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	5.45	5.48	5.05	5.33		
Vermi-compost	4.42	4.41	4.10	4.31		
Bokashi	4.31	4.27	3.84	4.14		
Poultry manure	6.28	6.33	5.59	6.07		
Mean of biofertilizer	5.12	5.12	4.65	4.96	399.22*	0.13
F value of biofertilizer				48.69*		
LSD of biofertilizer				0.11		
LSD _{0.05}				ns		
CV (%)				2.7		

*, significant; ns, not significant

Table 2. Effect of different compost materials and bio-fertilizers application on number of nodes per plant in bush bean during autumn seasons of 2010 and 2011

Organic manures	Bio-fertilizer			Mean of organic manures	F value of organic manures	LSD of organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	28.13	27.07	26.33	27.18		
Vermi-compost	22.93	22.53	21.43	22.30		
Bokashi	23.57	23.50	22.43	23.17		
Poultry manure	30.00	28.20	27.27	28.49		
Mean of biofertilizer	26.16	25.33	24.37	25.28	42.62*	1.35
F value of biofertilizer				*		
LSD of Bio-fertilizer				ns		
LSD _{0.05}				ns		
CV (%)				5.5		

*, significant; ns, not significant

Plant height

The plant height differed significantly among the different compost materials and bio-fertilizer application (Table 3). The interaction of different compost materials and bio-fertilizer application was found insignificant. The tallest plants were produced by the application of poultry manure with an average of 27.79 cm and the shortest plants were produced by the application of Bokashi with an average of 23.02 cm. Similarly, the tallest plants were produced by the application of EM with an average of 25.76 cm and the shortest plants were produced without application of bio-fertilizer with an average of 24.19 cm. Poultry manure and cattle manure application in combination with either EM or *Rhizobium* enhanced the growth of bush type French bean.

Flower buds

The number of flower buds per inflorescence was significantly different among the different compost materials and bio-fertilizer application (Table 4). The interaction of different compost materials and bio-fertilizer application was found insignificant. The highest number of flower buds per inflorescence was produced by the application of poultry manure with an average of 4.99 and the lowest number of flower buds per inflorescence was produced by the application of vermi-compost and Bokashi with an average of 3.36 and 3.37, respectively. Similarly, the highest number of flower buds per inflorescence was produced by the application of EM or *Rhizobium* with an average of 4.19 and the lowest number of flower buds per inflorescence was produced without application of bio-fertilizer with an average of 3.66. Poultry manure application in combination with either EM or *Rhizobium* enhanced flowering and the number of flower buds in bush type French bean.

Table 3. Effect of different compost materials and bio-fertilizers application on plant height (cm) in bush bean during autumn seasons of 2010 and 2011

Organic manures	Bio-fertilizer			Mean of Organic manures	F value of Organic manures	LSD of Organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	26.90	26.47	25.00	26.12		
Vermi-compost	23.47	23.20	23.13	23.27		
Bokashi	23.50	23.33	22.23	23.02		
Poultry manure	29.17	27.80	26.40	27.79		
Mean of biofertilizer	25.76	25.20	24.19	25.05	160.57*	0.53
F value of biofertilizer				25.40*		
LSD of biofertilizer				0.46		
LSD _{0.05}				ns		
CV (%)				2.2		

*, significant; ns, not significant

Pod length

The pod length differed significantly among the different compost materials and bio-fertilizers application (Table 5). The interaction of different compost materials and bio-fertilizer application was found insignificant. The longest pods were produced by the application of poultry manure with an average of 10.76 cm and the shortest pods were produced by the application of Bokashi and vermi-compost with an average of 7.61 cm and 7.72 cm, respectively. Similarly, the longest pods were produced by the application of EM and *Rhizobium* with an average of 9.19 cm and 9.16 cm, respectively and the shortest pods were produced without application of bio-fertilizer with an average of 7.78 cm. Poultry manure application in combination with either EM or *Rhizobium* enhanced fruiting and the fresh pod length in bush type French bean.

Table 4. Effect of different compost materials and bio-fertilizers application on number of flower buds in bush bean during autumn seasons of 2010 and 2011

Organic manures	Bio-fertilizer			Mean of Organic manures	F value of Organic manures	LSD of Organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	4.53	4.59	3.90	4.34		
Vermi-compost	3.49	3.42	3.16	3.36		
Bokashi	3.49	3.50	3.13	3.37		
Poultry manure	5.26	5.25	4.45	4.99		
Mean of biofertilizer	4.19	4.19	3.66	4.01	596.44*	0.10
F value of biofertilizer				118.26*		
LSD of bio-fertilizer				0.08		
LSD _{0.05}				ns		
CV (%)				2.4		

*, significant; ns, not significant

Pod width

The pod width among the different compost materials and bio-fertilizers application differed significantly (Table 6). The interaction of different compost materials and bio-fertilizer application was found insignificant. The widest pods were produced by the application of poultry manure with an average of 9.72 mm and the narrowest pods were produced by the application of vermi-compost with an average of 6.07 mm. Similarly, the longest pods were produced by the application of EM with an average of 8.48 mm and the narrowest pods were produced without application of bio-fertilizer with an average of 7.09 mm. Poultry manure application in combination with either EM or *Rhizobium* enhanced fruiting and the fresh pod width in bush type French bean.

Table 5. Effect of different compost materials and bio-fertilizers application on pod length (cm) in bush bean during autumn seasons of 2010 and 2011

Organic manures	Bio-fertilizer			Mean of organic manures	F value of organic manures	LSD of organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	9.33	9.35	7.85	8.84		
Vermi-compost	7.95	7.98	6.92	7.62		
Bokashi	7.95	7.93	6.95	7.61		
Poultry manure	11.52	11.37	9.40	10.76		
Mean of biofertilizer	9.19	9.16	7.78	8.71	357.47*	0.23
F value of biofertilizer				139.73*		
LSD of biofertilizer				0.20		
LSD _{0.05}				ns		
CV (%)				2.7		

*, significant; ns, not significant

Table 6. Effect of different compost materials and bio-fertilizers application on pod width (mm) in bush bean during autumn seasons of 2010 and 2011

Organic manures	Bio-fertilizer			Mean of Organic manures	F value of Organic manures	LSD of Organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	9.53	9.23	8.00	8.92		
Vermi-compost	6.70	5.83	5.67	6.07		
Bokashi	7.17	7.00	6.20	6.79		
Poultry manure	10.53	10.13	8.50	9.72		
Mean of biofertilizer	8.48	8.05	7.09	7.88	59.57*	0.66
F value of biofertilizer				13.49*		
LSD of biofertilizer				0.57		
LSD _{0.05}				ns		
CV (%)				8.5		

*, significant; ns, not significant

Pod yield

The fresh pod yield among the different compost materials and bio-fertilizers application differed significantly (Table 7). The interaction of different compost materials and bio-fertilizer application was found insignificant. The combined analysis over the years showed that the highest fresh pod yield was produced by the application of poultry manure with an average of 11.81 t/ha followed by the application of cattle manure with an average of 9.72 t/ha. The lowest fresh pod yield was produced by the application of Bokashi with an average of 6.46 t/ha. The highest fresh pod yield was produced by the application of EM with an average of 10.11 t/ha followed by the application of *Rhizobium* with an average of 8.37 t/ha. The lowest fresh pod yield was produced without application of bio-fertilizers with an average of 7.85 t/ha. Poultry manure application in combination with EM produced the highest fresh pod yield in bush type French bean. The results showed that the application of poultry manure is better than other compost materials and bio-fertilizer application is more beneficial than without application.

Table 7. Effect of different compost materials and bio-fertilizers application on fresh pod yield (t/ha) in bush bean during autumn seasons of 2010 and 2011

Organic manures	Bio-fertilizer			Mean of Organic manures	F value of Organic manures	LSD of Organic manures
	Effective micro-organism	<i>Rhizobium</i>	No bio-fertilizer			
Cattle manure	11.32	9.20	8.66	9.72		
Vermi-compost	8.03	7.07	6.23	7.11		
Bokashi	7.46	6.07	5.85	6.46		
Poultry manure	13.63	11.16	10.65	11.81		
Mean of biofertilizer	10.11	8.37	7.85	8.78	477.96*	0.33
F value of biofertilizer				146.74*		
LSD of biofertilizer				0.29		
LSD _{0.05}				ns		
CV (%)				3.9		

*, significant; ns, not significant

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Use of Information and Communication Technologies (ICT) in Organic Farming Research and Development

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ABSTRACT

The information and communication technologies (ICTs) and its use in agriculture are pivotal for the transformation of agricultural technologies to its clients. ICTs empower farming community by providing latest knowledge to make commercial agricultural production more profitable. ICTs can help farmers in contributing to organic agriculture farming by providing online information, text information, digital information and others that has been utilized for commercial organic farming. The informed and empowered farmers keep abreast with latest knowledge on organic agriculture and know their role in an environmentally sustainable society. This paper has attempted to analyze the present situation of ICT use in organic agriculture, its importance to farmers involved in organic agriculture. Furthermore, it assesses the media involvement in dissemination of organic farming, software and hardware utilized in organic agriculture, development of web-based software applications and finally capacity building of the agricultural researchers as well as extension professionals engaged in organic agriculture farming. Now, organic agriculture is the debate of present context due to imbalance use of pesticides, inorganic fertilizers and other chemicals that directly or indirectly affect the human health. The global information will help stakeholders involved in organic farming to minimize such hazardous issues by using web-based search engines, web-based agricultural databases and full text journals which is available free of cost. Different digital-based information is coming up to ease the researchers in developing new concept on organic agriculture and helps in conducting advance research. ICT tool can also help planners and policy makers in prioritizing the important issues of organic agricultural components and successful planning of the research activities.

INTRODUCTION

Information and communication technologies (ICTs) play a critical role to sustainable development. ICTs are the most inclusive infrastructure on the planet, with 90% of the world population connected to mobile services and over one-third connected to the internet. ICTs are a truly unique platform for progress that creates wealth, optimize the use of natural resources, enables a low carbon economy and give equitable access to basic public services, such as farming, health care and education. ICTs play a pivotal role in monitoring, predicting and detecting natural disasters. Using these technologies to mitigate disasters contributes to saving human life, protecting infrastructure, and supporting economic activity leading to sustainable development. ICT is a tool to transfer technologies to different strata in a user friendly fashion to satisfy its clients by providing timely and desirable information. The information about organic farming practices is now available by using different ICT tools that brought about revolutionary changes to physical, social and economic infrastructure of the farming community. Use of online information, databases, CD-ROM web-based search engines and other digital devices are becoming basic part accessing the information about organic agriculture. ICT is now used as technology transfer and extension process which enhance research output and quick transmission of latest technologies to its clients.

Scientific knowledge on organic farming has to be provided in such a way that can help in order to satisfy the need of information on organic farming practices for increasing production and productivity of the farmers. It can be effectively done only when information and adoptive technologies generated by research system are successfully transmitted to its clients. Similarly, agriculture scientists and researchers' ability to conduct high quality research and generate farmers' need-based vis-à-vis problem-oriented technologies in organic farming would be enhanced if they are well facilitated with access to modern information communication technology. We all know information is knowledge and knowledge is power. We should use the ICT tool for the communication of scientific knowledge to our farming community. Now the farmers know very well the importance of scientific knowledge and always looking for the latest information.

The advancement in technological development has fostered the importance of information and communication in all sectors of science and technologies including organic farming. There can't be any controversy that ultimate aim of improved technology is to raise the productivity and production of agricultural commodities consequently raising the living standard of the rural people. It becomes possible only when knowledge and skills related to such practices are communicated to the villages particularly farm families. The use of television, FM radio and national dailies are becoming popular means of communication to cater the scientific knowledge on agriculture to farm families. In the present context when the extension channel is not reaching to every farm household the mass media channels are more reliable source of information aiming of reaching a considerably large number of farmers. Providing agricultural development information to all farmers of the country is beyond the capacity of inter-personal and group communication channels and it is the mass media which is more appropriate to convey the updated technical information to farmers and other clients in an efficient and effective manner. Among other mass media FM radio are becoming more informative to provide agricultural news and latest technical events. The objectives of the present study were to assess the importance of ICT in organic farming research and development, to find the ICT tool and use of ICT in organic farming research and development, and to provide information with regard to the ICT tool available in the Nepalese organic agriculture so as to improve the quality of research and advance techniques of dissemination.

MATERIALS AND METHODS

The methodologies used to gather information were desk study of available literatures in different library, mass media coverage in agriculture, digital media, online search, different users group, and experiences of the author. It is a content analysis of past one decade on ICT use in organic agriculture farming by different agriculture research and development institutions.

RESULTS AND DISCUSSION

Importance of ICT in organic farming

Twenty-first century is the age of information and communication technologies (ICTs). Not only scientists/technicians use the computers but farmers they started to use the computers for information browsing. They know the importance of information and cyber marketing which is one of the best options for the accession of information. Now the scientists/researchers they upload their research outputs to World Wide Web (WWW) and share information to others. The uploaded information is downloaded by the other scientists, researchers, end-users, extension agents, farmers, policy makers, planners, bureaucrats, agro-entrepreneurs, I/NGOs, private agencies, politicians, and other related clients for different purposes. The advancement in software helps to the computer users more friendly environment to download the required information. The FM radio and local magazines also covers the

news and current affairs in agriculture which is very useful for the farming community. The timely information on weather forecast and market price information helps farmers to cope with the climate change effects on crop and marketing of their product.

Since the need of technical information is diversified and more demanding by the different stakeholders, we should have to change our traditional practices of transfer of technology and its dissemination to different clients. The conventional extension system is unable to reach each and every doors of farm house due to different constraints. In this context, the mass media and digital media plays a pivotal role in transferring the most up-to-date technologies in organic agriculture.

ICT use in organic agriculture

The use of ICT is growing in every field of science, humanities, management and other allied fields due to its importance to deliver knowledge and skills to the end users. ICT use in agriculture has started two decades before in Nepal when it was regarded as the fancy and entertaining kits for Nepalese community. Its importance was merely justified when the information sharing through ICT was exposed and the use of computers, television and radio programs were given priority to deliver development news and information to its clients. The use of ICT was tremendously increased when the digital information sharing through World Wide Web was introduced and easily accessible to the users. In this regard, the internet was made the remarkable revolution in this area. Agriculture and allied field also speed up pace with this revolution and used briskly for the well beings of the rural community. There is some global information given below on organic agriculture where ICT has been used.

TEEAL

It stands for The Essential Electronic Agricultural Library (TEEAL), also called "Library in a Box" which includes full text and bibliographic CD-ROM library of over 140 titles of the world's most important scientific journals in the field of agriculture. Among 140 title journals some of the journals are covered the research papers/articles on organic agriculture that are given as follows.

- African Crop Science Journal
- African Farming and Food Processing
- African Journal of Agricultural Research
- African Journal of Food, Agriculture, Nutrition and Development
- Agronomy Journal
- Australian Journal of Agricultural Research
- Bio-Control Science and Technology
- Crop Science
- Eco Science
- FAO Research and Technology Paper
- International Journal of Plant Science
- International Journal of Vegetable Science
- Journal of Agricultural Extension and Rural Development
- Journal of Cereals and Oilseed
- Journal of Crop Improvement
- Journal of Crop Production
- Journal of Horticulture and Forestry
- Journal of Plant Breeding and Crop Science
- Journal of Sustainable Agriculture
- Journal of Vegetable Crop Production
- Journal of Toxicology and Environmental Health
- Netherlands Journal of agricultural Science
- Nigerian Agricultural Journal

AGORA

It is web-based information portal which can be accessed free of cost on www.aginternetwork.org with full text research articles. AGORA stands for "Access to Global Online Research in Agriculture". It provides series of information on organic agriculture and sustainable agriculture carried out in different countries.

Organic Farming Research Foundation (OFRF)

It is a leading, national, non-profit organization that champions the organic farmer by building infrastructure that ensures their success. It provides information on different aspects of organic farming particularly for the farmers. You can go through the web <http://www.ofrf.org> to access more information on organic agriculture.

OARE

It is the Online Access to Research in Environment that provides global information on agriculture environment which is useful information for organic farming. The more information can be found at www.oaresciences.org but you need to sign-up for getting log in and it is simple, just follow the guidelines given in the website.

ARDI

It is the Access to Research for Development and Innovation that provides research articles on new innovations in agriculture and allied subjects. It also covers the articles on sustainable agriculture and organic farming. To find out more information go to the ARDI web page by browsing www.wipo.int/ardi/en.

In addition to above mentioned information sites there are other websites which deals with organic farming such as Research4Life (www.research4life.org), National Sustainable Agriculture Information Service (www.attra.ncat.org), ITOCA website (www.itoca.org), which provide online global information on organic agriculture.

Besides online information, CD-ROM, DVDs and other digital information is also available to access information on organic farming. NARC is also doing research on organic agriculture and the successful technologies generated by NARC have been disseminated through different media in order to sensitize people about organic farming. Nepal Television is telecasting daily agriculture programme on agriculture that also covers organic agriculture. There is also daily 15-minutes agriculture programme from Radio Nepal and it is very effective at the rural community to transfer our latest technology of agriculture. It also covers organic agriculture activities going on in the country. FM radio and daily newspapers are also giving priority to cover the agricultural events. The STAR FM aired weekly programme of agriculture called KRISHI SANDESH on every Wednesday at 6.30 PM.

The promotion of electronic communication facilities is a major research issue for Nepalese agriculture where traditional extension system is not satisfying the information need of rural community. The electronic media can be intensively used for the exchange of literatures, the submission of papers for correction and publication, getting help in data analyses and the collection of references. Encouraging scientists to use this media to keep in touch with international scientists, learn from their peers abroad, and share their experiences and findings with others.

Major plunge on ICT

If agriculture scientists are responsible to communicate their research results to different level of target audience, the present communication strategy of CPDD need to be changed to meet farmers demand of information. CPDD would need to focus its activities on most priority area based on the national agricultural perspective plan. It need to review, revise and refocus CPDD's program and activities to provide effective information services for the production, storage and dissemination of research information. NARC has to formulate set of communication policies and program to provide CPDD with a new approach and mechanism in information production and delivery. Considering the growing need of information and communication services, CPDD (NARC) is strengthening its capacity in terms of its staffing, physical facilities, resource allocation and program. Regarding the improvement of NARC's information and communication services, certain long-term, medium-term and short-term strategies have to be formulated and adopted on a phase-wise basis. Some medium-term communication strategies are drawn out here and suggested to be adopted for the gradual improvement of CPDD to cope with the NARC's growing information and communication services. The growing needs of information and communication services in NARC system and increasing workload for CPDD, its capacity should be developed in phase-wise basis. CPDD's capacity in terms of organization, manpower, equipment, skills and programs should be strengthened to meet the growing needs of NARC communication, publication and documentation services. Until and unless technologies generated by research systems are not appropriate and user friendly to farmers, it will be very difficult to adopt and disseminate. It should be demand-driven and not seen only with scientist and extension personnel perception. Beneficiaries must be involved in the whole process to give the feeling of their ownership. They should be the active partner and others should be facilitator. Then only transfer of technology or dissemination plus adoption will be successful.

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Organic Agriculture in Nepal and its role in GHGs Emission

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ABSTRACT

Organic agriculture and greenhouse gases (GHGs) emission are important issues in the Nepalese agricultural system in the context of food security. Agricultural CO₂, CH₄ and N₂O emission in the atmosphere is partly causing climate change. In a global estimation, agriculture sector contributes 10 to 12 percent of the total estimated GHG emissions each year. Large quantities of organic manure added every year to agricultural soils for supplying nutrients, contribute significantly to CO₂ emission. In a finding, 38.6 and 18.6% higher carbon emissions were reported from organic amendment of wheat straw and FYM application as compared to chemical fertilizer, respectively. Sequestration of carbon in soil due to organic agriculture has even greater potential to increase organic carbon in the soil. On the other hand, chances of GHGs emission increase with the increase of organic carbon in the soil. As of IFOAM, 2008, organic agriculture has been practiced in about 8059 hectares of land in Nepal and is still expected to increase further in coming years. In the context of high pesticide application in modern agriculture and its impacts on human kind and environment, the need and the importance of organic agriculture is becoming a matter of growing concern to all who are working for the development of organic agriculture in the country. Organic agriculture has been found beneficial to improve soil physical properties, improve soil biodiversity, safe, healthier, eco-friendly and climate resilience in rural livelihoods. However, considering the possible impacts of organic agriculture on climate change, it is equally important to find out timely mitigation options for reducing GHGs emission from organic agriculture.

INTRODUCTION

Organic agriculture is becoming a matter of great concern with respect to food security. It is a production system that sustains the health of soil, ecosystem and people and it combines tradition, innovation and science to benefit that shared environment and promote fair relationship and a good quality of life for all involved (IFOAM 2009). Sequestration of carbon in soil due to organic agriculture has even greater potential to increase organic carbon in the soil. But there are equal chances of increase in GHGs (greenhouse gases) emission and shows the practice has both positive and negative effects on environment and livelihood. Large quantities of organic manure added every year to agricultural soils for supplying nutrients, contribute significantly to GHGs emission. According to Agri-environment unit, 38.6 and 18.6% higher carbon emissions were observed in organic amendment of wheat straw and FYM application as compared to chemical fertilizer, respectively. In the finding, incorporation of wheat straw in rice field has not only improved soil health and increased GHGs emission also decreased rice production by 26%, 28% and 17.2% lower than inorganic fertilizer used plots in the year 2007/08, 2008/09 and 2009/10, respectively (AEU 2008, AEU 2009, AEU 2010). Considering the possible impacts on GHGs emission, it is equally important to find out timely mitigation options for reducing GHGs emission. Strong national policy, careful monitoring, evaluation and analysis are required to increase the Organic agriculture practice in Nepal. The objective of this paper is to familiarize organic agriculture, its trend and sustainability along with the introduction of challenges, gaps and constraints.

Effects of organic agriculture on GHGs emission

Agriculture sector contributes 10 to 12 percent of the total estimated GHG emissions each year (FAO 2009). In agricultural system, it is generally considered that emission of CO₂ from soil and its uptake by plants during photosynthesis is a self sustaining system. This means that in the ecosystem the quantity of carbon released from the soil as CO₂ during the year is roughly the same as is fixed by plants through photosynthesis (Pathak et al 2003). But findings showed that emission of GHGs was higher and production was lower due to incorporation of organic amendment in soil. Thus, careful management is required to increase sequestration in the soil than the GHGs emission. Some of the findings regarding organic agriculture and its effects on GHGs emission are as follows:

- 38.6% and 18.6% higher carbon emission was observed in wheat straw and FYM incorporated crop as compared to inorganic fertilizer.
- Incorporation of straw increased CO₂ flux from 0.3 to 1.3 kg CO₂ ha⁻¹ d⁻¹ (Curtin 1998)
- Decreased of rice production by 26%, 28% and 17.2% lower than inorganic fertilizer used plots in the year 2007/08, 2008/09 and 2009/10, respectively.
- 50% urea along with 15 cm wheat stubble applied plot showed 46.4% higher methane emission as compared to chemical fertilizer alone @ 100:30:30 NPK (Malla 2007).
- Application of organic matter such as manure and crop residues enhances chance of methane emission from soil (Chidthaisong et al 1999).
- Lu et al (2000) reported that in irrigated rice fields in southeast China incorporation of organic amendments promoted the CH₄ emission.
- Majumdar (1999) reported that incorporation of rice straw in the soil increased CH₄ production by 1.2-7.9 times over that of unamended soils.
- Wassmann et al (2000) found that a CH₄ flux generated from the application of straw was 3-4 times higher than those generated with use of urea. Application of green manure (*Sesbania rostrata*) gave only 3 fold increase in emission as compared with urea-treated plots.
- Hou et al (2000) reported that rice straw and organic manure increased CH₄ production rate significantly. Thus, organic agriculture is an important practice for human lives as well as in climate change.
- Adoption of C sequestration measures in the soil can considerably reduce the rise in atmospheric CO₂ level (Rastogi et al 2002).
- According to the *Nepal Khadhyia Surakshya Anugaman Pranali* (NeKSAP 2010), the food self sufficient ratio is in decline with the current food grain shortage for the 2009 fiscal year estimated at approximately 400,000 Mt.
- Ammonium sulphate used as nitrification inhibitor decreased methane emission by 51% and carbon emission by 66% whereas Neem oil-coated urea used as nitrification inhibitor decreased methane emission by 29% and carbon emission by 36% (AEU 2008/09).

TREND OF ORGANIC AGRICULTURE

Organic agricultural practices and organic farm is most important practice for human being for safety food production. In Nepal, organic agricultural is in rudimentary stage and only negligible area is under formal organic practice and very few farms have been identified as an organic farm. Recent

trend of organic agriculture is little positive in the world but data shows negative trend with respect to area coverage in Asia. Globally, number of certified organic farms had increased till 1999 then decreased after 1999. Coverage farm land (hectare) in the world showed increasing trend in 2000 - 2008 and found lowest increment in Africa (1 million ha) and highest in Oceania (36 million ha.). In the world, 32.2 million hectares were under organic management in 2007. In 1999, only 11 million hectares of organically managed land has been reported.

Table 1. Trends of organic farm in Asia (ha)

Country	2005	2006	2007	2008	2009	% change
Asia	2678720	3000610	2895760	3551070	3581180	
China	2300000	2300000	1553000	1853000	1853000	48.25728
India	185937	432259	1030310	1018470	1180000	36.31948
Nepal	1000	7762	8194	8498	8059	

Source: IFOAM (2009)

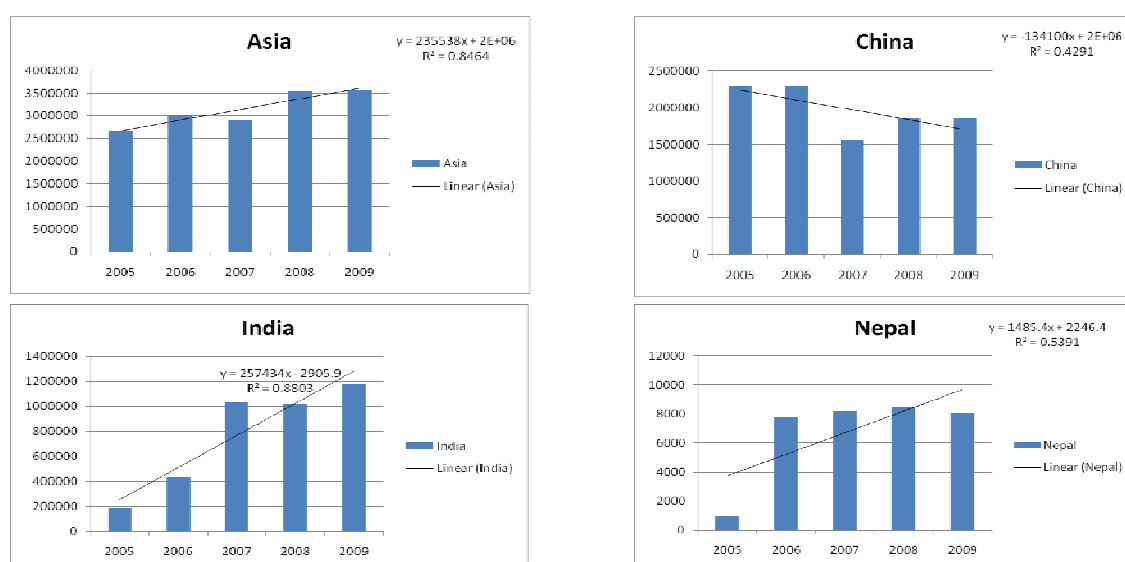


Figure 1. Trends of organic farm in Asia, China, India and Nepal

According to IFOAM, the coverage of the organic farmland in Nepal had been increasing since 2005. There was a steep increase in 2006 with coverage of 7762 hectares to that of 1000 hectares in 2005 and gradually increasing since then to the total of 8498 hectares in 2008. In 2009, there was a slight decrease with coverage of only 8095 hectares in total. It might be due to market problem for organic products and Government policy for the organic farm. In case of India the increase in use of organic farming ranged from 185937 hectares in 2005 to 1180000 hectares in 2009. In India, coverage of organic farm is positive (Fig. 1). In China, there had been a decreasing trend in organic farmland usage ranging from 2300000 hectares in 2005 to 1853000 hectares in 2009 with lowest point of 1553000 hectares in 2007. However, overall organic farmland coverage of Asia was gradually increasing from 2005 (2678720 hectares) to 2009 (3581180 hectares) (Table, 1). China covers 48.25% and India covers 36.31% of total organic farmlands in Asia.

ORGANIC AGRICULTURE AND CLIMATE CHANGE

Organic agriculture (OA) reduces the need for purchased inputs and minimizes pollution by utilizing agri-waste for organic agriculture. Crops with OA are more resistant to disease and insects and hence only a few protective treatments are required. It decreases cost of synthetic fertilizer and pesticide inputs. It has been found that about 2.5% of households of urban areas are consuming organic products and almost 30% are found to have its desire (Bhatta 2008). Sometimes, OA increases yields 70-90% more than conventional farms during droughts (Encyclopedia, Organic farming 2011). Organic farms are more profitable in the drier states of the United States, likely due to their superior drought performance. Organic farms survive hurricane damage much better, retaining 20 to 40% more top soil and smaller economic losses at highly significant levels than their neighbors (Organic farming, Wikipedia). So, organic farms have been found to be as or more profitable than conventional farms.

Nepal is labeled one of the top ten countries most likely to be impacted by global climate change and world's 4th most vulnerable country. Majority of farmers hardly produce enough to feed themselves due to the agriculture's low productivity. Change in weather patterns is affecting in food security and livelihood. Increase in the severity and frequency of extreme weather events, floods and landslides are affecting the crop production. An altitudinal shift in agro-ecological zones due to increased temperatures led to move certain crops and livestock to higher altitudes. There is an increased exposure of new pests and diseases in crops and livestock due to temperature increases.

SUSTAINABILITY IN NEPAL

Sustainability of organic agriculture emphasizes the conservation of its own resources for the practice to be a sustainable; it must produce adequate amount of high quality foods, be environmentally safe, and where appropriate, be profitable. Sustainable agricultural practices, such as organic agriculture, strongly reduce the reliance on external inputs by recycling wastes as nutrient source, using nitrogen-fixing plants, improving cropping systems and landscapes, avoiding synthetic pesticides, integrating crops and animals into a single farm production sector and including grass clover leys for fodder production, while avoiding purchase of feed concentrates (FAO 2009).

Nepal is a developing mountainous country and majority of farmers hardly produce enough to feed themselves due to the agriculture's low productivity. Number of industries is limited in the country and there are no industries that produce pesticides or chemical fertilizers. The little imported chemicals are also out of reach of the farmers in rural mountainous region due to lack of transportation facilities. Majority of farmers are not aware about these chemicals at all. Thus, the scope and sustainability of organic agriculture in the country is positive in future. Since the usage of agrochemicals in cultivation have negative impacts on physical properties of soil and crop productivity as well as in the environment, organic agriculture has scope and is practicable in Nepal due to mountainous country. In the long run organic agriculture will yield more because the soil productivity will not degrade as much compared to the chemical-used agricultural system. Thus, the organic agriculture is more beneficial and suitable system for Nepal in long run only. UN Environmental Programme (UNEP 2008) and UN conference on Trade and Development (UNCTAD) stated that "organic agriculture can be more conducive to food security in Africa than most conventional production systems, and that it is more likely to be sustainable in the long-term. To overcome long term food security problem the system could be helpful but in short run it may increase hunger in the country because of lower productivity.

MITIGATION OPTIONS

Rome 2009 Low Greenhouse Gas reported that there are many areas or techniques that can reduce GHGs emission. Areas for improvement of food production with low GHGs emissions include increased use of no-till cropping, agro-forestry, and integrated crop and animal farming, and decreased use of external inputs in food and agriculture. IPCC fourth Assessment Report has made four important recommendations for mitigating GHGs emission from soils: such as crop rotations and farming system design; nutrient and manure management; livestock management, pasture and fodder supply improvement; fertile soil maintenance and restoration of degraded land. Thus, given practices along with organic agriculture with management of soil is need of country to reduce GHGs emission in the country.

GAPS AND CONSTRAINTS

The reasons behind low coverage of organic agriculture practice in Nepal are as follows:-

- **Technological** - The knowledge of technology in organic agriculture is at a limited level.
- **Economic** - The economic condition is very weak and there are no facilities of subsidies on organic farming and market management.
- **Financial** - There is always a problem of lack of capital in our country. The chances of getting finances for organic agriculture improvement are unlikely.
- **Institutional** - There is very less supporting institutions and no standardizing institution. The legal and regulatory framework is inadequate for organic agriculture in the country.
- **Information** - The farmers do not have adequate access to the technical information about organic agriculture. There is also lack of information to the organic product users, policy makers and other interested groups.

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Technologies for Organic Crop Nutrient Management System (OCNMS) in Nepal: Practices and Promises

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ABSTRACT

Nepal, an agrarian country practicing self-sustained agriculture for generations, was used to be completely organic until late 1950s, and was self sufficient in food. The growing population, then after, necessitated a faster increase in food production, which, and also inspired by the success of “green revolution agriculture” in neighbouring countries, instigated Nepal to introduce high yielding varieties of food crops and agro-chemicals as demanded by them. The mission was successful in increasing food production to some extent. However, the recent decline in the yield of most of the crops, progressive degradation of soil and environment, food poisoning, increased cost of cultivation, etc. have seriously questioned the sustainability of chemical intensive agricultural systems in Nepal. Now about 60% of our agricultural soil has fallen under low category of organic matter content and 67% of the country's soil is acidic in reaction. Unbalanced and unscientific use of urea has created unfavourable conditions for soil health as a result of which the soils have become weak and fertility has been declining at an alarming rate. In search of alternative to chemical agriculture farmers and entrepreneurs have started organic farming with many successful results. Organic agriculture is often appreciated for its various qualities associated with sustainability such as healthy soil and food, self reliance, cost effectiveness, means for climate change mitigation and adaptation and, so on. However, organic agriculture in Nepal is still in infant stage and the country has to travel very long to make it practical and popular. The main limitations associated with organic agriculture in Nepal are lack of technology, awareness, policy attention and market. This paper describes about existing organic technologies being practiced for crop nutrient management at local levels; their successful evidences and means and ways for their improvement; research and development initiatives on them; and industrial technologies being promoted by the entrepreneurs along with their opportunities and limitations in making organic agriculture widely adoptable in Nepal.

INTRODUCTION

Agriculture is the backbone of Nepalese economy, which contributes about 35% to gross domestic product (GDP) (MOAD 2012) and provides employment to more than 65% of the workforce in the country (CBS 2011). Although the number of people depending on agriculture and the share of GDP contributed by agriculture are declining in recent decades, agriculture still remains the main source of livelihood of majority of the population in the country. Growing seasonal agricultural commodities using traditional knowledge with moderate yield in a self-sustained way by maintaining soil fertility and productivity through the proper land use; use of crop and animal by-products, suitable crop rotation, keeping the land fallow, etc were the typical features of Nepalese agriculture. This subsistent type of agriculture with extensive land use pattern was sufficient to feed the limited population till 1970s and the country even could export agricultural commodities to the neighbours. However, this type of production system could not support the growing population any further then after.

Increasing crop production to fulfil the food requirement of the people became the dire need of the time. As necessitated by the need to produce more food and, at the same time, inspired by the success of Green Revolution Agriculture in neighbouring countries and rising support by developed countries, Nepal started to modernize her agriculture by introducing high yielding varieties mainly of rice and wheat. As the varieties were high yielding, their fertilizer requirements were also high and introduction of chemical fertilizers became indispensable. Since then, Nepalese agriculture witnessed many transformations regarding the use of external inputs through the development and introduction of newer and more productive varieties of various crops and associated package of practices. The country through the past developments plans has also made significant efforts to increase agricultural production and productivity. Such efforts were fundamentally guided towards promoting intensive use of Green Revolution-based technologies and off-farm agricultural inputs such as chemical fertilizers, pesticides and improved breeds/varieties and planting materials (NPC 2010). Till date, fertilizer has been one of the prioritized inputs to enhance agricultural production and considered important to meet national food needs. Import and distribution of fertilizers in the country increased significantly after fertilizer control order 1998 and national policy 2002, decreased gradually with abolition of price subsidy on it and, following relocation of the subsidy in April 2009, increased abruptly (Pokheral 2012).

In such ground, traditional knowledge and local resources-based self-sustained and subsistence type of Nepalese agriculture has been gradually transforming to unsustainable type. The use of external inputs such as chemical fertilizers, pesticides and hybrid seeds is becoming important to the commercial pockets being developed in the accessible areas, regardless of their deleterious effects on human health, environment, natural resource and resilience of the ecosystem, farmers' livelihood and state economy.

Soil fertility management is the key to any successful agricultural production system and generally crop production is often limited by deficiencies of soil nutrients. Mineral fertilizer application in Nepal has supplied only a fraction of total nutrient requirements for the cropping systems as nutrient consumption in Nepal is one of the lowest in Asia (40 kg/ha) and is highly imbalanced as well in terms of N, P and K application (MoAC 2011). This is mainly due to unavailability of required type and amount of chemical fertilizers on time. On the other hand, annual fertilizer supplies in the country during two last two decades showed a high negative correlation with net annual edible cereals productions indicating at least that the state expenditures on fertilizers import and price subsidies is not contributing much to enhanced food production (Pokheral 2012). Not only this but continuous application of chemical fertilizers without organic manures has also caused decline in soil fertility in Nepal (Bhattari 2000) affecting various aspects of soil quality. Khadka (2012) states that soil quality could be deteriorated particularly physico-chemical properties as well as microbial activities in the soil system if continuous application of chemical fertilizers without addition of organic manures is done. Similarly, RSLT (2006) has reported that physical properties of the soils in the western mid hills of Nepal are deteriorating day by day due to sole use of chemical fertilizers with 80.9% of soils falling under acidic category. In this context maintaining soil fertility through organic means is key to sustainable, productive and healthy agriculture. Keeping this fact in view, the 20 year Agriculture Perspective Plan (APP) has also emphasized a boost in productivity to meet the needs of the growing population without deterioration soil and environment.

History of Nepalese agriculture development and the research indicate that the organic farming has been the integral part of agriculture system in this country for the time immemorial. Recent sustainable soil and nutrients management research studies have shown that there is higher sustainability potential in organic agricultural system than in fossil energy- based modern (chemical intensive) agriculture (KC 2006). However, at present due to various reasons, the application of chemical fertilizers is leading over organic manures rendering unsustainably to agricultural system.

This paper attempts to highlight on various organic methods of maintaining soil fertility being adopted by the farmers traditionally and the new methods that have emerged recently along with their promises and limitations.

METHODOLOGY

The article is based on the browsing of the literature available, internet search, information obtained through direct conversation with concerned individuals (face to face and in telephone), and visit to some of the farms conducted during September 2011-March 2011.

RESULTS AND DISCUSSION

Organic agriculture in a perspective

Organic agriculture is not an uncommon concept and practice in Nepalese context. Over centuries, resource poor farmers are doing such practices in traditional way, which is similar to present day organic agricultural movement. Organic agriculture is one of the valuable properties inherited from generation to generation in our rural communities (KC 2006) and it is also a life style and dignity of majority of Nepalese farmers.

Organic agriculture has been defined basically following two schools of thought: one is limited to technological realm whereas another one straddles whole way of living. The definition given by International Alliance for Sustainable Agriculture (1990) - "Organic agriculture/farming is a system of agriculture that encourages healthy soils and crops through such practices as nutrient recycling of organic matter (such as compost and crop residue), crop rotations, proper tillage and the avoidance of synthetic fertilizers and pesticides" represents the first school of thought (Reijntjes and Waters-Bayer 1992). The definition given by the International Federation of Organic Agricultural Movement (IFOAM, 2008), "Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved" represents the second school of thought. The common in these definitions is the "health of soils", which is the core of organic agriculture. Organic farming believes on the vicious cycle of healthy relationship among the components of agricultural system: healthy soil - healthy crop- healthy food- healthy people- healthy ecosystem-healthy world. The importance of utilizing available biodegradable waste materials to build and maintain soil fertility and humus content remains the central point of organic agriculture. This can be realized through the living and pragmatic connection between soil fertility and plant and animal health, and soil health and productivity are maintained by regular inputs of organic matter.

Organic crop nutrient management (OCNM)

Nutrient management is a system used by farmers to manage the amount, form, placement, and timing of the application of nutrients (whether as manure, commercial fertilizer, or other form of nutrients) to plants. The purpose is to supply plant nutrients for optimum crop yields, to minimize non-point source pollution (run-off of pollutants to surface water) and contamination of ground water, and to maintain and/or improve the condition of soil (NRCS 2006). If the management system in crop production is exclusively based on organic inputs, it is organic crop nutrient management.

Traditional organic nutrient management system in Nepal

Crop rotation. Use of location specific suitable crops and their spatial and temporal combinations (healthier cropping pattern) through the maintenance of high level of agro-biodiversity has long been

the key to sustainable agriculture in our country. Incorporation of grain legumes in various forms is still popular among farming communities. The popular maize-soybean intercropping of Kathmandu valley; planting of soybean in rice bonds in hills; planting of winter legumes in rice field in terai; mixing of wheat and pea/chickpea in inner terai are some of the examples of this practice. Similarly, mung bean is getting popularity among the rice-wheat farmers to plant between wheat and rice to catch fallow period as well as to enrich the soil. Table 1 shows the contribution of grain legumes, in addition to human nutrition, to maintain soil fertility through nitrogen contribution to the field.

Table 1. Amount of nitrogen (kg/ha) fixed by various legume crops in the field

Crop	Amount of nitrogen fixed
Horse gram	45-552
Cow pea	73-354
Chick pea	103
Lentil	88-115
Beans	40-70
Pea	52-77
Soya bean	60-168
Ground nut	72-124
Mung bean	63-342
Pigeon pea	168-280
Dhaincha	73-354

Farm yard manure (FYM or *Gotha mal*). FYM, a varying mixture of animal manure, urine, bedding material, fodder residues, and other components, is the most common form of organic manure applied in the mid hills of Nepal (ICIMOD 2008). It consists of three main components namely litter, like straw or other vegetable refuse, dung and urine of animals. Composition of farmyard manure varies according to the composition of these components and the proportion in which they are present. Table 2 shows the general features of animal dung. Generally, the dung of a young growing animal is poor in manurial ingredients than that of an adult animal. A working animal excretes dung of a richer quality than an animal at rest. Similarly, the dung of milking cow is poorer than that of a dry cow.

Table 2. Average nutrient content of the dung of farm animals (% on original matter)

Ingredient	Horse	Cattle	Buffalo	Sheep	Pig	Poultry
Water	76.8	82.4	81.1	61.9	80.7	57.0
Organic matter	21.0	15.2	12.7	33.1	17.0	29.3
Mineral matter	3.9	3.6	5.3	4.7	3.0	-
Nitrogen	0.47	0.30	0.26	0.70	0.59	1.46
Phosphorus	0.30	0.18	0.18	0.51	0.46	1.17
Potash	0.30	0.18	0.17	0.29	0.43	0.62
Lime	0.17	0.36	0.46	0.46	0.09	-

Source: INSEDA, undated

Indigenous methods of preparing and using farmyard manure vary widely depending on the ecological zone, access to bedding material from crop or forest land, access to crop residues and fodder, labor availability, and other factors. A prerequisite for the manure having a positive impact on soil fertility is that it is properly decomposed. The application of partially decomposed manure can increase the number of white grubs, red ants and other soil pests. On an average the traditional FYM contains 0.5% nitrogen, 0.25% phosphorus and 0.5% potash. Only about half of the nutrient content of farmyard manure becomes available for crop growth during the first year after it has been applied to the soil – the rest is channeled through soil biotic processes and the nutrients are released in the following years. In addition, FYM has a high proportion of organic material which nurtures soil organisms and is essential in maintaining an active soil life. The high organic matter content and the

active soil life improve or maintain friable soil structures, increase the cation exchange capacity, water holding capacity, and infiltration rate, and reducing the risk of soil pests building up.

While discussing about the use of animal manure in farming majority of our farmers generally seem to be more concerned with the dung and seldom think of proper use of urine. Almost the whole of urine is wasted as it is not properly collected. However, in recent years, proper collection of urine through improved cattle shed and its utilization for crop nutrient and pest management is being very popular with many success stories the among the farmers especially in working districts of Sustainable Soil Management Project (SSMP) in the mid hills of Nepal (Helvtas 2009).

Dung contains greater amounts of phosphorus and lime than that in urine, while the urine is richer in nitrogen and potash. When taken together dung provides nearly 55% of the total nitrogen, almost the whole of phosphorus and about 30-35% of total potash excreted by an animal. Using both dung and urine together makes good manure (INSEDA undated).

The problems associated with FYM are its preparation and handling. Studies have shown that quality of manure especially N content can be enhanced by 2-3 times through the proper selection of bedding materials; better mixing them with urine and dung; allowing better decomposition, protecting it from rain and direct sunlight; proper handling during application and so on (Regmi et al 2006; Subedi and Regmi 2006). However, common practice followed by our farmers is applying FYM in early spring season long before the field is ploughed, which severely reduces its use efficiency. A study has shown that that if FYM is not incorporated immediately in soil after application in the field and exposed to sun for 12 hours, 7% N is lost, if the exposure is for 36 hours, the loss is 23% and if it is 7 days, the loss is 36% (Khatiwada and Pokharel 2005). Thus, a large amount of nitrogen can be saved by properly handling FYM in the field by making small piles in the field, keeping them covered and broadcasting it just before ploughing. Recently, farmers in the mid hills have initiated this practice as well.

Penning animals in the field. When the field becomes vacant in the winter, farmers take their cattle outside the shed and pen them for few months in the field. The penning remains shifted covering the entire field of the farmer so that every parcel of the land gets manured. This is very important in the sense that the soil gets soaked by urine, even if the dung dries quickly as there is no provision of preserving the dung. The efficiency may be very low because the land is exposed to sun which coincides with windy season. This system is still common in many hilly areas and inner terai uplands. Farmers have reported that the crop yield in individual patches may be up to 50%.

Transhumance pastoralism. This is very important indigenous system of keeping livestock mainly sheep and goat in which the herder moves to high mountain in summer and comes down in winter. While coming down to valleys, the communities decide to pen the herd in fields, which remain vacant at that time, by rotation. For this, an individual land owner has to help in constructing the shed or pen for the herd and provide food to the herder. This system has very big role in maintaining fertility of the soil in such agricultural systems. While visiting some villages in Lamjung the author found the villagers much appreciating the system for fertilizing the land. Unfortunately, this system is facing several problems mainly due to the labour shortage, shrinking grazing land, community forestry, etc.

Compost. Organic matter that is prepared by mixing and decomposing of crop residues, forest litters, feed residues, kitchen wastes, etc. by heap or peat method, and used as soil amendment, is compost. Compost is a key ingredient in organic farming. Collecting litters from forest and plant materials from wastelands around the farm along with the weeds from the farm, and using them for fertilizing the land is common to most of the farmers especially in the hills and valleys. Common plants that are used for composting are *Eupatorium* spp., *Adhatoda vasica*, *Artimisia vulgaris*, *Bidens pilosa*, *Cassia*

tora, *Shima wallichii*, *Vitex* spp. Modern methodical composting is a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials, adding water and ensuring proper aeration by regularly turning the mixture. Not many farmers in Nepal follow the process as such, although many organizations involved in sustainable agriculture train the farmers in this line. Composting is mostly popular among the farmers who lack FYM. One study in Lamjung showed that only 46% of the farmers used compost whereas 100% of them used FYM. On average well composed compost contains 1% nitrogen, 0.5% phosphorus and 1% potash. In addition, compost enhances microbial activities, improves water holding capacity, ameliorates pH and promotes the overall soil productive capacity of the soil (Khatiwada and Pokheral 2005). Research has shown that the application of well decomposed compost @ 30 ton/ha increased the yield of cabbage head significantly as compared to recommended dose of chemical fertilizers (120:60:40 N:P:K kg/ha), and similar was the result in cauliflower where the head yield of 19.35 t/ha of fresh weight was obtained with the application of 30 t/ha of well decomposed compost as compared to 17.03 ton/ha produced with the application of 120:60:40 N:P:K kg/ha (Khadka 2012).

According to farmers, the compost is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, and addition of life to soil and as a natural pesticide. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover. In recent years, use of city waste in agriculture through composting is gaining popularity.

Poultry manure. In the areas where poultry industries are developed, manure from chicken sheds is also popular. Poultry manure is an important source of soil nutrient supplement as it contains on average 3% nitrogen, 2.6% phosphorus, 1.4% potash (Bhandari 2006). The main concern in using this manure is the bad odour while handling, and the level of decomposition at the time of application. Not well decomposed manure (consists mainly of rice husk as litter) often carry weed seeds and creates problem. Not only this, but this also cause short-term nitrogen deficiency in the crop if used such manure just before planting.

Oilcake. Oil cake, mainly mustard cake, is also good quality manure used by the farmers depending upon its availability. It contains 2-8% nitrogen, 0.8-3% phosphorus, 1-2.2% potash with quickly soluble nitrogen. However, recent decline in mustard cultivation has reduced the availability of this manure. Similarly, farmers prefer to feed cake to cattle rather to use in the field.

Biogas slurry. Increasing national and international interest in biogas plants has created an opportunity to avail its slurry for use as manure. The slurry contains 1.5% nitrogen, 1% phosphorus and 1% potash. Research conducted with biogas slurry in vegetables has shown an increment in yield by 10-30% (Bhandari 2006). However, handling and storage of slurry is very critical, as generally farmers let the slurry to get exposed to sun and rain when it comes out from the plant and the loss of nutrient is inevitable.

Mulching. Though limited only in few crops such as zinger, turmeric and few vegetables in kitchen gardens mulching is an important system of enriching soil with organic matter and thereby making the soil fertile. Mulch has many other benefits as well like regulating the thermal regime of the soil, suppressing weeds, sequestering carbon, etc. Positive effect of mulch even in rice crop has been reported by Gurung et al (2009).

Green manuring. Green manuring is a practice of ploughing or turning into soil fresh green plant residues for improving the soil fertility and scale of plant nutrition (Gaur 2011). The importance of green manuring in agriculture has been recognized from early times in our country but not in the form of *in-situ* manuring as it is commonly understood by many people at present. *Ex-situ* manuring of rice wet seed bed or rice fields by bringing leaves and twigs of plants preferably from legume family

growing around and incorporating them in the soil is being practiced in the mid hills. Incorporation of mung bean plants after harvesting the pods during field preparation well before rice transplanting is also becoming more and more common in the places where water is not a problem for the germination of the crop and later for decomposition. Green manuring practice especially *in-situ*, although it is well practiced in research stations and documented in papers, is not common in our farmers' field partly because of lack of water and partly because farmers do not want to sacrifice the field at the cost of food crop i.e., maize in most of the cropping patterns. Growing of cow pea preceding rice crop seems very beneficial as it contributes 65 kg/ha of nitrogen in addition to 500 kg/ha of grain (John et al 1989). Similarly, mung bean can contribute 50 kg of nitrogen along with one ton of grains (Meelu et al 1986). Planting of fast growing multipurpose trees in waste/community lands and using them for *ex-situ* green manuring purpose should be encouraged as it serves other good purposes as well.

Non-traditional organic nutrient management system in Nepal

Vermi-compost. Vermi-compost is the compost produced by the conversion of solid wastes of animal and plant origin into valuable organic manure under aerobic conditions through the activity of earthworms (Gaur 2011). *Eisenia foetida* is the species of earthworm used for the production of vermi-compost. Generally vermi-compost contains 2% nitrogen (up to 4.4%), 1.75% phosphorus, 1.5% potash, 1% micronutrients, 12-15 C:N ratio and has pH of 7-7.5. In addition, it contains many beneficial organic compounds useful for soil and plant life. However, the quality of the product depends on the materials that are fed to the worms. Vermi-compost can be easily handled, stored or directly used on land without any negative effect on the environment. A research in Khumaltar showed higher yield in wheat and maize in vermi-compost applied plots than that in only compost applied plots (Khatiwada 2005). At present, vermi-compost is getting popularity among our farmers as it is produced in the country by many individual farmers, and by entrepreneurs in commercial scale. Moreover, the government has issued the rule that farmers seeking to get chemical fertilizers in subsidy should include vermi-compost in the package. Not only this, the government has also provisioned subsidy in equipment for those who want to establish factory in the country to produce bio-fertilizers including vermi-compost. However, the quality of the product and the effect of alien species of earthworm on soil ecosystem in the long run remains considerable concern.

Gitimal. Gitimal is a liquid manure and is prepared by fermentation of cattle urine along with decomposition of some locally available indigenous plant species of various properties. The leaves of locally available indigenous plant species like Bojho (*Acorus calamus*), Pudina (*Mentha piperita*), Timur (*Zanthoxylum armatum*), Neem (*Azadirachta indica*), Asuro (*Adhatida vasica*), Titepati (*Artimisia vulgaris*), etc. are chopped into small pieces of about 5- 7 centimeters. The chopped leaves along with detergent soap and water are put into the drum containing urine and the mixture is allowed fermenting for 15-30 days under air tight conditions. The decomposed leaves attain foul smell and yellowish colour, which is an indication of completed fermentation and the ready product as liquid manure is called Gitimal. The liquid is then filtered with a thin cloth and stored in a cool place for agricultural use. Before its use to crops, this is diluted with water in the ratio of 1:5-8 times, depending upon the crop and nature of the pests. The quantity of water for dilution is decreased when the plants become mature. It can be used for spraying or drenching. *Gitimal* supplies nutrients to the crop plants as well as acts as a preventive measure against insects and disease attacks. *Gitimal* has no single standard for its preparation. Farmers have been practicing their own experiences for its production. They are using locally available types and kinds of indigenous plants, sometimes more than those mentioned above. For example, Chandrajyoti Integrated Rural Development Society uses leaves of Titepati 2.0 kg; leaves and grain of Timur 1.5 kg; leaves of Neem 1.0 kg; leaves of Asuro 0.5 kg; leaves of Bojho 0.5 kg; leaves of Pudina 0.5 kg; detergent soap 0.25 kg; water 5.0 litre; and cattle urine 15.0 litre. This preparation is one of the most common locally made inputs and is very popular among the organic or IPM farmers. According to the farmers, application of *Gitimal* has dual

benefits of nourishing the crops as well as protecting them from pests (Jyoti Sharma, Personal communication).

Bokashi. Bokashi is a Japanese word for the manure prepared by decomposing the locally available materials of plant and animal origin. Generally, prescribed ingredients are 100 kg of rice bran, 10 kg of bone meal, 10 kg of oil cake, 150 ml of effective microorganism (EM), 150 gram of loaf-sugar (sakhkhar) and 15 litres of water. The product is prepared following a certain process in which EM and loaf sugar is mixed in water first and is kept it for 48 hours. Then the materials mentioned above are collected and soaked with the EM solution already prepared. The materials are kept in a room avoiding the direct rain or sunlight by covering the mixture with plastic. The mixture is turned once in 4-5 days. It takes bokashi to be ready for use in 15 days in summer and may take up to 40 days in winter. Other ingredients such as ash, charcoal, forest soil, etc. can be added depending on the availability. The preparation is reported to enhance the crop yield and soil quality.

Industrial biofertilizers. In recent years, many products produced in the country as well as imported from outside, are floated in the market and are being advertised daily as successful aids to organic agriculture. Some of them are Bio-organic fertilizer (IAI, Nepal); Bio-organic fertilizer (Asia Agrotek, Thailand); *Jaibik* Superphosphate (P), *Jaibik dhulo* (N) and plant tonic, *Jhol mal*, (Lumbini Agro Organic Fertilizers Pvt Ltd.); Chao Nang granules, Super green plus, Super green plant, Super green mix (Thailand), HB 101 (NAF Pvt Ltd., Nepal), Bonsoon Super *Prangarik Mal* (BBPI, Pvt, Ltd. Nepal); Primimum Azosp, Primimum phospofix, Primimum Azotoplus (IPL, India); Quine Thang (Thailand) Green Gold Super *Prangarik Mal* (GGI, Kathmandu, Nepal) and many more, and the list is ever increasing. These products may not be completely futile and may contribute to the promotion of organic agriculture in Nepal. However, their quality and consequent effect on the field and ecosystem have not been well tested so far under our conditions. Since the country has no regulatory mechanism to control over the production, import and sells of such products, farmers are relying on advertisements and are using the products.

Organic agriculture is not new concept and practice for most of the Nepalese farmers. The renewed interest in organic production system in the present context of chemical-based modern agriculture is aimed at production of healthy food from healthy soil and maintains agricultural sustainability. To keep the productivity capacity of soil retained, soil and crop nourishment practices based on organic management is of paramount importance. Nepalese farmers are maintaining soil fertility and productivity through various means and commotion, as a whole known organic crop and soil nutrient management (OCNMS). Most of the practices are traditional and need verification through research and refinement. Recent new inputs and technologies for the same purposes being floated in the market also need verification and regulation which will be helpful in making organic agriculture productive and popular in Nepal.

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Crop Disease Management through Eco-friendly Tools

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ABSTRACT

Managing plant diseases without using chemical pesticides has been a challenge to the growers to keep their production in acceptable level. There are several non-chemical tools for eco-friendly management of diseases, such as use of resistant varieties, biocontrol agents (eg, *Trichoderma* spp.), cultural practices (eg, crop rotation), organic amendments in soil (eg, mustard cake, biogas slurry), botanicals (eg, garlic clove extract, mugwort extract, nettle extract) and certain non-hazardous chemicals (eg, elemental sulphur, copper, potassium). Of them, using resistant varieties is the most effective approach. Grafting technology using resistant root stocks has been successful for managing some soil-borne diseases (eg, wild eggplant against root-knot nematodes and bacterial wilt in solanaceous vegetables). Some of the technologies, especially the biocontrol agents and the botanicals have shown success under controlled conditions. Most of such technologies are limited to controlled conditions and hence should be verified in the field conditions. Non-chemical tools generally do not give 100% control but those can be effectively used as the components of integrated disease management for their additive efficacy. Available non-chemical tools from research results and the literatures for the management of diseases of different crops are presented.

INTRODUCTION

Managing plant diseases without using chemical pesticides has been a challenge to the growers to keep their production in acceptable level. Pesticides use especially in vegetable farming is of great concerns as vegetables are consumed uncooked or raw as well. It is a general practice in our conditions that farmers do not wait for required period for harvest after the use of pesticides. Some awareness has been raised towards safe and minimal use of hazardous pesticides by utilizing environment friendly and indigenous technology for producing safer food for consumption and to maintain healthier environment.

Researches have been conducted on different non-chemical aspects. That include use of host resistance, cultural practices, biological control, botanicals, organic amendments, non-hazardous substances and several other methods. Non-chemical tools, especially biological agents generally do not show consistency in effectiveness under field conditions though they are effective under controlled conditions. This paper presents some of the research findings conducted by Plant Pathology Division and other research stations of NARC, and also list some technologies reported from other sources.

HOST RESISTANCE

Host plant resistance has been an important tool for achieving sustainable crop disease management though it is a relatively long-term activity. Use of resistant varieties is the easiest, safest, economical and efficient method for the control of plant diseases. Searching for resistance against various diseases of different crops has been conducted for major diseases of various crops as an integral part of research at Plant Pathology Division, various commodity research programmes and research stations of NARC. Followings are the resistant/tolerant varieties of crop plants to some of the major diseases:

Rice

Blast (*Pyricularia oryzae*): Khumal-2, Khumal-4, Khumal-5, Khumal-7, Khumal-9, Khumal-11, Palung 2 and Machhapuchhre 3, Chhomrong, Chandannath 1 and Chandannath 3, Sabitri, Laxmi, Rampur Masuli, Mithila, Ram Dhan, Hardinath 1, Radha 4 and Radha 12, Sukha Dhan 1, Sukha Dhan 2, Sukha Dhan 3, and Tarahara 1

Foot rot (*Fusarium moniliforme*): Kanchan, Himali and Taichung 176

Bacterial blight (*Xanthomonas oryzae* pv. *oryzae*): Sabitri, Makwanpur-1, Radha-4, Radha- 7, Radha-11, Radha -12, and Hardinath-1

Maize

Gray leaf spot (*Cercospora zeae-maydis*): Ganesh-1, Manakamana-1, Manakamana-3 and Deauti

Northern leaf blight (*Exserohilum turcicum*): Manakamana-3 and Ganesh-1

Ear rot (*Fusarium moniliforme*): Kakani yellow

Wheat

Yellow rust (*Puccinia striiformis*): WK 1204, Pasang Lamhu and Gautam

Foliar blight (*Bipolaris sorokiniana*/*Drechslera tritici-repentis*): Achyut, Rohini, Brikuti and Gautam

Lentil

Wilt and root rot (*Fusarium solani*): Shikhar, Simal, Simrik and Khajura-1

Chickpea

Botrytis gray mold (*Botrytis cineria*): Dhanush, Gaurav and Tara

Potato

Late blight (*Phytophthora infestans*): Khumal Seto 1, Khumal Rato 2, Janakdev, NPI 106

Wart (*Synchytrium endobioticum*): NPI 106, Cardinal, Krufri Jyoti, Khumal Seto 1, Khumal Rato 2, Janakdev

Bacterial wilt/Brown rot (*Ralstonia solanacearum*): BR 63-73, MS 35-22, BR 63-65

Peppers

Phytophthora blight (*Phytophthora capsici*): Pepper hybrids such as Tara, Premium, NS 1701, Karma 757, Chandani and Angarika

Tomatoes

Late blight (*P. infestans*): Hybrids such as Arka Alok and KWR

Bacterial wilt (*Ralstonia solanacearum*): Hybrids such as Srijana, CLN 2026 C and CLN 2026 D

Eggplant

Bacterial wilt (*Ralstonia solanacearum*): TS 64, EG 203, EG 190 and EG 190

Cauliflower and cabbage

Clubroot (*Plasmodiophora brassicae*): Cauliflower hybrids such as Clapton A, Clapton B, Clarify A and Clarify B, and Cabbage hybrids such as Tekila, Kilaherb, Kilaton, Kilaxy and Kilazol

CULTURAL PRACTICES

Many cultural methods have been practiced by farmers. They are environmentally safe and compatible with other control measures. Modifications in different usual cultural practices in the cultivation of different crops have contributed in reducing disease severity or incidence. Recommended cultural practices have been listed by Amatya et al (1992). Some of the researched cultural practices are given below.

Seedling age effect

Age related resistance play an important role in reducing certain soil-borne diseases. Older seedlings of 7 weeks or more had reduced clubroot severity in cauliflower compared to younger seedlings of 4 weeks (PPD 2001/02).

Mulching/Flooding

Mulching/flooding in soil surface is useful in reducing infection with certain soil-borne pathogens thereby reducing disease incidence or severity. Mulching with rice straw reduced stalk rot (*Sclerotinia sclerotiorum*) incidence by 71% in cauliflower (Timila and Shrestha 1999). Flooding of stalk rot infested field for three weeks reduced the disease in cauliflower.

Planting date manipulation

Some of the diseases can be managed by manipulating planting dates that skip the most favorable conditions for disease development.

- Early planting (3rd week of February to 2nd week of March) reduced rust (*Uromyces appendiculatus*) in bean by 33-53% (Timila and Shrestha 1998).
- Late planting by 2 weeks (third week of July planting) reduced late blight of tomato compared with the first week of July planting under the mid hill conditions (Shrestha and Ashley 2007).
- Late sowing (last week of November to first week of December) compared to second week of November reduced botrytis gray mold severity in chickpea (Joshi 2001).

BIOLOGICAL CONTROL

It is one of the potential tools for the management of plant diseases especially of soil-borne nature. However, their efficacy is higher under controlled conditions. Their efficacy may vary with location, environment and soil conditions. Researches have been conducted using *Trichoderma* spp. and some other bio-agents against various diseases.

Clubroot of Brassica vegetables

Three species of *Trichoderma*, *T. harzianum* (T22) and two native isolates (T69 and TS) reduced clubroot severity by 35-40% in the field conditions at farmers' fields in Makwanpur (Timila 2011).

Damping-off of radish

Trichoderma harzianum, *T. auroviride*, and one native isolate of *Trichoderma* reduced damping-off of radish caused by *Rhizoctonia solani*. The disease was reduced by 50-80% in pot trials (PPD 2001).

Phytophthora blight of pepper

Gliocladium virens and *Trichoderma harzianum* (T22) significantly reduced Phytophthora blight (*Phytophthora capsici*) of pepper by 27 and 38%, respectively under greenhouse conditions (Timila 2004).

Seed-borne infection of wheat

T. harzianum (T22) and one native isolate (A23) increased germination of wheat seed infected by *Bipolaris sorokiniana* and significantly reduced root rot in pot trial (PPD 2007).

Botrytis gray mold of chickpea

T. viride reduced Botrytis gray mold (*Botrytis cinerea*) severity significantly in chickpea (Joshi 2001).

Blast disease of rice

A non-rice pathogen *Bipolaris sorokiniana* and avirulent isolates of *Pyricularia oryzae* reduced neck blast (*Pyricularia oryzae*) in rice significantly when sprayed at booting and heading stage (Manandhar et al 1998).

BOTANICALS

A large number of plant species have been reported having pesticidal properties. Of them, only a few are known for fungicidal or antibacterial activity. Some results obtained at PPD, Khumaltar are given below and other reports are summarized in table 1.

Garlic clove (*Allium sativum*)

Drenching of twelve percent garlic clove extract reduced clubroot incidence by 52% and Phytophthora blight of pepper by 71% under screen house conditions (PPD 2009) and reduced seed infection of wheat with *Bipolaris sorokiniana* by 62% (PPD 2008).

Sichuan pepper (Timur) (*Zanthoxylum armatum*)

Timur fruit extract (10%) reduced bacterial wilt incidence in tomato by 53% and 18% under screen house and field conditions, respectively (Timila and Shrestha 2001). Application of 50 kg timur powder per ha found effective to manage rhizome rot (*Fusarium/Rhizoctonia/Pythium* complex) of zinger (Choudhary 2008).

Nettle (*Urtica dioica*)

Nettle extract in cattle urine (1 kg in 5 liter) diluted with water at the ratio of 1:4 spray reduced powdery mildew (*Erysiphe cichoracearum/Sphaerotheca fuliginea*) and downy mildew (*Pseudoperonospora cubensis*) of cucumber (Gautam and Gauli 2007).

Simali (*Vitex negundo*)

Foliar spray of 10% extract of Simali reduced 45% seed-borne infection of *Bipolaris oryzae* in rice (PPD 2008).

ORGANIC AMENDMENTS

Mustard meal

Mustard meal amendment in soil reduced *Phytophthora* blight incidence in pepper by 77% and 35-63% under greenhouse and field conditions, respectively (Timila 2004). It also reduced root knot nematode galling index in tomato by 50% under field conditions (PPD 2010).

Biogas slurry

Biogas slurry amendment in soil reduced root knot nematode galling index by 48% when used 250 g per tomato plant under plastic tunnel (PPD 2009). Farmers of Hemja in Kaski district are using this technology.

Table 1. Some botanicals reported for managing diseases

Name of Botanicals	Preparations	Target Plant Disease	Reference
Ginger (<i>Zingiber officinale</i>)	Pure powder 20 g in one liter water	Collar rot of potato	Budhathoki (2006)
Turmeric (<i>Curcuma longa</i>)	Turmeric powder:ash @ 1:4	Powdery mildew	Budhathoki (2006)
Onion (<i>Allium cepa</i>)	50 g in one litre water	Leaf spot and Collar rot of different vegetables	Budhathoki (2006)
Pire jhar (<i>Polygonum hydropiper</i>)	50 g in 2 litre water	Blight diseases of tomato and carrot	Budhathoki (2006)
Neem (<i>Azadirachta indica</i>)	One ml Neem oil in one litre water	Stem blight and root rot	Budhathoki (2006)
Chilli powder	100g in 1 litre water/soap water soaked overnight and diluted to 1:5.	Viral diseases	Anonymous (2006)
Tobacco leaves and stem	Tobacco leaves and stem in water (1:15) boiled for half hour and diluted to 1:4	Rust of bean	Anonymous (2006)
<i>Symbucus nigra</i>	Flower and leaves, 400-550 g in 3 litre water (boiled, cool and spray)	Powdery and downy mildew of cucurbits and beans	Anonymous (2006)
Lemon grass	250 g paste and dilute in 4 litre water	Blight disease of potato and tomato	Sapkota (2005)
Agave	Aqueous extract	Bacterial leaf blight of rice	Sapkota (2005)
Papaya (<i>Carica papaya</i>)	1 kg/lit water mixed with soap water (16 g/lit water) @ 1:4	Blight disease of coffee and powdery mildew	GC (2067 BS)
Chinaberry, (<i>Melia azadirach</i>)	1 kg leaves in 5 litre water	Soil borne pathogens	SSMP (2059 BS)
Marigold (<i>Tagetes</i> spp.)	Intercropping with main crops works as trap crop	Nematode diseases	GC (2067 BS)
Tulsi (<i>Ocimum sanctum</i>)	0.1% steamed aqueous extract	Blast of rice	Tewari (1998)

OTHER ORGANIC AND INORGANIC SUBSTANCES

Most plant diseases are reduced by proper application of potassium nutrition (Hedge et al 1998). Application of potash in soil reduced foliar blight of wheat by 70% and increased grain yield by 98% (Sharma et al 2004). Foliar spray of dipotassium phosphate and ferric chloride reduced neck blast (*Pyricularia oryzae*) in rice significantly when sprayed at booting and heading stage. Some other substances reported for managing plant diseases are listed in table 2, but most of them are yet to be verified experimentally.

Table 2. Some other substances reported for managing plant diseases

Materials	Preparation and application	Plant diseases	Reference
Milk	250 ml and 250 g sugar spray in the morning	Viral diseases	Anonymous 2006
Cattle urine	Cattle urine stored for 10-15 days and diluted to 1:5 and spray	Root and stem rot of beans, mosaic virus and powdery mildew of pepper	Anonymous 2006
Cow dung	2-3 handful in 10 liter of water and spray each day for 14 days	Mosaic of tomato and pepper, bacterial leaf blight of rice	Bhandari 2063 BS
Loamy red soil	Apply as paste*	Stem rot of tomato	
Sodium bicarbonate	1.5 g/l, spray weekly	Powdery mildew	Bhandari 2063 BS

*Farmers' practice

GRAFTING

Grafted tomato plants in the root stock of wild eggplant (*Solanum sysimbriifolium*) resistant to root knot nematodes had no nematode galls and double yield compared with the non-grafted plants at Hemja in Kaski under plastic tunnel (PPD 2009). This technology has been adopted by nursery growers and farmers of Kaski and Syangja districts.

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Varietal Response of Different Tomato Cultivars to Organic Materials in Rainy Season in Tanahun, Nepal

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ABSTRACT

A field study was carried out to evaluate the performance of the different tomato (*Lycopersicum esculantum*) cultivars under organic and off-season conditions in GSOARC organic farm, Pokharelphant, Tanahun, Nepal from August to December 2010. Treatments were varieties with nearly equal potential yield, comprising BL 410 (open- pollinated), Queen Bell (hybrid) and Zebra (organic variety). Each variety was grown in similar organic nutrient and bio-pesticides conditions and replicated four times in one factor randomized complete block design. Organic nutrients FYM @ 48 t/ha and vermi-compost @ 20 t/ha were applied as basal dose and 'Panchagabya', a liquid biofertilizer, was sprayed 30, 60 and 90 days after transplanting @ 5 liters diluted with 50 liters of water. Titepati (*Artemisia vulgaris*) and Banmara (*Eupatorium adenophorum*) leaf extracts sprayed 10 times, first spray at the day of sowing followed by consecutive sprays at 14 days interval @ 750 ml per spray mixed with 7.5 liters of water. The yield of the BL 410, Zebra and Queen Bell were 30.17 ton/ha, 18.26 ton/ha and 13.81 ton/ha, respectively. Net return from BL 410, Zebra and Queen Bell were NRs.1632317, NRs. 678928 and NRs. 323082, respectively under the organic and off-season conditions. Value of benefit-cost ratio clearly depicted that production of the open- pollinated varieties like BL 410 resulted in highest economic return to hybrid and organic varieties. Hybrid tomato was highly susceptible to the bacterial wilt; BL 410 was less susceptible than Zebra and insignificant among themselves. Queen Bell was highly susceptible to powdery mildew and BL 410 was least affected. Zebra was medium in susceptibility to powdery mildew with BL 410 and Queen Bell.

INTRODUCTION

Tomato (*Lycopersicum esculantum*) is considered as one of the most widely grown vegetable crops in the world. It has been designated as the most versatile commodity that can be eaten fresh or processed for a wide range of products, and can be utilized to improve flavors and taste of other foods (Villalual 1979). In Nepal, tomato is being cultivated in both sub-tropical and warm temperate regions from 100 m to 1500 m. Generally, it is transplanted after rainy season in the terai and in February to March in the hilly regions. It cannot thrive frost and snowfall. It prefers monthly average temperature of 18-27°C. Proper plant growth can be obtained when the day temperature remains about 26°C and night temperature around 16-22°C (Yonjan 2000). At the end of 20th century, the total annual production of tomato in the world was highest among the vegetables and has reached 82,828,000 tons from 3,169,000 ha of land with an yield of 283 t/ha (FAO1999). Productivity of tomato is very high in central and northern Europe where tomato is grown mainly or totally under glass. The Netherlands has the highest average yield of 466.7 ton/ha.

In Nepal, an argument regarding organic and modern agriculture had begun from 2020 B.S. at the farmer's level. An organized movement towards organic agriculture was initiated in Nepal after the establishment of INSAN in 1986. According to Shakya (2005), there were 26 organic farms in Nepal but Sharma (2005) reported 4 certified farms and 2 in process in Nepal with 390 ha land. There are altogether 78 NGOs, 8 registered organic farms and 11 organic product outlets (shops) in the country (Sharma 2004). Large sum of money is used for importing the inorganic fertilizers, pesticides, etc. On

the other hand, a lot of local resources (plants rich in nitrogen, pesticide properties, dung, agricultural and farm wastes) are not properly managed and utilized. Even though the inputs such as vermi-compost, farmyard manure, bio-pesticides, organic insecticides, etc. are not abundantly available and accessible to the organic farmers, the use of locally available materials such as nitrogen rich Asuro (*Adhatoda vasica*), pesticidal property rich Neem (*Azardicata indica*) and Titepati (*Artemisia vulgaris*), all essential nutrients rich de-oiled cakes, etc. have been found to have a profound effect.

Conventionally, tomato is being grown popularly as winter crop in the plains and spring crop in the hills. The gradually ever increasing year round demand of tomato for fresh consumption and processing resulting from increased urbanization, hotels, tourism, nutritional awareness of the people etc. Tomato production in summer and rainy months is extremely limited by high temperature and shortage of moisture in early summer and high temperature and excessive moisture in rainy summer (Kuo et al 1979). At this time, high temperature and bacterial wilt (*Ralstonia solanacearum*) affect the plants drastically cutting down the yield (Villareal 1979) and as a result the price of tomato increases many folds. The consumers price of tomato during lean period of previous years (2005- 2008) went as high as Rs. 80/kg and came as low as low as Rs 10 during glut period. There is great possibility of producing tomato during this season using plastic houses. Moreover, because of economic concerns and public sensitivity to environmental destruction, chemical insecticide use is currently considered socially unacceptable (Giliomee 1994). Nepal is rich in natural resources and it may offer good alternatives to select suitable botanicals for insect pest control. For example, neem is a very useful plant which is the most effective against diverse range of pests, weeds (NAI 2005). With regards to chemical fertilizers, high nitrogenous fertilization stops symbiotic nitrogen fixation by Rhizobia (Eyhorn et al 2002).

MATERIALS AND METHODS

A field experiment was conducted at Govardhan Sharma Organic Agriculture Resource Centre (GSOARC), Pokharelphant of Vyas municipality, Tanahun district, Nepal to study the varietal response of different tomato cultivars to organic materials in rainy season. Research site was about 700 m above sea level with sandy loam soil and humid sub-temperate climate. Treatments were varieties with nearly equal potential yield, comprising BL 410 (o-pen pollinated), Queen Bell (hybrid) and Zebra (organic variety). Each variety was grown in similar organic nutrient and bio-pesticides conditions and replicated four times in one factor randomized complete block design (RCBD). There were altogether 12 plots and size of the plot was 7.28 m² (2.8 m x 2.6 m). The gross and net area the field was 120.435 m² and 109.56 m². Observations and biometric measurements recorded for phonological and yield attributing characters. The data were subjected to analysis of variance and correlation using MSTAT and SPSS software, respectively.

Plastic house construction: Plastic house was open from the sides for the better aeration. Plastic of thickness 120 gauze, bamboo poles, ropes and wire were used as construction materials.

Nursery raising: The seeds were placed at the distance of one cm between plants and ten cm between rows. The border of bed was sprayed with repellent liquid prepared by GSOARC in August 4, 2010.

Land preparation: Land was prepared by digging manually before two weeks of transplanting with about 15-20cm depth

Transplanting detail: Uniform-sized 21-day-old seedlings having 4 true leaves were transplanted manually in row to row spacing of 60 cm and plant to plant spacing of 45 cm.

Manuring: Organic nutrients FYM @ 48t/ha; vermi-compost @ 20t/ha were applied as basal dose and 'panchagabya'¹, a liquid biofertilizer, was sprayed 30, 60 and 90 days after transplanting @ 5 liters mixed with 50 liters of water.

Staking: Two bamboo stakes were fixed vertically along the length of each plot. Two bamboo stakes were tied horizontally to vertical stakes with the help of wire and ropes one at 60 cm and another at 120 cm from surface of the field.

Pruning, twisting and training: The main stem was allowed to grow but each maxillary shoots were pruned as soon as it appears. The string tied vertically between horizontal sticks at the top was twisted around the plant clockwise.

Plant protection measures: Titepati (*Artemisia vulgaris*) and Banmara (*Eupatorium adenophorum*) leaf extracts sprayed 10 times, first spray at the day of sowing followed by consecutive sprays at 14 days interval @ 750 ml per spray mixed with 7.5 liters of water.

Harvesting: Fruits were harvested six times October 26, November 7, November 19, December 3, December 17 and December 31, 2010 respectively manually, when 50% of the plants in each field mature completely.

RESULTS AND DISCUSSION

Emergence: Seedling emergence was 75%, 82% and 59% for BL-410, Queen Bell and Zebra respectively.

Fruit color: The color of the fruit for all the three varieties after maturity was red but it differed in intensity of the pigmentation i.e., light red for Queen Bell, dark red for BL-410, and medium red for Zebra.

Plant height: The tallest plant height was observed in Zebra (122.0 cm) and shortest plant height was of BL 410 (112.86 cm).

Number of leaves: The maximum number of leaves was found in BL 410 (70.5) followed by Zebra (52.0) and Queen Bell (41.5).

Leaf area: BL 410 had largest size of leaf (35.65 cm) and Queen Bell had smallest size of leaf (28.08 cm). BL 410 had greater breadth (25.38 cm) and Queen Bell had smallest breadth (20.8). BL 410 had highest value of leaf area (729.80 cm²) and Queen Bell had smallest value of the leaf area (448.53 cm²).

Bacterial wilt symptoms: Most of the Queen Bell plants showed deficiency symptoms (2.75) and BL 410 plant showed less deficiency symptoms (0.5).

Powdery mildew affected plants: Queen Bell was mostly affected (4 plants) and BL 410 was least affected (2 plants) by powdery mildew.

Yield: Yield was highest in BL 410 (8.3 kg/plant), intermediate in Zebra (5.0 kg/plant) and lowest in Queen Bell (3.8 kg/plant).

¹ Panchagavya is made with cow dung, urine, milk, curd, honey, banana, yeast and jaggery.

Table 1. Effect of variety on the growth and yield attributes of tomato in organic offseason conditions at Pokharelphant, Tahanun

Variety	Plant height (cm) **	No. of leaves/plant *	Length of leaf (cm) *	Breadth of leaf (cm)	Area of leaf (cm ²)	Fruit diameter (cm) **	Yield (kg) **	Bacterial wilt * symptom	Powdery mildew symptom
Queen Bell	133.0a	41.5b	28.08b	20.8a	433.5b	3.04b	3.795c	2.75a	4.0a
BL-410	112.9c	70.5a	35.69a	25.38a	669.8a	3.346a	8.291a	0.5b	2.0b
Zebra	122.1b	52.0b	31.43ab	23.81a	564.6ab	3.362b	5.017b	1.0b	3.25ab
Mean	122.65	54.67	31.73	23.33	555.99	3.58	5.02	1.42	3.08
SEM±	2.3169	4.6158	1.4654	2.3514	65.229	0.1736	0.313	0.389	0.464
LSD	8.017	15.97	5.071	8.137	225.7	0.6019	1.083	1.321	1.605
CV	3.78%	16.89%	9.24%	20.16%	23.46%	9.69%	10.98%	53.91%	30.1%

*, significant; ** highly significant; means with the same letters within the columns are not significantly different.

From the correlation analysis, it can be concluded that yield was highly significantly positively correlated with the fruit diameter and positively correlated with number of the leaf, length of the leaf, breadth of the leaf and area of the leaf, and negatively correlated with plant height, bacterial wilt and powdery mildew symptoms.

Economics of organic tomato production in off-season cultivation

Economic analysis depicted that total cost of organic tomato production under plastic house was NRs. 2,125,410 and actual cost for one season would be NRs. 782,022. Calculating the gross return by using the rate of NRs. 80/kg of organic tomato in off-season from all three cultivars grown in equal proportion, BL-410, Zebra and Queen Bell showed NRs.1,660,131, NRs. 2,414,339, NRs.1,460,950 and NRs.1,105,104, respectively, and after reducing the actual cost of production the net return was found to be NRs. 8,781,092, NRs. 1,632,317, NRs. 678,928 and NRs. 323,082, respectively. The B:C ratio decrease as BL-410 (3.09) > when all three cultivars grown in equal proportion (2.1) > Zebra (1.86) > Queen Bell (1.41).

Table 2. Details of the cost incurred during the cultivation of the offseason and organic tomato in 109.56 m² field and computation of cost for the one hectare area

Particulars	a	b	c	d	e	f	g
Seed	3 packet	273 packets	40	120	10,920	120	10,920
Plastic	1 piece [#]	91 piece [#]	10080	10,080	917,280	1,680	152,880
Thick aluminum wire (to hold plastic)	30 m	2730 m	10	300	27,300	300	27,300
Iron nail	1 kg	91 kg	90	90	8,190	90	8,190
Wire(to tie bamboo)	1 kg	91 kg	120	120	10,920	120	10,920
Plastic rope	3 roll	273 roll	35	105	9,555	105	9,555
Bamboo	40 Thana	3640 Thana	100	4,000	364,000	1,334	121,333
Labor (plastic house construction)	16 labor hours	1456 labor hours	300	4,800	436,800	1,600	145,600
Labor(cultural practices)	9 labor hours	819 labor hours	250	2,250	204,750	2,250	204,750
Plastic pipe (to hold plastic)	2 roll	182 roll	135	270	24,570	45	4,095
Irrigation pipe	1 roll	91 roll	325	325	29,575	54	4,929
Land rent	109.56 m ²	13.3 m ²	1000	107	13,300	107	13,300
FYM	20 doka	1820 doka	30	600	54,600	600	54,600
Panchagabya organic fertilizer	5 liters	455 liters	30	250	13,650	250	13,650
Total				23,417	2,125,410	6,922	782,022

, dimension of plastic was 36×47 ft² which was sufficient for the area of 109.56 m²; a, units of particulars required for construction of one plastic house for 109.56 m² area; b, units of particulars required for construction of 91 plastic house for one hectare; c, cost per unit of particular (NRs.); d, total cost (NRs.) for 109.56 m²; f, actual cost (NRs.) for 109.56 m²; e, total cost (NRs.) for one hectare; g, actual cost (NRs.) for one hectare.

The durability of plastic is assumed to be for six seasons. The bamboo can be used for the three seasons for the plastic house. The durability of plastic pipe is assumed to be six year and so is the irrigation pipe.

Table 3. Yield, total cost of production, gross return, net return and B:C ratio

Yield and economics	Yield (kg/6 plants)	Yield (ton/ha)	Total cost/ha (NRs.)	Gross return/ha (NRs.)	Net return/ha (NRs.)	B:C ratio
3 cultivars	5.701	20.75	782,022	1,660,131	878,109	2.12
BL 410	8.291	30.17	782,022	2,414,339	1,632,317	3.09
Zebra	5.017	18.26	782,022	1,460,950	678,928	1.8
Queen Bell	3.795	13.81	782,022	1,105,104	323,082	1.4

6 plants were the sample from one plot. The cost of 1kg of organic tomato in off-season cost Rs.80/kg in the fair that organizes every Saturday in 1905 restaurant in Jamal, Kathmandu, Nepal.

CONCLUSION

Open-pollinated variety, BL-410 had better performance with higher return in organic and off-season conditions at Pokhrelphat in Tanahun. In developing countries like Nepal, poor farmers can use locally selected open-pollinated varieties to gain more by growing in organic conditions in off-season since they are found higher responsive in organic conditions and are adaptable in adverse climatic conditions. From this study, it is also found that open-pollinated varieties are resistant to the most prevailing off-season diseases like powdery mildew (*Oidium neolycopersici*) and bacterial wilt (*Ralstonia solanacearum*), and are least affected by red ants and tomato fruit borers, if botanical pesticides are used.

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Scenario of Pesticide Application in Sunsari District

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ABSTRACT

A study was carried out to find out the status of pesticide use in Sunsari district. Data were collected from 35 farm households of six VDCs and Inaruwa municipality and 15 agro-vets using semi-structured questionnaires. It was found that about 600-700 kg of pesticides were sold to the farmers by an agro-vet each year for the control of pests and diseases in a wide range of crops (mostly vegetables), out of which more than 50% of the pesticides are of extremely hazardous categories. About 85% of the pesticides were imported from India (most of them without paying taxes). More than three-fourth of the farmers didn't have idea about integrated pest management (IPM). Immediate intervention is required against the unscientific use of pesticides, and eco-friendly and alternative methods of pest control has to be implemented for sustainable agriculture and prevent people from the consumption of poisons along with what the farmers produce.

INTRODUCTION

Fresh vegetables and cereals are essential parts of healthy diet. However, vegetables can also be the source of poisonous toxic substances eg, pesticides residue (Knezevic and Serdar 2008). Pesticides' striking efforts in preventing crop loss and controlling vectors of diseases have led to their acceptance and expanded use throughout the world (Sharp and Peter 2005). It has been observed that their long term, low dose exposure is increasingly linked to human health effects such as immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer (Wiles et al 1998). Pesticide residues in food are global problems (Abinash and Singh 2009).

The pesticide import data for the year 2006 was 131285 kg active ingredient (a.i.) and for the year 2007 it was 347495 kg a.i., which was almost 250% higher compared with the import in 2006 (PRMD 2009). Most of the pesticides (98%) were imported from India and some from China. Only about 2% were formulated in Nepal (Manandhar and Palikhe 1999). The open border trading of common, banned and expired pesticides is ever increasing and there is no mechanism for documenting the amount of such illegal trade. Reports suggest that use of pesticides in vegetables in Nepal is higher than in other food products (Koirala et al 2009).

Sunsari is a district located in the south-eastern part of Nepal at an elevation of 285 feet with the headquarter at Inaruwa. It is an industrial and agricultural estate and ranks first in jute and sugarcane production and third in rice production (MOAC 2007/08). No previous research reports are available for pesticide use in Sunsari district. Therefore, the this study aimed to know the current situation of pesticides sell and their use in different crops, and to investigate awareness, knowledge, practice, use and sell among agro-vets and farmers in the district. The study was carried out in the month of October, 2011.

METHODOLOGY

Six Village Development Committees (VDCs), Babiya, Jalpapur, Bhutaha, Narsingh, Gautampur and Horshahi, of the southern part of Sunsari, which are the vegetable pocket area of the district, and vicinity of District Agriculture Development Office (DADO) in Inaruwa Municipality were selected for the study. Farmers with more than 0.5 ha land along with age group of 25-49 years were considered for the study. Thirty-five farmers/households (five from each VDC and the Municipality) and 15 agro-vets were randomly selected and interviewed face to face. The questionnaire used was precisely developed and pre-tested prior to the field survey. All the collected data were tabulated and descriptive statistical analysis was employed using SPSS and other tools and techniques.

RESULTS AND DISCUSSION

Scenario of the society

The society has mixed existence of different castes, religion and linguistic groups. Madheshi and Muslims are predominant in the region. Of the respondents 45% were literate and among them 65% had less than primary level education. Farming is the main profession of more than 80% of the people and vegetables are important crops they grow.

Scenario of agro-vets and pesticides sale

The southern part of Sunsari has more than 70 agro-vets, some of them are even unregistered in the DADO. The agro-vets has transaction of pesticides from nearby markets of Biratnagar and Birgunj and about 55% are from illegal trade. More than 85% of the pesticides are of Indian companies. The transacting borders of India are Jogwani, Birpur, Basmatiya and Bhimnagar. Each agro-vet on an average has yearly transaction of Rs 150,000 of pesticides alone.

Agro-vets had transaction of pesticides such as Phorate, Thimet, Umet, Dichlorvos, Carbofuran, Methyl Parathion (extremely hazardous category I), Alphacypermethrin, Chlorpyrifos, Cypermethrin, Deltramethrin, Dimethoate, Endosulfan, Lambda-Cyhalothrin (highly hazardous category II), Dimethipin (moderately hazardous category III) and Agromin, Miraculan, Fertimin, Bio-Force, Biogen, Biovita (slightly hazardous category IV). The sale of pesticides of category I (Red), II (Yellow), III (Blue) and IV (Green) was 55%, 20%, 15% and 10%, respectively (Fig. 1) The sale of Phorate (profenophos) was found maximum followed by Bavistin (carbendazim) (Fig. 2). The study showed an increasing trend of pesticide sale. The yearly average sale of pesticides by an agro-vet was 450 kg, 600 kg, 850 kg and 1250 kg in the year 2065, 2066, 2067 and 2068 BS, respectively (Fig. 3). The pesticide sale in the year 2068 was increased by 47.06% compared with the year 2067.

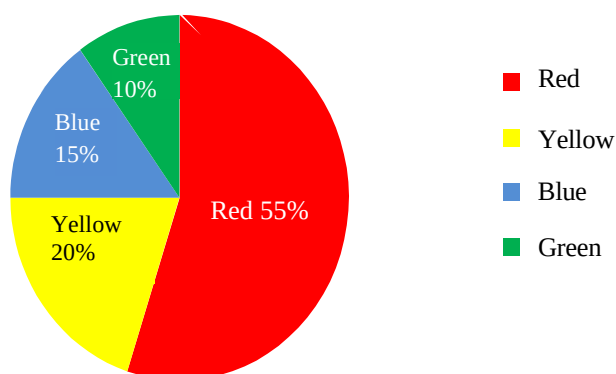


Figure 1. Percentage use of the hazardous pesticides sold by agro-vets

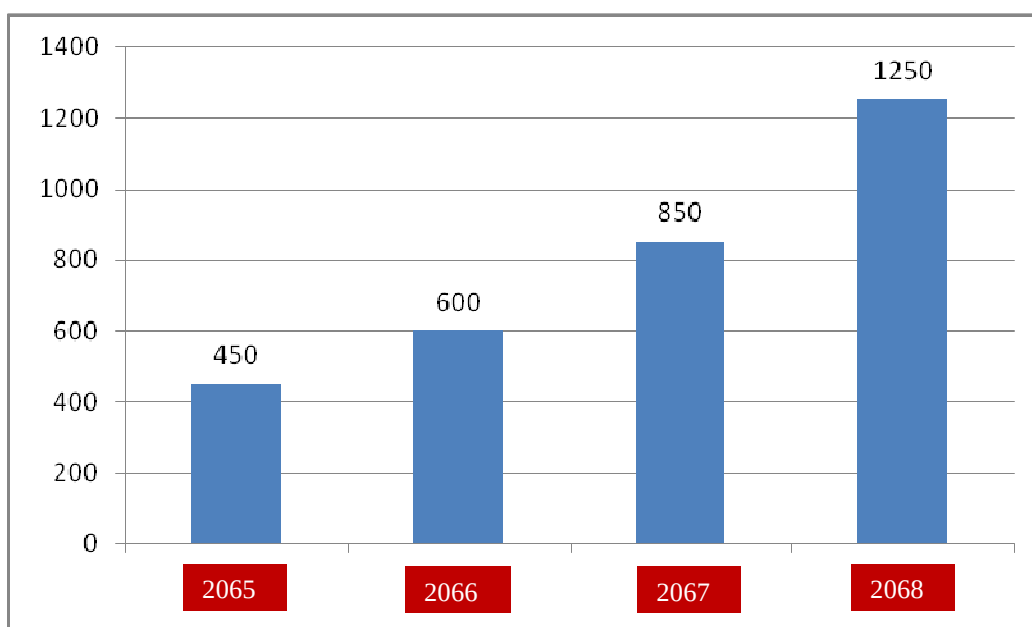
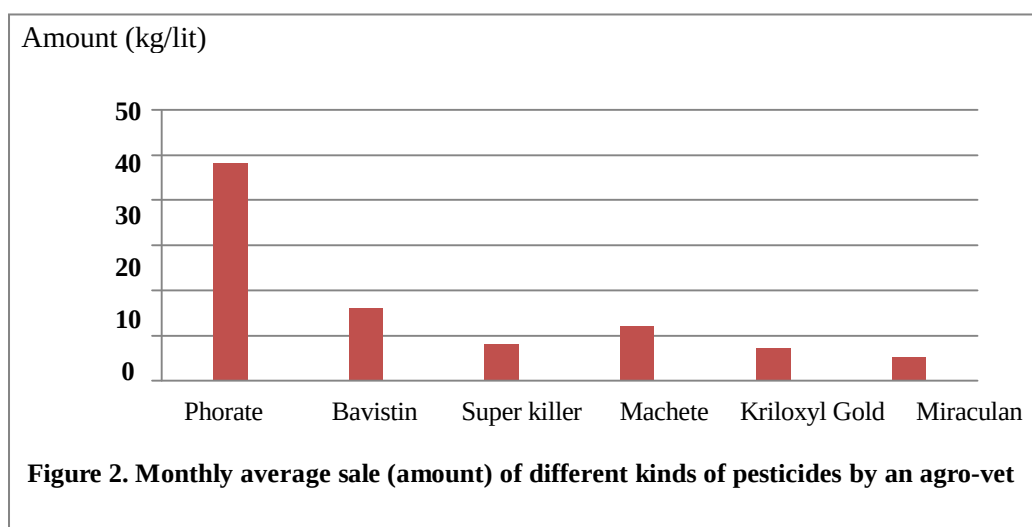


Figure 3. Trend of yearly average amount of pesticides sale by an agro-vet

Use of pesticides by farmers

Farmers were found to use pesticides as soil application, seed treatment, foliar spray, fumigants for grains and commodities, and aerosol insecticides for residential pest. The pesticides used were organochlorines, organophosphates, carbamates, pyrethroids, neonicotinoids, avermectins and diacyl hydrazines. Majority of the growers (91.43%) were not aware of different hazardous categories of pesticides and did not receive any training at all about their use. Even the DADO has not launched any IPM program or trainings in the farmers' fields in the region till now. Nearly half (42.86%) of the farmers do not have knowledge about health hazards of pesticides. However, 48.57% of farmers opined that use of pesticides should be reduced in the near future, 74.28% did not have heard about IPM and 51.43% did not have knowledge about organic or botanical pesticides. About three-fourth (71.43%) farmers said they need quick response and remedy to the pest of their crops for which they use extremely hazardous pesticide. Eighty percent of the pesticide users did not use any safety measures like masks/hanky, gloves, etc. while using pesticides, however, 82.86% were

reported to wash their hands and legs with soap or take bath after use. Three-fourth (74.29%) of the users reported that they visit the pesticide-applied field at an interval of 0-5 days and 68.57% farmers harvest the vegetables at an interval of 2-5 days of application. More than 35% of the pesticides used by the farmers have residual effect of above 15-20 days.

Though rice and sugarcane crops received the highest amount of pesticides followed by wheat and banana the intensity (frequency of application) of use is much higher in the case of vegetables, especially cowpea and tomato (Figure 4). Besides these, farmers use pesticides to kill household and animal pests. A farmer on an average spent Rs. 7000/year for the purchase of pesticides alone.

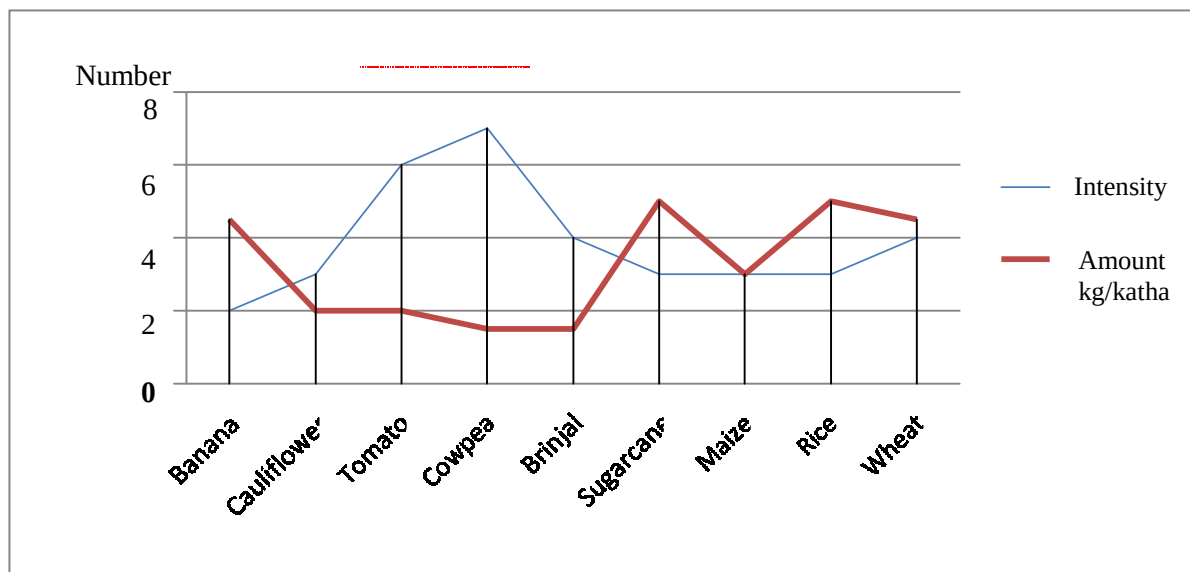


Figure 4. Amount and Intensity of pesticides use in different crops by the farmer

CONCLUSION

The study shows inappropriate and haphazard use of extremely hazardous pesticides in the study area. No intervention has been seen by DADO or any NGOs to stop or discourage its use and make the farmers aware about the alternatives for pesticides and give them training on IPM and safe farming. Majority of the users do not seem to have knowledge about the adverse effects of pesticides and do not adopt safety measures during its application. There has been misuse of pesticides resulting into poisoning and suicidal cases. Government agencies, development organizations, consumer associations should work together with farmers/growers and agro-vets to solve out the problems and enhance health and food security.

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Development of IPM Package for Vegetable Crops Specially Tomato in Nepal

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ABSTRACT

Attempts were made to identify pest problems of tomato from seedlings to harvesting stage of tomato, and to develop IPM package. Different formulations of bio-fertilizers and bio-pesticides were evaluated. Combined effect of bio-fertilizers and bio-pesticides on fresh yield of tomato var. Srijana was significantly high as compared to rest of the treatments. Some of the practices adopted include mulching, selection of resistant variety (against wilt) as a scion and grafting resistant rootstock (against root knot nematode), seed treatment with microbial consortium, raise seedlings in poly bags, use of solarized soil, bio-fertilizers, bio-pesticides-amended farm yard manure. Regular monitoring and scouting of major pests were carried out using pheromones and traps for need-based control decision using economic threshold level (ETL).

INTRODUCTION

Tomato is an important vegetable crop of Nepal. Out of the cultivated land area of Nepal (3,091,000 ha), tomato alone occupies 25609 ha (Anonymous 2011). Total annual production of tomato in the country is 242018 tons with average productivity of 15.5 t/ha (Annual Report 2010). Tomato variety 'Srijana' produced more than 65 t/ha through result demonstration plots of integrated pest management (IPM) package tested in Dhikurpokhari-1, village development committee (VDC) ward No.1, Kaski, Nepal indicating possibility to fill up yield gap by 22.5 t/ha to tomato yields being produced on farmer's practice (42.5 t/ha) through scale up the tomato IPM package.

Different formulations of bio-fertilizers and bio-pesticides are being available in the Nepalese market. They are easy to apply, and are suitable for tomato IPM package. It was necessary to verify them in farmer's fields at least for two years (seasons) in mid-hill conditions of Nepal. Bio-fertilizers are specific to the targeted crops and their response and requirement differ according to the varieties of the crop selected. Applications of bio-fertilizers and bio-pesticides improve the color, taste and flavor of tomato as compared to them with chemical fertilizers and chemical pesticides. Bio-fertilizers are safe to soil health and they improve physical as well as chemical properties of soil. They are cheaper, sustainable and produce positive impact on health, environment and create a conducive environment for biodiversity of beneficial organisms.

Economic threshold level (ETL) is the diversity at which control measures initiated to prevent an increasing pest population from reaching the economic injury level (EIL) (Poston et al 1983, Gyawali 1988 and Gyawali et al 2012). Cost benefit analysis is widely applied for decision-making process and economic injury level (EIL) integrate biology and economics. According to Stone (1972) control costs, crop market value, proportionate injury per individual pests and crop response to injury are four determinants of EIL. Result demonstration trial was carried out in Dhikurpokhari-1, VDC-1, Kaski, Nepal with an objective to integrate all possible verified management technologies available in Nepal from seeding to harvesting for high yield and profit from tomato cultivation, to minimize use of chemical fertilizers and pesticides on tomato and to compare new components with farmers practice (chemical fertilizers and pesticides), and thereby to develop IPM package.

MATERIALS AND METHODS

The result demonstration trial was carried out with five treatments replicated four times on farmer's fields. Each treatment contained 20 plants replicated in 4 farmers' fields and applied bio-fertilizers + bio-pesticides amended with farm yard manure (FYM). Tomato variety 'Srijana' was tested for two years in the same land. The recommended dose of chemical nutrients for tomato was used as per the farmer's practice, and bio-fertilizers were used for supplying all the required balanced nutrients to the crops.

Among bio-fertilizers, Nitrofix-A (*Azospirillum* sp.) 21.76 g, P sol B (Phosphate solubilizing microorganisms, *Bacillus megaterium*) 20.4 g, K sol B (Potash mobilizing bacteria, *Frateuria aurantia*) 54.4 g and Agri VAM (*Vesicular Arbuscular Mycorrhiza*) 22.0 g; and bio-pesticides, *Metarhizium anisopliae* 5.5 g, *Trichoderma viride* 2.76 g, *Trichoderma harzianum* 2.76 g, *Pseudomonas fluorescence* 2.76 g, *Bacillus subtilis* 11.0 g and *Paecilomyces lilacinus* 5.5 g were mixed in 5.5 kg of FYM to apply for 20 tomato plants of each treatment.

Each plant under IPM package received a total of 680 g FYM (275 g amended FYM during planting as basal application and 405 g non-amended FYM after planting as top dressing) and compared with farmers practice (using urea 40 g, di-ammonium phosphate (DAP) 60 g, murate of potash 10 g and FYM) in terms of yield, quality, plant growth, and cost-benefits. The remaining dose of bio-fertilizers and bio-pesticides was used in first and second top dressing in one month after field transplant or at flowering stage and at fruit development stages respectively in half portion of the basal dose.

Tomato variety 'Srijana' was tested for two years in the same land. Srijana is the variety preferred by the farmers and tolerant to bacterial wilt disease. Seedlings were raised in poly bags using forest top soil or solarized soil, neem seed powder, bio-fertilizers, bio-pesticides amended compost. Seedlings were drenched by mixing oxyrich-N @ 6.25 g with 625 ml of water sufficient for 1 ropani (500 m² of land). Soil test was done from well-drained field plot to determine the requirement of nutrients and its availability accordingly, bio-fertilizers applied. Soil pH was determined before and after harvest of the crop to maintain 6.2 - 6.8. Staking, mulching, hand weeding and lower leaves were clipped-off from the main stem. Two new shoots of each plant only were maintained at 45 cm high and kept them in opposite direction. All undesired new shoots, old and diseased leaves were removed. Pheromone traps using "Heli-lure or Spodo-lure in a funnel trap" were installed to monitor the adult moths of tomato fruit worm or tobacco caterpillars. Regular monitoring and scouting of pests was done from seeding to harvest of the crop.

RESULTS AND DISCUSSION

Combined effect of bio-fertilizers and bio-pesticides on fresh yield of tomato variety 'Srijana' was significantly high as compared to rest of the treatments (bio-fertilizers, bio-pesticides, farmer's practice and control in Dhikurpokhari-1, VDC-1, Kaski District of Nepal (Table 1). Similarly, there was no significant difference in terms of yield between bio-fertilizers and bio-pesticides but significantly differed with farmer's practice and control. Therefore, it was necessary to deliver IPM package to meet the current need of farmers in Nepal.

Table 1. Effect of bio-fertilizers and bio-pesticides on tomato variety 'Srijana' in Dhikurpokhari-1, VDC-1, Kaski, Nepal (IPM CRSP, 2012)

Treatments	Mean fresh weight (kg)		
	Year I (2010)	Year II (2011)	Pooled (Year I & II)
Bio-fertilizers	69.9 b	69.9 c	69.9 b
Bio-pesticides	59.4 c	76.5 b	67.95 b
Bio-fertilizers + bio-pesticides	80.25 a	101.9 a	91.1a
Farmer's practice	53.15 c	66.15 cd	59.65 c
Control	35.85 d	39.35 e	37.6 d

Mean in a column followed by the same letters are not significantly different at 5% level (ANOVA).

Bio-fertilizers are organism-based fertilizer that enriches the nutrient quality of the soil. The main sources of bio-fertilizers are bacteria, fungi and blue green algae. The organisms are known to deliver a number of benefits, such as plant nutrition, plant diseases resistance, and tolerance to adverse soil and climatic conditions. Slow release of nutrients is required for the sturdy growth of plants that helps the selected crop to tolerate against the pathogenic diseases and phytophagous insects.

Bio-pesticides are inherently less toxic as compared to conventional chemical pesticides. They generally affect targeted insect pests, as well as closely related organisms in contrast to broad-spectrum conventional chemical pesticides. Bio-pesticides are effective in very small quantities, and often decompose quickly, thereby resulting in lower exposures and largely avoiding environment pollution. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pests.

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Adoption of Organic Farming-Related Practices in Eastern and Central Region of Nepal

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ABSTRACT

A study was carried out to examine the socio-economic and adoption of organic farming-related practices by the Nepalese farming communities in four districts of eastern and central region of Nepal. A total of 180 farmers were purposively selected for administering a structured interview schedule for collecting necessary data. Most of the respondents were male (82%) and of middle age group (60%). The respondents were literate (35%), followed by high school education (17%), primary education (15%) and middle level education (11%), respectively. Most of the farm families were involved in cereal production and the family size of 3-5 members was maximum (42.67%). Majority of the respondents (45%) were found to be medium level of adopters of organic farming-related practices followed by low (31.67%), and high (23.33%) level of adopters. Majority of the respondents had adopted selection of good quality seed and application of FYM followed by practice of seed inoculation, use of green manure, in-situ incorporation of plant residues, use of ash by burning crop stubble, use of biogas slurry, application of vermin-compost. Very few had adopted the *Sesbania* cultivation in their field. Moreover, regarding the integrated pest management, majority adopted summer ploughing followed by using herbal leaf (Titepatti, Bakaino etc.), hand weeding, cow urine, neem leaf extract, pheromone trap/light trap, neem oil, tobacco decoction. Majority of the respondents suggested that farmers' training, on-farm demonstration and their exposure visits farms would motivate farmers to adopt organic farming.

INTRODUCTION

Modern agriculture based on the use of chemical fertilizer and pesticides certainly has helped to increase farm productivity. However, the high cost of these chemical inputs, their adverse environmental effects and implications to human health have prompted both farmers and agricultural researchers to develop alternative farm techniques. Organic farming is the solution to mitigate the above problem.

Any attempt to produce food grains in excess of the restrictions set by soil and climatic conditions would, in long run, result in failure. Therefore, the only alternative is to increase crop productivity and output together with more optimal utilization of natural resources without disturbing natural balance. We have to think of the people and the land on which they are dependent along with crops, livestock, horticulture, agro-forestry etc. as an integrated system. A sustainable land use by integrating all such and other related practices with crops is the need of today to provide different channels for income and employment opportunities throughout the year. It is high time to think upon organic farming for the sustainable agriculture.

The importance of organic farming manures despite its declining use has never been in doubt both in maintaining the soil and augmenting the availability of nutrients particularly the secondary micronutrients. It is estimated that Nepal has a potential of about 2.7 million tones of compost, which could provide around 0.4 million tones of plant nutrients. Moreover, there is scope for conversion of human and animal refuse in to valuable organic manure directly or through suitable bioconversion. Organic source of nutrients are free from the problems of pollutions, they can be generated at the farm level and are less costly.

In Nepal, organic farming is mostly practiced by the semi-urban farming community. However, a lot of government and non-government efforts have been made to accelerate the organic farming technology. The non-government organizations are massively involved in organic farming to provide technical assistance to the farmers to reduce the increasing cost of chemical fertilizers and pesticides. The objectives of this study were to examine the adoption rate of organic farming practices by the farming community and to understand the sociological perspectives of the farming community involved in organic farming.

METHODOLOGY

The study was conducted in four districts of eastern (Morang and Jhapa) and central region (Chitwan and Nawalparasi) of Nepal. The VDCs Jhorahat, Bayarban and Sidraha in Morang; Maharani and Kohabara in Jhapa; Khairani, Ratnanagar and Chainpur in Chitwan; and Chisapani in Nawalparasi were selected purposively as the farmers were practicing organic cultivation in the areas. A structured interview schedule was designed and introduced for collecting information. A total of 180 farmers were selected for the interview.

The organic farming practices were classified into two major categories, viz. integrated plant nutrient management and integrated pest management. In each practice ten items were included for study purpose. A score of 2 was given for complete adoption, 1 for partial adoption and 0 for non-adoption. Percentage was calculated to study the practice-wise adoption by the respondents. Further, mean and percentage adoption score were also calculated for necessary interpretations and inferences.

RESULTS AND DISCUSSION

General information of the respondents

Age: Maximum respondents were middle age group (60%) followed by old age group (29%) and young (11%) respectively.

Gender: Male respondents were dominated (82%) over female respondents (18%).

Education: Most of the respondents were literate (35%) followed by high school education (17%), primary education (15%), middle education (11%), intermediate (10%) and graduate levels (7%) respectively. Only 5% of the respondents were illiterate (Table 1).

Table 1. Distribution of respondents according to education

Education category	Frequency	Percentage
Literate	63	35
High school	30	17
Primary	27	15
Middle	21	11
Intermediate	18	10
Graduate and above	12	7
Illiterate	9	5

Profession: Agriculture was the main profession of most of the respondents (74.67%). Other groups included servicemen (12%), traders (9.33%), students (2%) and carpentry (1.33%).

Social participation: Most of the respondents (62%) were involved in different social institutions. Around 33% of the respondents were engaged in more than one social institution, where as 38% were not involved in any social institution. Maximum respondents (32.8%) were involved in cooperative followed by youth club (16.80%). In addition, respondents were involved in women group, adult forum, school development committee, village development committee, community development forum, drinking water committee, small farmer's development group and health volunteer group.

Farming

Cereal production was the dominating farming by most of the farmers (58.67%) while 14% farmers adopted livestock farming. Some farmers were involved in poultry production, vegetable farming, bee-keeping, fisheries, fruit farming and other crops.

Land holdings

Most of the farmers (52.90%) had unirrigated land followed by irrigated land (40.70%). Some of the respondents (6.40%) had irrigated as well as unirrigated land (Fig. 1). Similarly, maximum irrigated land owned was observed up to four bigha (2.66 ha) and minimum of one katha (0.03 ha), whereas maximum unirrigated land owned by the farmers was up to eight bighas (5.33 ha.) and minimum of one katha (0.03 ha). The big land holders adopted multi-culture farming system.

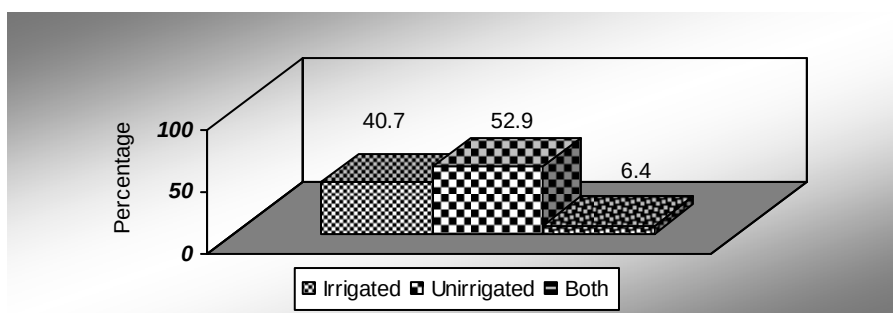


Figure 1: Types of land

Family size

In all the four districts, maximum member in a family was observed twelve and the minimum was one. Family members having 3-5 was maximum (42.67%) followed by 5-7 members (30.67%), 7-9 members (13.33%) and more than 9 members (7.33%). Only 6% had the family size of 1-3 members (Fig. 2). The large size families were involved in producing different crops, rearing livestock and producing vegetable crops while small size families were occupied with monoculture type of farming. Positive correlation was observed between the size of family and adoption of cropping system pattern.

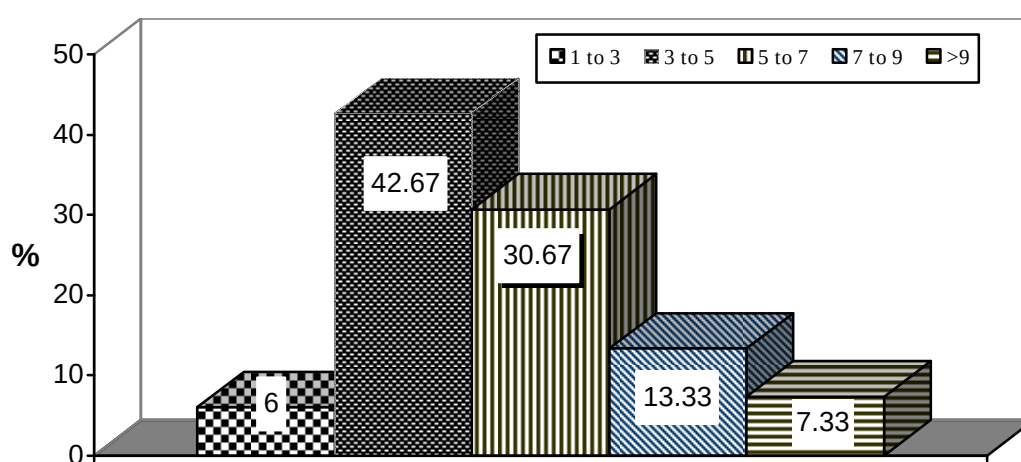
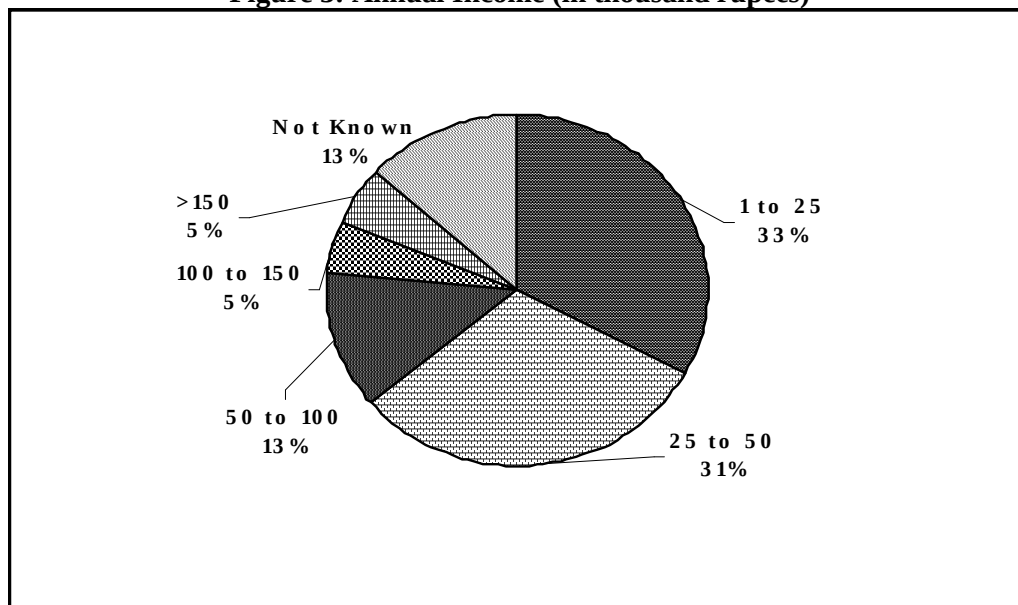


Figure 2. Size of the family

Annual income

The annual income was categorized on the basis of respondent's annual gross income and great variation was observed in annual income. Most of the respondents (33.00%) had annual income of Rs.1,000 to 25,000 (Fig.-3) followed by Rs. 25,000 to 50,000 (31.00%). Similarly, the maximum annual income of the respondents was found up to Rs.300,000 and the minimum was Rs. 2000.

Figure 3: Annual Income (in thousand rupees)



Interpersonal contact

Interpersonal contact of the respondents was categorized on the basis of regular, sometimes, and never (Fig. 4). It was found from the study that agriculture technician had very poor contact with the farming community, where as VDC worker had moderate interaction. Among different interpersonal contact VDC workers had frequent contact with the farming community and therefore they would be more effective in communicating and persuading farmers about new technologies. Most of the respondents opined that they sometimes meet and discuss with the development worker in their community and therefore they would be as much effective as VDC workers in disseminating technology to the farmers.

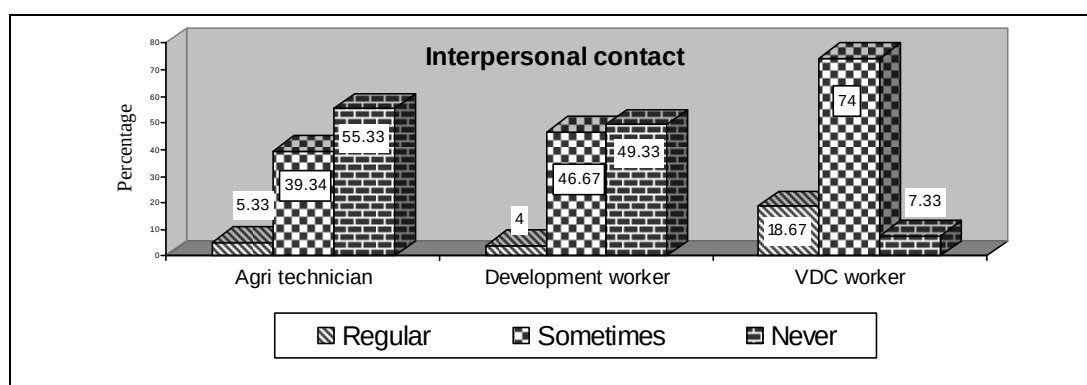


Figure 4. Interpersonal contacts

Adoption of organic farming practices

The data presented in Table 2 indicated the extent of adoption of organic farming practices. It was observed that majority of the farming community (45%) were found to be medium categories of adopters followed by low categories (31.67%), and high (23.33%) level of adoption about organic farming practices. Farmers just started to adopt organic farming practices as they know the value of organic products. Farmers complained that the management of organic farming is a bit tedious job as frequent visits of the farm to monitor the crops are required and it would ultimately increase the production cost. On the other hand, the consumers are not ready to pay more for organic products though it has great value in the daily diet.

Table 2. Distribution of respondents according to level of adoption of organic farming practices (n = 180)

Categories of adoption	Number of respondents	Percentage
Low (13-16)	57	31.67
Medium (16-19)	81	45.00
Large (19-22)	42	23.33
Total	180	100.00

The data presented in table 3 shows the practice-wise adoption of organic farming by the respondents. All the organic farming practices in the study were categorized in two major categories viz. integrated plant nutrients management (IPNM) and integrated pest management (IPM), with 10 practices to each. The mean percentage of adoption of IPNM and IPM was 61.33 (Table 3a) and 66.49 (Table 3b), respectively.

Out of the 10 practices included in IPNM, all the respondents had adopted selection of good quality seed and application of farm yard manure (FYM) in their field. Majority of the respondents adopted seed inoculation (86.67%), use of other green manure (70.00%), practices of cropping system (68.33%), in-situ incorporation of plant residues (65.00%), use of ash by burning crop stubbles (63.33%). Similarly, less than half of the respondents used biogas slurry (30%) and applying vermicompost (26.67%) in their field. Further, it was observed that some of the farmers (3.33%) adopted *Sesbania* (Dhaincha) as a green manure by incorporating in their field and leave for decomposition to maintain the soil fertility and improve status of the soil.

Regarding the 10 practices included in IPM, all the respondents practiced summer ploughing. Most of the respondents adopted the practices of using herbal leaf (Titepatti, Bakaino etc.), hand weeding, cow urine, neem leaf extract, pheromone trap/light trap as an organic farming practices. Some of the respondents adopted the practices of using tobacco decoction and neem oil, whereas few respondents adopted biological control of pests, and very few respondents adopted shifting cultivation.

Table 3a. Practice-wise adoption of integrated plant nutrient management (IPNM) by the respondents

Practices	Frequency	Percentage
In-situ incorporation of plant residues	117	65.00
Selection of good quality seed	180	100.00
Seed inoculation	156	86.67
Application of FYM	180	100.00
Use of <i>Sesbania</i> (Dhaincha)	6	3.33
Use of other green manure	126	70.00
Application of vermi-compost	48	26.67
Use of bio-gas slurry	54	30.00
Use of ash (burned crop stubble)	114	63.33
Use of appropriate cropping pattern	123	68.33
Mean percentage		61.33

Table 3b. Practice-wise adoption of integrated management of pest (IPM) by the farmers

Practices	Frequency	Percentage
Summer ploughing	180	100.00
Hand weeding	162	90.00
Use of neem oil	108	60.00
Use of neem leaf extract	156	86.67
Use of tobacco decoction	69	38.33
Use of pheromone trap/light trap	114	63.33
Use of cow urine	156	88.33
Practice of shift cultivation	27	15.00
Practice of biological control of insect pests	54	30.00
Use of herb leaf (Titepatti, Bakaino etc.)	168	93.33
Mean percentage		66.49

About the Fourth Convention of the Society of Agricultural Scientists, Nepal (SAS-N)

The Fourth Convention of the Society of Agricultural Scientists, Nepal (SAS-N) was held in Lalitpur, Nepal with various programs from 4 to 6 April 2012 (Chaitra 24-26, 2068). The theme of the convention was "Agricultural Research for Development".

Day 1:

The convention was inaugurated by Honourable Om Prakash Yadav, Minister of State for Agriculture and Cooperatives, amid a special function held at Nepal Administrative Staff College, Jawalakhel, Lalitpur. The inaugural session was chaired by the Immediate Past President of SAS-N, Dr. Adarsha Pradhan. The other distinguished guests were Prof. Dr. Surendra Raj Kafle, Vice-Chancellor of Nepal Academy of Science and Technology (NAST); Prof. Dr. Kailash Nath Pyakurel, Vice-Chancellor of Agriculture and Forestry University; Dr. Dil Bahadur Gurung, Executive Director of Nepal Agricultural Research Council (NARC); Mr. Ganesh Kumar K.C., President of Nepal Agriculture Federation; CIMMYT/Nepal Representative, Dr. Guillermo Ortiz-Ferrara, and IRRI Representative Dr. Jagadish Kumar Ladha. President of SAS-N, Dr. Hira Kaji Manandhar, welcomed the guests and participants and delivered presidential address.

All the guests spoke about the importance of national agricultural research system and the role of agricultural research in the nation's development. A special video message for the convention was received from Prof. M. S. Swaminathan, a well known eminent agricultural scientist, the Member of Parliament (Rajya Sabha) of Republic of India and Chairman of MS Swaminathan Research Foundation. In his message, he emphasized the use of modern technologies for advancement of agriculture sector and pleaded for investment in agricultural research.

On the occasion, SAS-N presented honors and awards to various 15 institutions and individuals for their remarkable contributions on agricultural research and development. **'Award of Honor'** was presented to International Maize and Wheat Improvement Center (CIMMYT) and International Rice Research Institute (IRRI) for outstanding technical support and research partnership in Nepal. *Kantipur* National Daily was honored for pioneering *Krishak ko Pana* (Farmers' Page) providing special coverage to agriculture sector. Similarly, three former scientists: Mr. Bhola Man Singh Basnet (agri-information), Dr. Madhu Sudan Ghale (horticulture) and Mr. Sadhu Ram Basnet (fisheries) received **'Award of Honor'** for significant contributions in their respective fields. **'Award of Honor for Farmers and Entrepreneurs'** was presented to Mr. Hira Mani Dulal of Kavrepalanchowk for participatory research; Mushroom Cooperative Limited of Balambu, Kathmandu; and Lumbini Agro-Products and Research Centre of Rupandehi for their entrepreneurship in mushroom and dairy, respectively. NARC scientists Mr. Madan Raj Bhatta (wheat research), Dr. Doj Raj Khanal (management of Khari disease of buffalo), Mr. Shreemat Shrestha (design and development of small farm tools) and Ms. Neelam Subba (research on plantation crops) received **'Award of Excellence'** with a cash prize of rupees five thousand each for their contribution in the respective research field. **'Award of Honor for Special Contribution'** was presented to Prof. Dr. Subodh Narayan Jha, former member of National Planning Commission, for his contribution in prioritizing and strengthening agricultural research in Nepal. Finally, Prof. Dr. Fanindra Prasad Neupane was presented with **'Lifetime Achievement Award'** for his outstanding contributions to entomological research and education in Nepal.

Dr. Ortiz-Ferrara and Dr. Ladha, on behalf of CIMMYT and IRRI, respectively thanked SAS-N for the award and highlighted the research and development work in Nepal. On behalf of awardees Prof.

Dr. Fanindra Prasad Neupane thanked SAS-N for the recognition of their contributions in agricultural research and development in the country.

The inaugural programme conducted by Dr. Tek Bahadur Gurung, General Secretary of SAS-N, was attended by over 350 participants. On the occasion, the Minister also launched the website of SAS-N 'www.sas-nepal.org'. Dr. Jagat Devi Ranjit, Vice President of SAS-N gave vote of thanks to all guests, participants and those who made valuable contributions. Other SAS-N executive committee members responsible for various activities and events were Mr. Keshav Prasad Shrestha, Treasurer; Dr. Bhoj Raj Joshi, Secretary (Coordination); Mr. Surya Narayan Sah, Secretary (Administration); Mr. Tulsi Prasad Poudel, Secretary (Finance); Mr. Suresh Rai, Member (Publication); Dr. Neena Gorkhali, Member (Membership); Ms. Deepa Singh, Member (Seminar), Mr. Bedanand Chaudhary, Member (Planning).

After the inaugural session, two special technical sessions were held in the first day. In the first session, chaired by Mr. Ganesh K.C., following four presentations were made: (1) World Food Crisis: Reality or Myth? by Dr. G. Ortiz-Ferrara; (2) Role and Responsibilities of Nepal Agricultural Research Council (NARC) in the National Agricultural Research System by Dr. Dil Bahadur Gurung; (3) Integrating All Research Providers into National Agricultural Research System: Status, Rationale and Strategies by Dr. Hari Krishna Upadhyaya, chairman of CEAPRED; and (4) Role and Contribution of Private Sector in Agriculture Research and Development by Pradeep Maharjan, Executive Director of Agriculture Enterprise Center of FNCCI (Federation of Nepalese Chambers of Commerce and Industry).

The second session, chaired by former Executive Director of NARC, Mr. Dhruva Joshy, included six presentations: (1) Public Investment and Performance of Agricultural Sector: Strategic Framework for Agricultural Research Policy by Dr. Devendra Gauchan; (2) Contribution of Agro-biodiversity in Global Food Security by Mr. Madan Raj Bhatta; (3) Crop Research: Present Status and Future Strategies by Dr. Shambhu Prasad Khatiwada; (4) Current Scenario and Future Strategy of Horticultural Research in Nepal by Dr. Krishna Prasad Paudyal; (5) Livestock Research in Nepal: Present Status and Future Strategies by Dr. Bhoj Raj Joshi; and (6) Fisheries Research in Nepal: Present Status and Future Strategies by Dr. Tek Bahadur Gurung.

Day 2:

Five parallel sessions on (1) crops, (2) horticulture, (3) livestock, (4) Organic Agriculture: Trends and Sustainability, and (5) Advancement in Aquaculture Research in Nepal were organized on the premises of National Agriculture Research Institute and Nepal Academy of Science and Technology, Khumaltar, Lalitpur. The session on organic agriculture was jointly organized by SAS-N, Nepal; Horticulture Society, Institute of Agriculture and Animal Sciences (IAAS) of Tribhuvan University, Horticulture Research Division, NARC; Asian Network of Organic Farming Technology (ANSOFT) of Asian Food and Agriculture Cooperation Initiatives (AFACI, Korea), Nepal Permaculture Group (NPG) and Sustainable Agriculture Development Program (SADP), Nepal. The session on aquaculture was jointly organized by Fisheries Research Division of NARC, Nepal Fisheries Society (NFS) and SAS-N.

Altogether over 150 papers on food security, agro-biodiversity, agronomy, horticulture, plant breeding, crop and soils management, physiology, micro-nutrients, irrigation, livestock improvement, livestock production, animal nutrition, animal health, fodder and pasture, fisheries, agro-forestry, climate change and socio-economics were presented in the second day. The crop session had altogether 37 papers presented in three sub-sessions, chaired by Dr. Guillermo Ortiz-Ferrara, CIMMYT representative, Dr. Niranjana Prasad Adhikary, Director, Crops and Horticulture Research of NARC, and Dr. Suroj Pokharel, Program Director, Crop Development Directorate of Department of Agriculture. The sessions were facilitated by Dr. Mina Nath Poudel and Dr. Shambhu Prasad Dhital,

senior scientists of NARC. The horticulture session had 30 papers presented in two sub-sessions, chaired by Prof. Gyan Kumar Shrestha of Tribhuvan University and Dr. Chiranjibi Regmi, Principal Scientist of NAST. The sessions were facilitated by Dr. Krishna Prasad Paudyal and Mr. Yagya Prasad Giri, Principal Scientists of NARC. Similarly, livestock session had 20 papers presented in two sub-sessions, chaired by Mr. Dinesh Pariyar, Principal Scientist and Dr. Bhoj Raj Joshi, Principal Scientist / Dr. Nanda Prasad Shrestha, former Executive Director of NARC. The sessions were facilitated by Dr. Prakash Pokhrel, Senior Scientist of NARC.

The fisheries session had 28 papers presented in four sub-sessions, chaired by Prof. Madhav Shrestha of Tribhuvan University, Mr. Ash Kumar Rai, former senior scientist of NARC, Dr. Deep Bahadur Swar, former Director General of Department of Agriculture, and Dr. Tek Bahadur Gurung, Principal scientist of NARC. The sessions were facilitated by Mr. Suresh Kumar Wagle and Ms. Neeta Pradhan. Likewise, the session on organic agriculture had 27 papers presented in three sub-sessions, chaired by Mr. Shiv Bahadur Nepali, former Executive Director of NARC, Prof. Dr. Fanindra Prasad Neupane, academician of NAST, and Dr. Samundra Lal Joshi, former principal scientist of NARC. The sessions were facilitated by Dr. Yajna Gajghar Khadka, Principal scientist of NARC.

An official dinner was hosted at Indreni Food Land in honor of all participants of the Convention. Amid a function at the dinner, Honourable Om Prakash Yadav, Minister of State for Agriculture and cooperatives, presented plaque of honor to all executives of the past four executive committees of SAS-N for their contribution in establishing and expanding the role and scope of the Society.

Day 3:

Following the day 2 of the conference, five working groups comprising the participants of the respective parallel sessions were organized to draw the recommendations and research agendas. The working group sessions on crops, horticulture, livestock, fisheries and organic agriculture were coordinated by Dr Shambhu Prasad Khatiwada, senior scientist of NARC, Mr. Dev Kanta Chaudhary, senior scientist of NARC, Dr. Chet Raj Upreti, principal scientist of NARC, Prof. Dr. Madhav Kumar Shrestha and, Dr. Samundra Lal Joshi, former principal scientist of NARC, respectively; and facilitated by Dr. Anand Kumar Gautam, senior scientist of NARC, Mr. Yuba Raj Pandey, senior scientist of NARC, Mr. Bhola Shankar Shrestha, senior scientist of NARC, Dr. Dilip Kumar Jha of IAAS / Mr. Jay Dev Bista senior scientist of NARC, Prof. Dr. Khem Raj Dahal of IAAS, respectively. Each group discussed and worked in detail on the given agendas and presented the issues and recommendations in the plenary session chaired by Dr. Nanda Prasad Shrestha, the former president of SAS-N and the former Executive Director of NARC. The Convention at the conclusion produced recommendations on crops, horticulture, livestock, fisheries and organic agriculture.

At the end of the day, 11-member new Executive Committee was elected: Dr. Hira Kaji Manandhar (President), Dr. Keshab Babu Koirala (Vice-President), Dr. Yuga Nath Ghimire (General Secretary), Mr. Keshav Prasad Shrestha (Treasurer), Mr. Suraj Baidya (Secretary, Administration Management), Ms. Chetana Manandhar (Secretary, Coordination), Dr. Neena Gorkhali (Secretary, Financial Management), Ms. Deepa Singh (Member, Seminar/Conference), Mr. Ram Babu Paneru (Member, Publication Management), Dr. Ramesh Prasad Sah (Membership Management) and Mr. Tika Bahadur Karki (Member, Planning and Technical Service).

Exhibition

On day 2 and 3, ten agri-enterprises exhibited various agri-products, inputs, modern tools and equipment. The exhibition helped both the participants and entrepreneurs on sharing and getting acquainted with new technologies.

Recommendations of the Fourth Convention of SAS-N

A. Crops Research

Issues	Recommendations
1. Policy Reform 1.1 Lack of National Agricultural Research Policy (NARP) 1.2 No mandatory involvement of Nepal Agricultural Research Council (NARC) in various development programs and projects of Ministry of Agriculture Development (MoAD) 1.3 NARC is detached from decision making process of MoAD	1.1 Formulation of NARP by GON with recommendation of NARC and approval of NARC Vision document by GON are required 1.2 Development and mission based programs should be research led as in neighboring countries 1.3 NARC Executive Director must be ex-officio (Technical) Secretary in MoAD
2. Organizational Reform 2.1 Research providers working in isolation 2.2 Inadequate research stations in far-western region according to agro-ecological zone	2.1 NARC should lead the NARS 2.2 Establishment of RARS/ARS in far-western region and agro-ecological based stations
3. Strengthening Human Resource Capabilities 3.1 Political interference in recruitment process 3.2 Brain drain of scientists (researchers)	3.1 Public Service Commission should be given full responsibility for the recruitment of human resources within NARC 3.2 Attractive salary and incentives (Pension, research allowances, increase the service period, timely promotion system)
4. Strengthening Infrastructure 4.1 Poor infrastructure	4.1 Strengthening of national, regional and local level infrastructures (labs etc)
5. Research Strategy 5.1 Low priority for basic research 5.2 No GON policy on Hybrid and GMOs research 5.3 Research on post harvest and value addition is not sufficient for	5.1 NARC should also focus on basic research as needed 5.2 GON should formulate the national policy on Hybrids and GMOs research with strong financial support and commitment 5.3 Strong support for post harvest and value addition research

commercialization 5.4 Least priority on climate change issues in agriculture	5.4 Development of research facilities to address climate change in agriculture
6. Globalization, Commercialization and Trade 6.1 Lack of competent agricultural technologies 6.2 Poor agri-mechanization 6.3 Fragmentation of agricultural land	6.1 Identify commodities for import substitution and export promotion 6.2 Promotion of mechanization in agriculture providing subsidies and remuneration for manufacturers, soft loan to the provider and users 6.3 Land consolidation, community/co-operative farming
7. Strategy and Approach for Technology Transfer 7.1 Poor technology transfer mechanism 7.2 Weak outreach research policy	7.1 Establishment of training centers within NARC (For SMS) 7.2 Revision of outreach research policy and strengthen the outreach research

B. Horticultural Research

Issues	Recommendations
1. Policy Reform 1.1 Lacking agricultural research policy 1.2 Horticulture Master plan aborted 1.3 Horticulture contribution undermined within agriculture sector 1.4. Least focused on research sector in ADS	1.1 Need to formulate separate agricultural research policy 1.2 Need to develop and endorse Horticulture Master Plan 1.3 Separate horticulture research policy needed 1.4 NARC should be intensively involved in policy formulation as per Act (NARC Act 2048)
2. Organizational Reform 2.1 No functional NARS in the country 2.2 Scattered and unorganized research in horticultural crops	2.1 NARC should have clear mandate to act as NARS and HQ should work as NARS 2.2 Need to establish a horticulture research institute. Commodity programmes should function under institute

2.3. Not clear mandate of different organization (Divisions, RARS, ARS) 2.4. Insufficient agro-ecological coverage by existing research centers	2.3 Need to carry out core function analysis of each level of institutes 2.4 Develop/acquire new research centres to cover major agro-ecological zones
3. Strengthening Human Resource Capabilities 3.1 Insufficient number 3.2 Unplanned posts and placement 3.3 Unplanned HR development 3. 4 High rate of brain drain	3.1 Post and positions should be increased as per need 3.2 Proper planning of hierarchical posts and deployment in respective field 3.3 Need analysis 3.4 Retention strategies
4. Strengthening Infrastructure 4.1 Running labs inadequate 4.2 Poorly maintained mother stocks	4.1 Establishment of well equipped lab and trained manpower 4.2 Lands back to NARC from Nepal Army and maintain mother stocks
5. Research Strategy 5.1 Postharvest technological research services inadequate 5.2 Lacking clear policies on GMOs 5.3 Outflow of national currency for hybrids 5.4 Lack of knowledge/practice on value addition 5.5 Research on climate change not focused well 5.6 Core function analysis of different entities under NARC not defined in relation to basic, strategic, applied, adaptive, core research	5.1 Technical manpower need to be fulfilled and research and training facilities should be upgraded 5.2 Enforcement of GMO law (lab establishment, develop technical manpower) 5.3 Prioritize and strengthen hybridization research 5.4. Link research to processing industries to develop technologies for value added products 5.5 Focused research programs in horticulture in relation to climate change 5.6 Define clear mandate of Divisions, commodity research programs, RARS/ARS
6. Globalization, Commercialization and Trade 6.1 Poor competitiveness of Nepali products 6.2 No clear cut incentive package for export promotion and import substitution 6.3 Research programs are not focused to	6.1 Develop low cost and market led technologies 6.2 Incentive to growers and exporters in end product should be provided 6.3 Research execution in exportable

promote export market	commodities in PPP model
7. Strategy and Approach for Technology Transfer 7.1 Low priority on trainings for technology seekers in NARC 7.2 Poor direct linkage of researchers to end users 7.3 Public extension service is more focused on input supply rather than dissemination of new technologies 7.4 First hand information on technologies are not published and made available to the farmer 7.5 Strength of NGO sector network not adequately utilized by research system for technology dissemination	7.1 Regular training programs to SMS 7.2 Increase/strengthen outreach research sites in the command of RARS 7.3 Need mandatory extension programs to disseminate new technologies in commercial scale with the involvement of technology inventor 7.4 Increase farmers' friendly publications and made available to clients 7.5 Maximum use of ICT by NARC to disseminate new technologies Outreach Research system of NARC should focus on delivery of technologies through NGO network

C. Livestock Research

Issues	Recommendation
1. Policy Reform 1.1 NARC vision endorsement 1.2 Non-access to community forestry for livestock feed resources 1.3 Mandate on pet animal research	1.1 Endorsement and integration of NARC vision into national agriculture policy, ADS 1.2 Policy for fodder species and access for fodder production in community forestry 1.3 Policy for research on pet animals
2. Organizational Reform 2.1 Institute-based livestock research 2.2 Research farms for livestock research	2.1 Research institutions (e.g. Dairy, Goat, Veterinary, Pasture, Swine, Poultry etc.) must be established 2.2 Leading research farms (by livestock commodity) and satellite farms need to be established
3. Strengthening Human Resource Capabilities 3.1 Inadequate posts 3.2 Inappropriate placement (by discipline)	3.1 Post creation and new recruitment 3.2 Readjustment of disciplinary group

3.3 Expertise in emerging field/balance 3.4 Shortage of mid level technicians 3.5 Disciplinary experts in each livestock commodity 3.6 Series conversion - qualified manpower	3.3 Training, higher education 3.4 Recruitment 3.5 Post creation and recruitment/ adjustment 3.6 Rational conversion (seniority and salary)
4. Strengthening Infrastructure 4.1 Old/outdated infrastructure (office/ lab) 4.2 Lab manpower 4.3 Scattered lab/unused equipment 4.4 Accredited lab	4.1 Renovate, rebuild, modern equipment 4.2 Recruitment of lab technician (with suitable academic qualification) and training 4.3 Central lab/ best utilization of limited resources 4.4 NARC lab should be accredited
5. Research Strategy 5.1 Compartmental/fragmented research 5.2 Intermingled approach for commercial and subsistence production 5.3 Untapped potential of existing organic livestock products 5.4 Vulnerability of livestock to climate change 5.5 Indigenous knowledge/ resource documentation 5.6 Absence of breed and technology releasing mechanism	5.1 Focused, prioritized and coordinated research 5.2 Separate research strategy for commercial and subsistence production system 5.3 Promotion and certification system for organic livestock production 5.4 Climate change adaptation strategy 5.5 Indigenous knowledge/ resources identification/ documentation/ evaluation and utilization and patenting 5.6 Technology releasing mechanism need to be developed Inclusion of equine species in research Import of exotic livestock species
6. Globalization, Commercialization and Trade 6.1 Self sufficiency for meat 6.2 Lack of package of practices for commercial livestock production 6.3 Disappearing indigenous knowledge and natural bio-resources	6.1 Commercialization of goat production on cultivated system (research) 6.2 Research to develop package of practices 6.3 Patenting indigenous Knowledge and agro-biodiversity resources
7. Strategy and Approach for Technology Transfer 7.1 Poor adoption of technologies 7.2 Weak collaboration between research and	7.1 Outreach sites focusing on livestock system 7.2 Need to be inbuilt in National Agriculture

extension 7.3 NTWG Recommendation	Policy 7.3 Information centre at different locations Filtering and prioritizing field issues Fact sheets for each technology from each project approved by NARC and implemented by researchers Model Village Concept

D. Fisheries Research Group

Issues	Recommendations
1. Policy Reform 1.1 Lease policy 1.2 Subsidies for production / marketing inputs 1.3 Utilization of irrigation canals 1.4 Water use for fish ponds	1.1 Lease policy for utilization of public land/wetland through local/ethnic community 1.2 Subsidies for production/marketing inputs as other agricultural sectors 1.3 Irrigation canal and reservoir should be utilized by aquaculture 1.4 Water supply for fish ponds should be subsidized as in irrigation
2 Organizational Reform 2.1 Ministry 2.2 Directorate 2.3 Fisheries Research Institute and Programs	2.1 Livestock and Fisheries Ministry and Department of Fisheries need to be established or Fisheries Division under Ministry which can be easily coordinated among the research, development/extension and education should be formed 2.2 In NARC, separate Directorate of Fisheries and Aquaculture for effective implementation and coordination of fishery R & D 2.3 Fisheries Research Institute • Warm water aquaculture research program to address the most potential warm water areas in terai regions • Cold water aquaculture research program to address cold water aquaculture in mid and high hill regions • Natural water fisheries and biodiversity

2.4 Disciplinary Divisions 2.5 Fisheries Research Stations 2.6 Education 2.7 Training and technology transfer	research program to address the open water fisheries, biodiversity and environmental / climate change of rivers, lakes and reservoirs 2.4 Disciplinary Divisions are necessary in the following areas: • Fish breeding, genetic and biotechnology • Aquaculture management (limnology, water quality and pond management) • Fish nutrition and health management 2.5 Research Stations in Far western and Eastern region (representation for eco-region) to address need/problem-based research 2.6 College of fisheries and aquaculture under Agriculture and Forestry University 2.7 Provision of training for SMS, technicians and farmers within the NARC system
3 Strengthening Human Resource Capabilities 3.1 Human Resource Development 3.2 Training and higher education	3.1 Human resource should also be recruited with the specialization in all sub-sectors and fields in fisheries and aquaculture: • Aquaculture • fisheries biology (ichthyology) and • food technology to address culture based fisheries, biodiversity, natural resources management and post harvest technology, value addition and quality control 3.2 Training and higher education opportunities should be provided to scientists, technicians and NARC staff
4 Strengthening Infrastructure 4.1 Laboratories	4.1 Well facilitated laboratory should be established in central level including fish biology/ water quality /limnology, nutrition and health management facilities with • skill full /trained lab technicians and • lab engineer

5 Research Strategy 5.1 Collaboration for research and teaching 5.2 Post harvest and value addition 5.3 Climate change adaptation	5.1 Institutional collaboration • Institutional collaboration among different professional organizations, universities and NARC for research and education/teaching. • Manpower utilization according to level of research - Core-research: higher level scientist - Adoptive research: by other researchers • Students can be as a part of support for research • Scientists should be participated in teaching at collage for refreshing the knowledge 5.2 Facilities for technology development in post harvest and value addition should be established. • Subsidies for chilling centers, solar dryers etc 5.3 Research focus on impact assessment of climate change to biodiversity, habitat shifting, spawning behavior
6 Globalization, Commercialization and Trade 6.1 Institutional Property Right (IPR) 6.2 Commercialization 6.3 Quarantine and certification system	6.1 Intellectual Property Right (IPR) and Patent Right (PR) • Act formation • SAS-N should initiate 6.2 Promotion of potential commercial fish species 6.3 Policy for certification and quarantine of live and fish products
7 Strategy and Approach for Technology Transfer 7.1 Technology transfer	7.1 Collaborative actions need to be carried out involving • Development agencies • Universities • Outreach programs • Training

	• Farmers to farmers • Commodity-wise representation in Outreach Research Division and Socioeconomic Division
8 Miscellaneous	• Linkages and coordination between national and international organization

E. Organic Agriculture

1. Policy Reform

- Site and commodity specific programs
- Niche area, high valued and exportable crops and livestock commodity
- Holistic approach integrated: cereals, vegetable, fruits, plantation crops, livestock, and forestry
- Local innovation (Technological and Social from different stakeholders)
- Subsidy: FYM improvements, industrial inputs(production and marketing)

2. Organizational Reform

- National research policy for organic production
- Identify Organic Farms under NARS for research

3. Strengthening Human Resource Capabilities

- Develop and implement academic and non-academic courses/programs on organic agriculture
- Create opportunity for manpower in organic agriculture in NARS
- Train in-service human resources
- Incentives for enhancing working capabilities of scientists/stakeholders

4. Strengthening Infrastructure

- Develop center for advanced research and studies
- Establish an accredited laboratory
- Establishment of quality control laboratories at regional level
- Establish training centers at niche-based commodity areas

5. Research Strategies

- Research to find out the basic status of organic agriculture in Nepal
- Research to address the problem of soil degradation, climate change, and ecological system and environmental services
- Long term holistic research
- Exploration, verification, and validation of indigenous knowledge and skill, and local innovations
- Strengthening existing core researches vis-à-vis organic agriculture
- Encourage cross pollinated crops for hybrids developed in local condition, but discourage GMOs for organic production
- Verify and promote local/safe technology for Post harvest value addition

6. Globalization, Commercialization and Trade

- Explore national and international markets opportunities
- Develop and institutionalize national certification systems in compliance with international standard
- Orient existing national “One Village One Product” program towards organic production
- Develop, monitor, and supervise organic market

7. Strategies and Approach for Technology Transfer

- Develop national system for organic agriculture technology
- Adoption and strengthening the existing systems
- Strengthening outreach research in different agro-ecological zones
- Encourage farmers to farmers (FTF) technology transfer system

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