ISSN 1682-6566

"Food Security and Poverty Alleviation Through Sustainable Agriculture Research"

# Advances in Agricultural Research in Nepal

Proceedings of the First SAS/N Convention

March 30-31, 1999, Kathmandu

Society of Agricultural Scientists (SAS), Nepal

January 2001

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## Proceedings of the First SAS/N Convention
March 29-31, 1999, Kathmandu

Edited by

H. K. Manandhar, C. L. Shrestha, R. K. Shrestha and S. M. Pradhan

Nepal Agricultural Research Council

Society of Agricultural Scientists (SAS), Nepal
January 2001

# First SAS/N Convention

**Organizer** : Society of Agricultural Scientists, Nepal (SAS/N)

**Theme** : Food Security and Poverty Alleviation through Sustainable Agriculture Research

**Venue** : Nepal Administrative Staff College, Jawalakhel, Kathmandu, Nepal

**Date** : March 29-31, 1999

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ISSN 1682-6566

**Publication Sponsor:**

**CARE NEPAL**

Krishna Galli, Patandhoka, Lalitpur, Nepal
P.O. Box: 1661
E-mail: care@carenepal.org
Phone: 977-1-522800
Fax: 977-1-521202

Printed at: Palhi Chhapakhana Pvt. Ltd.
New Baneshwor, Kathmandu
Phone: 977-1-493342
Fax: 977-1-478258

# Dedicated to

## Late Netra Bahadur Basnyat
## (1928-1999)

This publication is dedicated to late Netra Bahadur Basnyat. Mr. Basnyat started his scientific career with the Ministry of Food and Agriculture of Nepal in 1952 and was active and creative till his retirement. He rendered his valuable service to almost 12 different governmental and non-governmental organizations. He held key positions such as Chief Commissioner, Nepal Agriculture Research Service Commission, Nepal Agricultural Research Council; Registrar, Tribhuvan University; Dean, Institute of Agriculture and Animal Science, Tribhuvan University; and Director General of Department of Agriculture Education and Research. He received honors as Trishakti Patta III and Gorkha Dakshin Bahu III from His Majesty's King of Nepal. He was a source of inspiration for young and energetic agricultural scientists. He is to be remembered ever for his honest efforts and outstanding contributions on institutional capacity building and human resource development in agricultural education and research. The Society of Agricultural Scientists (Nepal) deeply mourns and condoles the death of the highly respected and reputed personality of his time.

# Foreword

Food security and poverty alleviation, a foundation for the development of a country, goes hand in hand. Sustainable food security and poverty alleviation are linked to each other in complex ways. The United Nation Conference on Environment and Development (UNCED) in Rio in 1992, Agenda 21 envisions the worldwide mobilization of scientific resources to alleviate poverty by promoting sustainable agriculture.

Society of Agricultural Scientists (SAS), Nepal was established in 1995 to promote agricultural research. The SAS, Nepal organized the first convention on "Food Security and Poverty Alleviation through Sustainable Agriculture Research" during 29-31, March 1999 in Kathmandu. The objectives included creation of forum to interact among the researcher engaged in research on technology generation on sustainable agriculture, increase public awareness on agriculture research, recognize agriculture scientist, suggest Nepal Agricultural Research Council (NARC) and the government in formulating national policy and strategies on agriculture research and strengthen linkages among government and non-government organizations. This publication contains the 45 papers presented at the symposium. We hope that this will be a useful source of information.

Madhusudan Upadhyay
Chairman, Society of Agricultural Scientists (SAS), Nepal

# Preface

This is the first comprehensive publication of Society of Agricultural Scientists (SAS), Nepal, presenting a complete overview of agricultural research in Nepal. The proceedings include five invited reviews on agricultural research and development in relation to food security and poverty alleviation, 34 original research papers on various disciplines of crop and livestock sectors, six research-based review papers on crop science and one general review paper on livestock science. The papers were presented at the First SAS/N Convention held in Kathmandu, Nepal from March 29 to 31, 1999. Of the 33 research papers, three were based on Ph.D. theses carried out abroad by Nepalese scientists. One paper, "Status of rhizome rot of ginger in Nepal and possible options for disease management" presented at the Convention, is excluded from the proceedings as it was earlier published in Nepal Agricultural Research Journal Vol. 3, No. 1 (1999).

Though it is beyond the scope of this publication it provides an overview of advances in agricultural research in Nepal. The publication is aimed at documenting the research results and making them available for farmers, researchers, extension workers, planners and policy makers. This is particularly important since many of the research results are left unpublished or remain in the researchers' files, resulting in limited or no dissemination. Successive publication of these proceedings in coming years is expected to continue playing an important role in documentation and dissemination of research findings.

My colleague editors and I would like to express our sincere gratitude to SAS, Nepal for giving us this opportunity to work for the proceedings. Sincere thanks are due to Mr. K. R. Bhatta, Communication, Publication and Documentation Division of Nepal Agricultural Research Council (NARC) for the scanning and placing of figures, page layouts and for obtaining the ISSN number and to Ms. Kalpana Pant, former Administrative Assistant of Agronomy Division of NARC for word processing. The dedication write-up to Late Netra Bahadur Basnyat was prepared by Mr. D. N. Manandhar, Entomology Division of NARC.

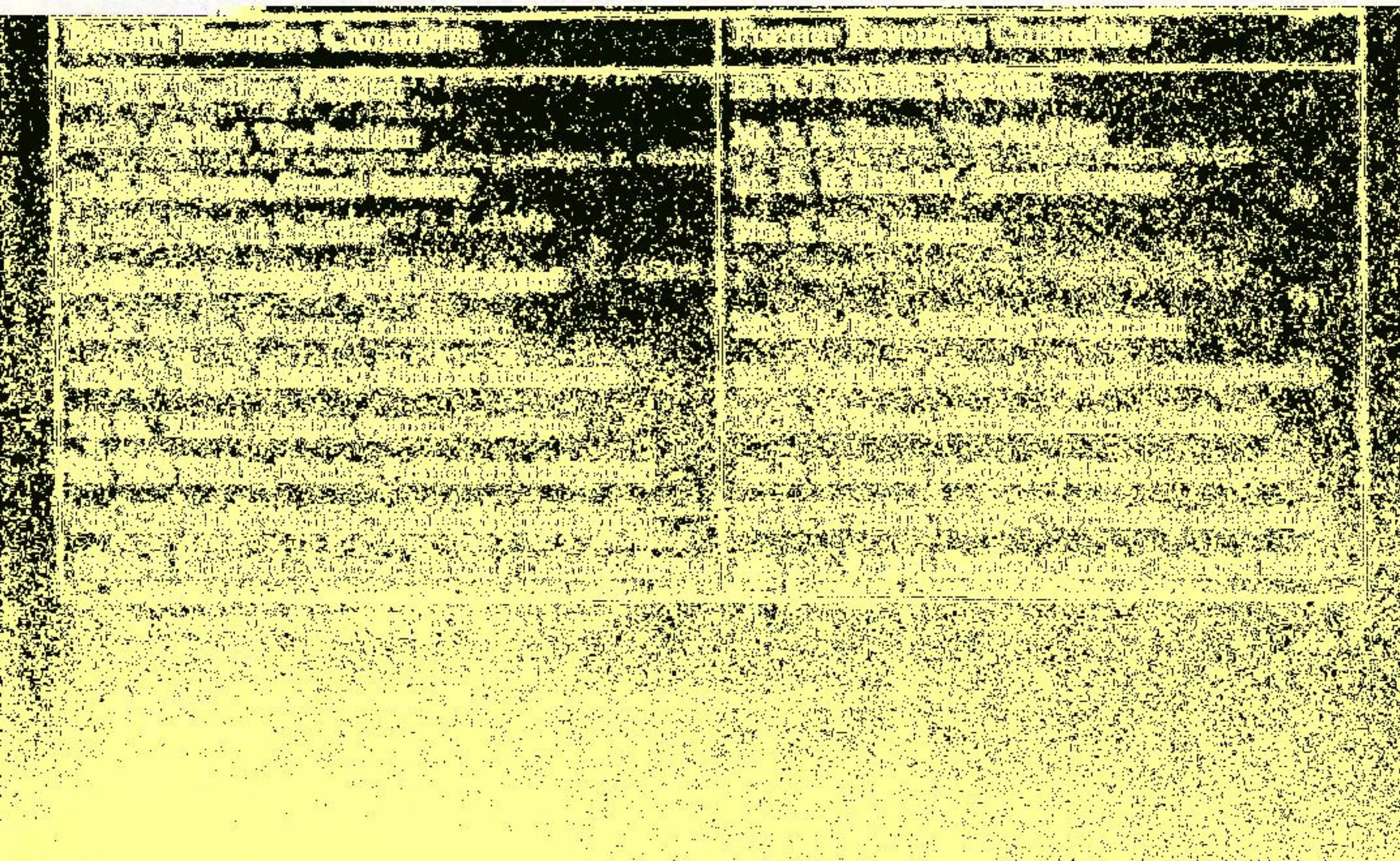
H. K. Manandhar, Chief Editor
Plant Pathology Division
Nepal Agricultural Research Council

# SAS: A Brief Introduction

Society of Agricultural Scientists (SAS), Nepal is a non-profit professional organization, providing a common platform for agricultural scientists and researchers involved in the profession. The society was established in 1995 with the view to help promote the economic development of the country through agricultural research.

General goal of the society is to unite and bring all the agricultural scientists and researchers of Nepal to a common forum supporting the economic development of the country through the promotion of agricultural research and safeguarding the professional rights and welfare of the society members. To achieve the goal, the society has the following objectives:

- Protect the professional rights and welfare committed to democracy, human rights and public welfare as stipulated by the constitution of Nepal 2047.
- Serve with an advisory role to His Majesty's Government on formulation of research policy and seek solution to the agricultural problems.
- Organize workshop, seminar, conference on national and international levels concerning agricultural research and development issues.
- Promote publications related to agricultural research and development to advance scientific knowledge and create public awareness.
- Establish cooperation and collaboration with other national and international institutions and promote exchange of agricultural researchers and experiences.
- Provide consultancy services to organizations, institutions or persons within the country or abroad.
- Maintain close relationship with the sister organizations of agriculture and other related organizations facilitating the mutual exchange of help and cooperation.
- Maintain regularity in the publication of scientific journals.



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Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# HISTORICAL REVIEW AND FUTURE STRATEGIES OF AGRICULTURAL RESEARCH IN NEPAL

N. B. BASNYAT
Kathmandu, Nepal

## INTRODUCTION

Agriculture development work in Nepal started in 1925 with the establishment of the Department of Agriculture guided by a-Board of Agriculture. During this period, three pioneer agriculturists trained in India, joined the Department who initiated agricultural development of Nepal.

Due to the lack of trained manpower, inadequate funds and transportation difficulties, limited development works on fruits and vegetables were done in and around Kathmandu valley. Fruit tree saplings and vegetable seeds were introduced from different countries and put under test. Proven varieties were multiplied and distributed to the growers.

Due to shortage of Nepalese experts, Indian experts were recruited to join the Department of Agriculture Services. Their contribution to the development of horticulture in Kathmandu and irrigation system in Bara District of Terai (Dhudaura Irrigation Project) was significant.

In 1940's fresh batch of students were sent to different agricultural colleges in India. During 1940-44 nine agriculture graduates joined the Department of Agriculture. These nine graduates formed a core staff for future development and expansion of the Department of Agriculture. The recruiting process continued and in 1951 - 52, ten agriculture and nine animal science specialists joined the Department. During that period Agriculture Board was demolished and the secretary of the Agriculture Board became a full-fledged Director.

Agriculture and livestock research and development work carried out in Nepal, can be divided into five phases in accordance with the changes in the organizational structure brought about by policy makers. This phase-wise division is an arbitrary division and is used to see the effect on working program due to structural changes. Phase - wise changes brought about by change in organizational structure are given below.

| Phase | Period | Change in organization structure |
|---|---|---|
| First | (1953-66) | Department of Agriculture (DOA) |
| Second | (1966-72) | Department of Agriculture Extension (DOE)<br>Department of Agriculture Research and Education (DOARE)<br>Department of Livestock Development and Veterinary Services (DLDVS)<br>Department of Horticulture (DOH)<br>Department of Fisheries (DOF) |
| Third | (1972-79) | Department of Agriculture (DOA) |
| Fourth | (1979-87) | Department of Agriculture Development (DOAD)<br>Department of Livestock Development and Animal Health (DLDAH) |

| | | |
|---|---|---|
| Fifth | (1987 - present) | Department of Agriculture (DOA)<br>Department of Livestock Services (DLS)<br>National Agriculture Research and Services, Centre (NARSC), 1992 upgraded to Nepal Agricultural Research Council (NARC) |

## FIRST-PHASE (1953-66)

In the year 1953, with the availability of increasing number of agriculture graduates returned from Indian colleges, the Department of Agriculture (DOA) created six sections namely: Agronomy, Agriculture Engineering, Entomology, Livestock and Dairy, Horticulture and Fisheries. These sections were established at Singhadurbar, in addition to the Veterinary Section, which already existed at Tripureswor. Later, Dairy Section at Lainchwor, Plant Pathology Section, Agriculture Botany Section and Extension Section were established at Shreemahal Jagadamba Krishi Bhawan.

In this phase the creation of the sections of different disciplines can be considered as an era of beginning of scientific research and development of agriculture and animal science in an organized way. The DOA took pronged action for the development of infrastructure, technical manpower and scientific agricultural research, which was continued up to 4th phase (1979-87).

### Infrastructure development

In this phase, major role was played by sectional heads to expand their activities in the related fields outside Kathmandu valley. Most of the sections concerned with the fields had to move out of Singhadurbar. Budgetary provision was made by HMG for acquisition of land and construction of the buildings. First, Agronomy Section was shifted to Khumal Agronomy Farm and then after the completion of the buildings Soil Science, Entomology, Plant Pathology, Agricultural Botany, Agricultural Engineering were established in Khumal complex. Khumal complex became a focal point for providing research program in their respective fields situated at different locations outside Kathmandu valley.

Agronomy Section established seven agronomy farms at Khumal, Nepalgunj, Dhankuta, Pokhara, Janakpur, Jumla and Doti, and four agricultural stations at Parwanipur, Bhairahawa, Biratnagar and Rampur. Out of seven agronomy farms, Pokhara and Dhankuta farms were handed over to horticulture because these areas were suitable for citrus cultivation.

At the end of the first phase, in 1967, Livestock Section was shifted to Khumal complex from Singhadurbar. This section established five livestock and sheep farms at Jiri, Lamapatan, Rampur (buffalo and Hariyana breeding), Khimti (cattle breeding), Tarahara (buffalo breeding) and Chitlang (sheep), covering hills and Terai regions of Nepal.

Horticulture Section established 10 horticulture orchards at Parwanipur, Tarahara, Palpa, Trisuli, Kakani, Daman, Marpha, Helambu, Jumla and Janakpur, covering mountain, hill and Terai regions of Nepal. Veterinary Section established 33 veterinary hospitals, 14 zonal and 19 District level and 4 check posts.

Fisheries Section had a modest start to stock fingerlings imported from India in the existing ponds around Kathmandu and Lalitpur area and also in Janakpur. With the introduction of German and Israeli carps with induced breeding technique it made possible to produce fingerlings, which could be restocked after harvest. During this phase fish farms at Godawari, Parwanipur, Bhairahawa, Janakpur Tarahara, and Pipley (Makawanpur) were established for pond fish culture, and at Trishuli and Pokhara for river and lake fish culture, respectively.

### Technical manpower development

During Rana autocratic region, Nepal was not diplomatically exposed to the outside world except close relations with the British regime in India. During later part of the Rana regime, Nepal extended

its diplomatic relation with the USA and France. Then after, the diplomatic relation with other countries of the world was gradually extended. In the year 1951, Nepal became member of Food and Agriculture Organization (FAO). In 1955, Nepal joined the United Nations (U.N.). With the increasing diplomatic relation, Nepal became recipient of foreign aid and technical cooperation program from friendly countries. In the beginning, Nepal Government initiated agriculture manpower development by providing stipend to Nepalese students with the qualification of School Leaving Certificate (S.L.C.) to the agriculture collages and institutions in India. Initially, this program provided manpower to start agriculture research and development work.

In 1952, United States Operation Mission (USOM) was established at Rabi Bhawan, Kalimati Durbar in Kathmandu. The Mission provided a team of technical experts in different faculties of agriculture. Later in 1961, the Mission was renamed as United States Agency for International Development (USAID). It has substantially contributed to manpower development by providing higher education to Nepalese students as well as Department's technical staff in the Universities of the USA and third countries. Also, under the PL 480 grant money, UASID provided higher education in agriculture in the agricultural universities in India.

In 1956, Indian Aid Mission (IAM), later known as Indian Cooperation Mission (ICM), was established in Nepal. The Mission has also contributed manpower development in agriculture by providing graduate (B.Sc. Ag.) and postgraduate level (M.Sc. Ag. and Ph.D.) education in universities and collages in India, under Colombo Plan grant. Similarly, Governments of Australia and New Zealand provided higher education under Colombo Plan grant to the Nepali scholars. These programs have become a source of constant flow of technical manpower to be absorbed in the expanding agricultural programs. The program was continued up to fourth phase (1979-87).

## Scientific research

In the beginning to start with the agriculture and animal science research, the prerequisite was to introduce plant and animal genetic materials from other countries. In this effort of introducing plant and animal genetic materials, support was obtained from USAID, ICM, FAO, and Governments of Australia and New Zealand (under Colombo Plan).

*Rice.* Varietal trials of rice varieties introduced from the USA, Philippines, India, Taiwan and Japan were conducted at different locations. Outstanding varieties selected from the trials were recommended. They include CH 45 (early variety), IR 8, Taichung Native 1, Masuli for inner and outer Terai; Taichung 176, Chinan 2 and Chinung 242 for temperate region particularly for three districts of the Kathmandu valley.

*Wheat.* Wheat varieties were introduced through USAID from Colombia, the USA, and India (NP series). Varietal trials were conducted at different locations. Outstanding varieties were recommended as follows: Lerma Rojo 52 for the temperate region and NP series for inner and outer Terai.

*Maize.* Open pollinated varieties of maize were introduced from the USA, which could not become popular with the farmers. Agronomy Section had linkage with Inter Asian Corn Program (IACP) situated at Pantnagar (U.P.) and received some crosses and composites for the trial to be conducted at Khumal. The composite varieties were tested at three locations Khumal (mid hills), Rampur (inner Terai) and Kakani (high hills) and released as Rampur yellow for inner Terai, Khumal yellow for mid-hills and Kanani yellow for higher altitude.

*Livestock.* The livestock activities were concentrated on cross breeding program - Local x Jersey at Khumal, Hariyana (draft animal) x local at Rampur, Murra buffalo x local at Rampur, Brown Swiss x local at Jiri livestock farm. Sheep breeding program with the sheep introduced from Australia and New Zealand was started at Chitlang, the oldest sheep-breeding farm in the country.

***Horticultural crop.*** Activities on tropical fruits like mango, litchi, pineapples, orchards were started at agriculture stations at Biratnagar, Parwanipur, Yagapuri and Janakpur. Tested varieties of mango, litchi saplings and crowns of pineapple were distributed to the growers.

***Fisheries.*** The fish-breeding program was continued, with the help of FOA experts. Lake fish culture was pushed ahead. New technology was developed to stock fingerlings of carps into the lake.

## SECOND PHASE (1966-72)

Ministry of Agriculture created full fledged independent five departments by combining related sections and their activities spread all over the country in the year 1966. They were Department of Agriculture Extension (DOAE), Department of Agriculture Research and Education (DOARE), Department of Livestock Development and Veterinary Services (DLDVS), Department of Horticulture (DOH) and Department of Fisheries (DOF). The directors of respective departments reported directly to the Secretary of Agriculture, who acted as the coordinator.

The DOAE and DOARE were supported by USAID. It also provided full support for institutional development of research, training and extension, the major components of the agricultural development process.

The DOARE had the responsibility of providing medium level manpower required for research, extension, livestock and veterinary projects. In 1959, the then DOA had started a School of Agriculture, to produce Junior Technician (J.T.) and Junior Technical Assistant (J.T.A.) to meet the medium level manpower required for the agriculture and livestock development work in the country. The school was located in Kathmandu valley. Later, it was upgraded to College of Agriculture. In 1972-73, the college was merged with and made a part of Tribhuvan University (T.U). It was named as Institute of Agriculture and Animal Science (IAAS) and shifted to Rampur, Chitwan in the old building complex of Panchayat Training Centre. IAAS designed a curriculum, which opened the lader to those who are capable and interested to continue their higher studies leading up to Diploma in Agriculture (B.Sc. Ag.). It also produced medium levels manpower.

In the later part of the second phase (1966-72), national crop commodity research and development programs were started. These were National Rice Improvement Program at Parwanipur; National Wheat Development Program at Khumal and later shifted to Bhairahawa; National Maize Development Program at Rampur; Sugarcane Development Program at Jitpur; and National Potato Development Program at Khumaltar. Researches conducted by these programs for more than 25 years have contributed to bring about change in production and productivity with the use of recommended package of practices. The internal rate of return (IRR) from the investment on food crops research is high. In the case of wheat the IRR is 75 to 80% where as in rice and maize the IRR value is high enough to justify investment on these crops.

The DOAE shouldered the responsibility of developing extension program of crops agriculture whereas extension program of livestock development and veterinary services was conducted by DLDVS. However, DOARE concentrated its activities only in crops development program. Department of Fisheries concentrated its activities in three areas - pond culture (Godawari, Janakpur and Bhairahawa), lake culture (Phewa and Begnas Tals in Pokhara) and river culture (Trisuli). It received technical support from FAO and Japanese Overseas Volunteer Corporation (JOVC). Department of Fisheries made a good progress in inland fish breeding program. It also organized training in fish breeding to the fisheries experts of Bhutan, Bangladesh and Laos at Janakpur Fish farm.

Department of Horticulture was supported by ICM. A good number of apple orchards were developed in Daman, Kakani, Helambu, Marpha and Jumla. Apple orchards situated at Daman, Kakani and Helambu were not productive because of heavy summer rain accompanied by hailstorms. Marpha and

Jumla apple produced by the farmers was of high quality, but the farmers could not fetch good price for it because of the transportation difficulty.

Two citrus orchards one in Pokhara and the other in Dhankuta were established. Citrus Development Program moved along but with the appearance of citrus decline disease and later found to the plasma disease, did a lot of damage to the fruit bearing trees. However, the production of fruit is maintained with proper management in the newly orchard planted areas.

Analyzing the second phase work, which lasted for six years only, it was observed that the spadework done by the individual sections had been pushed further by the respective departments. The achievements made by the individual department were the outcomes of the dedication of the scientists and technicians and dynamism of the department itself.

## THIRD PHASE (1972-79)

In the year 1972 all the departments were combined and brought under one umbrella of the Department of Agriculture (DOA). The rationale, for recombining to one department was that HMG approved ten years (1973-83) agriculture development plan, which had a provision of expanding Department of Agriculture to the grass root level with full coverage of all the seventy-five districts. To achieve this, it needed a structural change with provision of posts at different levels of operation.

The Director General (DG) of Agriculture headed the Department and was assisted by four Deputy Director Generals (DDGs). The DG was coordinator and overall in charge to formulate and implement the plan and program of the department. There were four DDGs for (i) planning and administration, (ii) livestock development, (iii) agricultural research and agriculture extension.

Similarly, posts of five Regional Directors (RDs) were created. They were posted at five regional head quarters specifically to implement and provide administrative support to the livestock, horticulture, agronomy farms, agriculture stations, and fisheries projects, veterinary services and agriculture extension program of their region. The RDs were supported by two senior officers.

The structural change in the DOA gave a thrust to push particularly crop production program with the combined effort of research and extension supported by the RDs in their region. Input Supply Corporation (ISC) and Agriculture Development Bank (ADB/N) were also involved in the process of agriculture development works in the district. Block Production and Training and Visit (T & V) programs were introduced.

Under the DDG research vegetable seed production was started at Thak Marpha and Kirtipur, later shifted to Khumaltar. The introduction and cultivation of carrot, cabbage and Japanese radish in Nepal is of high value. Supply of processed vegetable seed packets to the local consumers and export of quality vegetables seeds in other countries was primary goal of the FAO supported project. High quality apples were produced in Thak Marpha, Jumla and Dolpa, but the apple growers could not fetch good price for their products because of transportation difficulty from the remote area.

The livestock program under DDG livestock continued the breeding program. The veterinary service provided vaccine for the prevention of diseases such as rinder pest, foot and mouth diseases etc. The vaccines are produced in Veterinary Laboratory, Tripureswor, which have become basis for animal disease protection during disease out-breaks. The fisheries program encouraged private fish breeders to produce fingerlings of different carps and sell to the fish growers and also export it to the neighboring country India.

In this phase the Department of Agriculture was expanded to cover all the seventy-five districts of the country. The graduates and postgraduates in agriculture returning from different universities and collages of the USA and third countries, India, Australia and New Zealand, met the manpower required for its expansion.

## FOURTH PHASE (1979-87)

In the year 1979, the Department of Agriculture was reorganized to form Department of Agriculture Development (DOAD) and Department of Livestock Development and Animal Health (DLDAH). In this phase, all the activities of Department of Agriculture were carried out by DOAD. Department of Livestock Development and Animal Health was responsible to carryout all livestock and animal health activities.

The rationale to create two departments was increasing growth of livestock development activities in Nepal and also the resolution of the seminar that was organized by the Department of Agriculture. The Ministry of Agriculture/HMG decided to upgrade the Livestock Development and Animal Health sections to form a Department of Livestock Development and Animal Health (DLDAH) in 1979. The department was headed by Directors General (DG) who was assisted by two Deputy Director Generals (DDGs), one for livestock development and another for animal health. There was a team of administrative staff, central training and extension centre and Livestock Development Project directly under the DG. There were five Regional Directors of livestock who report to the DG. They were in charge of the livestock development and animal health programme of their respective regions.

The DLDAH has expanded its activities to cover all 75 districts of the country. The manpower required for its expansion was met by the officers who earned higher degree from overseas and Indian universities to head different divisions, which were created at Khumaltar livestock complex.

In the year 1997, DOAD was renamed as Department of Agriculture (DOA) and DLDAH as Department of Livestock Services (DLS).

## FIFTH PHASE (1987- PRESENT)

From the year 1979 the Department of Agriculture and the Department of Livestock services (DLS) were responsible to carry out development and extension activities in their respective fields. The sole responsibility of conducting agriculture and animal science research rested on National Agricultural Research and Services Center (NARSC), which was in Khumaltar complex, Lalitpur. NARSC's requirement for conducting research in plant and animal science was met by transferring DOA and DLS's property with manpower related to research. To make NARSC autonomous and apex body it was upgraded to Nepal Agricultural Research Council (NARC) by Nepal Agricultural Research Council Act - 1992. The formation of NARC is to identify problems and find ways and means of their solution through research in agriculture and animal science for raising financial status of the general public. After five years of this Act, it was considered necessary to revise this Act to suit the prevailing circumstance. The 1992 Act was revised as Nepal Agriculture Research Council revised Act - 1997. This Act created Research Council and Executive Board with defined duty, functions and their relationship. It also outlined hiring procedure of Executive Director with a four years tenure.

In the earlier part, NARSC suffered by loosing the scientists and technicians under the government policy of early retirement after 20 and 30 years of services. Filling vacant scientist posts with a qualified scientist was not possible because the higher education program on a regular basis supported as mentioned earlier, by Colombo Plan countries, USAID (under PL 40 grant money) was phased out. At present, the regular source of trained manpower is the Institute of Agriculture and Animal Science (IAAS). Word Bank, British Project, German Project, Japanese Project and USAID offer limited slots for higher education.

IAAS, however, during its existence of 23 years has only produced B.Sc. (Ag.) graduates. Very recently IAAS has started M.Sc. (Ag.) program in few disciplines. IAAS needs support, and its increasing number of 'brain drain' of qualified teaching staff should be stopped.

Most of the disciplinary research divisions situated at Khumaltar complex need additional qualified manpower to support ever-increasing program of work. Regional research stations are not in full operation due to lack of trained and qualified manpower. A Task Force Team (1994) reported that 180 B.Sc. Ag. graduates were working in scientist ($S_1$) and technical officer (TO-4) posts. Their promotion is sealed because they cannot be promoted to higher level unless and until they earned M. Sc (Ag) degree. Nepal Agriculture Research Council requirement of scientists can be partially fulfilled by providing opportunity to those in-service talented and dedicated graduates for M.Sc. (Ag.) program in order to boost their morale and create a sense of security within themselves.

NARC has a well-balanced research program covering different ecological zones of the country. It is supported by seven donor agencies and has linkage with the international agricultural research institutes and centers.

This phase can be called as an of insecure and unstable. In seven years of NARC existence six Executive Directors have been changed. NARC needs security and stability to perform agricultural research strategies, outlined in the Ninth Five-Year Plan (1998-2003). It is hoped that if Nepal Agricultural Research Council Revised Act (1997) is properly implemented the functions of NARC can be streamlined.

## FUTURE STRATEGIES OF AGRICULTURAL RESEARCH

It is out of the scope of this paper to give detailed agricultural research strategies of NARC. However, in the year 1998 a comprehensive report on research strategies of NARC was prepared by a team consisting Dr. B. R. Khadge, Dr. M. P. Upadhaya, Dr. N. P. Shrestha, Dr. K. B. Bohara and Mr. P. R. Bhurtel and a final touch was given by myself. It was presented to the Nepal Agricultural Research Council for final approval. It is learnt that it is still in process of approval. The agricultural research program strategies are briefly presented below:

### Food crops

Four food crops, rice, maize, wheat and potato are recognized for further research and development. These crops have covered 70% of the total cultivated area. There is a lot of potential to increase their production by disseminating agricultural production technologies through joint research and extension efforts. The available technologies are still untapped for adoption at farmers' level, which can be pushed through on-farm research sites making them to suit local farming situation. Terai is considered as a food bowel of Nepal and if all the required inputs are obtained for crop production, food security can be met.

### Industrial crops

There is a need for research on industrial crops like tea, sugarcane, tobacco, jute, cotton etc. to meet the national requirement. These crops can only be grown under special climatic conditions. Nepal Agricultural Research Council has organized research programmes on these crops by signing memorandum of understanding (MOU) with the related agencies. At the same time, technology exchange with the international and national industrial crop research centres will also be organized. There will be a programme to extend improved technologies so far available to the industrial crop growers.

### Livestock development and animal health

Livestock contribution in the total agriculture GDP is 31%. The 20 years Agricultural Perspective Plan (APP) has envisioned to increase the livestock contribution from 31% to 45%. To meet this commitment NARC has given priority to strengthen research on livestock and poultry development as well as buffalo breeding and for milk production. Studies will also be made on poultry development.

**Horticulture**

In the mountain areas of Nepal under specific climatic conditions, apple, citrus and vegetable seeds will be produced. In areas connected with roads, farmers will be encouraged to grow fruits and off-season vegetables, which will fetch them good price. Consumption of fruits and vegetables will also help to maintain nutritional balance in the food.

**Fisheries**

Biological and limnological studies done by the fisheries experts on lakes, river, ponds and reservoirs will be continued. Technologies on fish nutrition, fish disease, fish breeding and conservation of genetic resources of fish will be developed to support fish production program.

**Soil fertility management**

In the APP great emphasis is placed in the use of fertilizer and irrigation for increasing production of food grains. Constant use of fertilizers without proper soil fertility management has declined production due to the change in the physio-chemical properties of the soil, depletion of the organic matter content increased acidity and micro nutrient deficiency in soil. The strategy calls for agricultural research and extension to generate and disseminate knowledge to guide farmers' fertility management practices. Also, not much work has been done in developing fertility management technologies for the hills. NARC has taken the responsibility to conduct extensive research in this aspect.

**Intensive farming system**

Vast majority of small and resource poor farmers with small land holdings are totally ignored to participate in the main stream of production campaign in Terai. During the APP period, the irrigated area in Terai will expand from 40 to 86%. More than 80% of the additional area to be brought under irrigation will be from ground water pumped with the help of 188,000 shallow and 500 deep tube wells.

The strategy should be to expand research and extension efforts for developing farming system applicable to shallow tube well irrigated area. The focus on technology development should be on field crops, cropping intensity, seed production of high yielding varieties and production of fodder crops.

**Integrated pest management**

Increase of crop intensity and vigorous growth of plants have provided ample ground for multiplying pest and diseases. Due to lack of pest management knowledge, farmers are using heavy dose of pesticides that is health hazardous.

Alternate pest control strategy, Integrated Pest Management (IPM) is sustainable and eco-friendly. However, there is still a lot of research to be done to find the answers to pest-predator/parasitic interrelationship, biological control, resistance breeding and mass awareness of safe use of pesticides.

**Livestock feed, range/pasture land management, fodder cultivation and agro-forestry**

Livestock feed is the base for food production. The research carried in the utilization of by-products as cattle feed will continue. Range/pasture, fodder crops and agro-forestry protection and development research to be conducted in the agro-ecological zones will be emphasized. Northern region high altitude pasture development work will be continued.

### Conservation and utilization of biodiversity

Nepal with the geological and ecological variations is rich in biodiversity. Existence of wild relatives of cultivated crop plants provides valuable unidentified desirable genes, which can be used for the improvement of crop plants. It has become wild genetic resources for breeding disease resistance, male sterility etc, in cultivated crop plants. NARC's effort will be to organize along with the related agencies to survey, study, collect and catalogue as data base information of these wild relatives and *in-situ* conservation of these valuable natural resources.

### Irrigation

To increase food grain production year around well-controlled irrigation is needed. In the Ninth Five-Year Plan (1997-2002), heavy emphasis is put to coverage area under shallow and deep tubewell irrigation. NARC will develop appropriate water management technologies to improve water use efficiency at farm level.

### Other high value commodities

High value commodities like apple, apiculture and sericulture are neglected but they posses potential if the technology for their production and management is developed and pushed to the village women for their participation. NARC's strategy will be to establish farms at different ecological zones and provide technologies to the farmers engaged in apple, honey and silk production.

## RESEARCH APPROACH

### On-station research

On the basis of sociological and economical survey of adjoining areas, research program should be formulated and conducted at regional agricultural research stations (RARSs) and agriculture research station (ARSs). More emphasis is given to research program based on farmers' need and to generate technologies acceptable to farming situations. NARC has also conducted commodity-based researches at different RARSs and ARSs, and disciplinary research divisions located at Khumaltar complex.

### On-farm research

This research is conducted on farmers' fields to verify the technologies released from on-station research. The field activities on farmers' fields are conducted with joint efforts of farmers, researchers and extension workers, which promote horizontal linkages.

Research program is developed from identified farmers' problems, implemented and evaluated jointly and the outstanding results are disseminated. This process provides researchable problems to be incorporated in both on-station and on-farm agenda thereby creating a downstream and upstream feed back mechanism, creating vertical linkages. RARS does the coordinating work among farmers, researchers, and extension workers.

### Collaborative contract research

This type of research is conducted by signing MOU with the international organizations and agencies, international agriculture research centres and universities. Contract research with the Institute of Agriculture and Animal Science (IAAS), Forest Research and Survey Centre, Royal Nepal Academy of Science and Technology (RONAST), Department of Agriculture, Department of Livestock Services, Central Food Research Laboratory, Botany Department, Tribhuvan University etc. will be conducted.

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# POVERTY, FOOD SECURITY AND AGRICULTURAL RESEARCH IN NEPAL

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## INTRODUCTION

Agriculture is the engine for poverty reduction and economic development in agrararian economics, with agricultural research providing the energy to the engine. This is particularly true in the context of Nepal, where poverty is widespread and a vast majority of the people, including the poor, depends, directly or indirectly, on agriculture to meet their subsistence needs. The quality and quantity of agricultural research and extension determine the pace of agricultural development, which in turn determines the level of poverty. And poverty is often a major cause of food insecurity. No other story can better illustrate this interrelationship than the green revolution (GR) that took place as a result of international and national agricultural research in the 1960s.

Thomas Malthus had predicted in the 18$^{th}$ century that the population of any country would eventually outstrip its food supply (World Bank, 1999). Indeed, a declining trend in the food-population balance was observed in the following several decades. The population was growing rapidly due to reduction in mortality rates, while the cultivation frontier was closing. As a result, most Asian countries experienced reduction in per capita food availability. Thus, the fears continued to grow that the Malthusian prediction would soon become a reality. In their book published in 1967, Paddock and paddock wrote, "Ten years from now, parts of the underdeveloped world will be suffering from famines. In fifteen years, the famines will be catastrophic, and revolutions and social turmoil and economic upheavals will sweep areas of Asia, Africa and Latin America" (Paddock and Paddock, 1967).

However, the subsequent years of GR, led initially by the spread of new wheat and rice varieties, showed that such fears were groundless, and that these had under estimated the potential of new knowledge generated through agricultural research to transform food production.

There were concerns that the GR worked mainly for the benefit of the rich farmers and neglected the marginal farmers and the land-less households, who generally constituted the poor population. This was a matter of debate in the initial years of GR. A more recent work involving detailed country studies on the impact of modern rice technology has suggested that the GR did work for the benefit of the poor households as well due to increase in on-farm employment opportunities and reduction in rice prices (David and Otsuka, 1994). Between 1973 and 1994, real incomes of small farmers and landless households in southern India had reportedly increased by 90% and 125% respectively (World Bank, 1999).

Nepal presents a uniquely disappointing picture in this context. It is an overwhelmingly agrarian economy, with agriculture employing over 80% of the labor force and generating 42% of the gross domestic product. Thus, agriculture not only drives the engine of growth, it also holds the main key for alleviation of poverty, which is pervasive and widespread. However, the growth of this sector has remained at best slow and unstable during the past three decades, which mark the period of GR. While

many countries of Asia, including south Asia, were experiencing rapid gain in agricultural productivity during the period, Nepal was most of the time struggling to maintain its previous productivity levels. Understandably, factors associated with this lagged performance are many and difficult to prioritize. However, one or more of these factors will certainly relate to the country's research infrastructure and the ability of the national agricultural research system (NARS) to plan and conduct research in an effective and sustainable manner.

The challenge facing the NARS of Nepal today is to meet the demand for technologies that can help achieve high and sustainable economic growth, poverty alleviation and food security in the country. It is not an easy to meet challenge. It requires that the technologies generated by NARS be able to meet the needs of diverse clientele. For example, these should respond to the needs of farmers for increased farm productivity and incomes, of agricultural workers for higher income and employment opportunities, of agro-processor and industries for quality raw materials, and of consumers for products that suit their tastes and preferences and maximize their satisfaction. Meeting these needs is a great task. But such needs must be considered as the basic growing for research planning and policy formulation, if the agricultural research is to achieve the ultimate goal of economic growth, food security and poverty alleviation.

The above arguments raise several important questions in the context of Nepal's NARS. Most of these relate to the capacity of the NARS to meet its ultimate challenge. What has been the contribution of NARS to agricultural development in Nepal, in relation to agricultural productivity, food security and poverty in the country? Where does it stand now in term of meeting the needs for high-growth and poverty-focused technologies? Is it equipped with the necessary manpower, resources and infrastructure facilities to generate such technologies, or does it need to be restructured or reformed? What should the new NARS look like- structurally, administratively and functionally in order for it to be able to meet the above challenge? This paper attempts to answer some of these questions in a simplistic-but objective-manner, and is organized as follows. The next section presents a brief historical overview of agricultural research in Nepal. In section 3, the trends in agricultural productivity are analyzed, followed by the examination of the trends in food security and poverty in Nepal. In reference to these trends, a brief account of the key factors affecting the progress of the NARS is reported in section 4. Section 5 outlines some of the basic conditions, which must be met if the agricultural research system is to contribute to economic growth, food security and poverty alleviation in the country.

## OVERVIEW OF AGRICULTURAL RESEARCH IN NEPAL

Nepal's agricultural research system has been traditionally dominated by the public sector. Unlike in other countries, agricultural research within the university system is, at best, minimal. In recent years, the private and the non-governmental sectors have initiated some applied research, which is even negligible compared to the extent and scope of research conducted within the public sector. Hence, the governments have had a leading role in setting the stage for as well as in determining the pace of agricultural research in the country. This also means that the shape and the size of the Nepal's agricultural research system, as it exists now, is an outcome of the policy and other interventions introduced by the government from the beginning of organized agricultural research in the country.

As far as the information is available, organized agricultural research in Nepal began in 1924 with the creation of the Department of Agriculture (DOA) and the establishment of two trial demonstration farms within the Kathmandu Valley. Since then for several decades, the agricultural research remained within the mandate of DOA. The main goal of agricultural research was to increase the production and productivity of food crops. In the initial stage, research efforts were concentrated on testing exotic varieties of major cereal crops (i.e. rice, maize, and wheat) for their adaptability to local conditions. However, with the creation of various disciplinary divisions (e.g. agronomy, entomology) and commodity research programs at the national level, there has been some shift of research efforts to other commodities and disciplines. Nevertheless, as in the past, the main emphasis of agricultural

research still continues to be largely on enhancing crop yields through the selection and development of high-yielding crop varieties.

Over the years, the government introduced a number of administrative and structural changes in the agricultural research institution, without any appreciable change in research policy, process and procedures. In 1966, the DOA was dissolved and five new departments were created, which were merged in 1971 to one DOA again. In the 1980s, the DOA was again divided into three new departments (one each for crops, horticulture and livestock). But this structure also did not last long. Soon, the number of departments was reduced to two. The two different departments for crops and horticulture were merged into one, and this new department was renamed as the Department of Agricultural Development. The department for livestock remained separate. Since then, there has been no further restructuring, and the two departments continue to exist. The main functions of these departments are to deliver the agricultural and livestock extension services to the farmers, while research is the mandate of Nepal Agricultural Research Council (NARC).

While the agricultural research was still within the DOA, the need for an independent and specialized national institution for agricultural research was felt by all, including the donors. As a result, in 1985, the National Agriculture Research and Services Center (NARSC) was created within the Ministry of Agriculture to take over the research functions of the DOA. The NARSC, which became the National Agricultural Research Center (with its service functions omitted) after about three years, was to plan and coordinate all research activities on crops, horticulture, livestock and fisheries. However, being under the Ministry of Agriculture, the need for an autonomous national agricultural research institution was yet unfulfilled until 1990, when the Nepal Agricultural Research Council (NARC) was created under a separate Act.

Legally, NARC is an autonomous national institution responsible for agricultural research planning, coordination and policy making in the country. However, concerns have been emerging that it is not yet truly autonomous. NARC's organizational structure provides for a governing Council at the top, which formulates policies and provides guidelines to the Executive Board. At present, the council is composed of 16 members, including the Executive Director (ED) of NARC, and is chaired by the Minister for Agriculture. The Council members are either government functionaries or persons nominated by the government. The Executive Board, chaired by the ED, consists of 8 members representing the related line ministries, departments, and NARC's own research programs and stations.

At present, NARC operates with 14 commodity research programs, 15 technical disciplinary divisions, 4 regional agricultural research stations and 18 agricultural research station located in different parts of the country (NARC brochure, 1998). It has a total staff strength-technical, non-technical and support staff of 1765. Of this, the proportion of trained and qualified researchers, however, is likely to be very small. In 1993, the number of technical manpower in NARC with M. Sc. or higher degree was only 122 with only 19 of them having a Ph.D. degree and 103 having a M. Sc. degree (HMG/NPC, 1965).

From 1924 to present day, Nepal's agricultural research system has gone a long way in terms of its administrative and organizational structure. But the primary goal of research, that is, to improve agricultural productivity and raise farm incomes has been hardly met. Neither is there any significant shift in the emphasis of research in terms of commodities, disciplines and problem areas. Research efforts have continued to concentrate on the major cereal crops, particularly rice, maize and wheat and within these crops, on the development of new varieties. For example 80-90% of the total research efforts (in terms of the number of research experiments) on rice were concentrated on varietal improvement during 1978-1991(Upadhayaya, 1996). This great emphasis on varietal development has led to the introduction of a large number of improved crop varieties in the country since the 1960s.

Altogether 165 improved varieties of different crops have been released in the country (Table 1). Nearly three-fourth of these varieties are of cereal crops, with those of rice, maize and wheat accounting for half of these. Research on other crops appears to have begun much later. The improved

varieties of commercial crops such as sugarcane, jute, potato and vegetables were developed and introduced only in the 1990s.

In view of their share of cropped area and importance in terms of meeting the food demand, the greater emphasis on cereal crops and the allocation of research resources for developing improved varieties of these crops especially rice, maize and wheat- may be justifiable. However, the level of acceptance of these varieties by the farmers, measured by their adoption rates, raises doubt about the effectiveness of disproportionately large emphasis on variety development, and hence, about the efficiency allocation of the scarce research resources to this field.

**Table 1. Number of improved crop varieties released in Nepal, 1960 to date**

| Crop | 1960-69 | 1970-79 | 1980-89 | 1990-date | 1960-date |
|---|---|---|---|---|---|
| Rice | 6 | 11 | 14 | 13 | 44 |
| Maize | 3 | 4 | 5 | 3 | 15 |
| Wheat | 4 | 4 | 9 | 10 | 27 |
| Legumes and Pulses* | 0 | 8 | 4 | 15 | 27 |
| Barley | 0 | 5 | 0 | 1 | 6 |
| Millet | 0 | 0 | 2 | 1 | 3 |
| Oilseeds** | 0 | 0 | 6 | 4 | 10 |
| Potato | 0 | 0 | 0 | 6 | 6 |
| Sugarcane | 0 | 0 | 0 | 23 | 2 |
| Tobacco | 0 | 0 | 1 | 0 | 1 |
| Jute | 0 | 0 | 0 | 2 | 2 |
| Vegetables*** | 0 | 0 | 0 | 22 | 22 |
| **Total** | **13** | **32** | **41** | **79** | **165** |

Source: NARC, * Include lentil, redgram, moongbean, soybean, cowpea, pigeonpea, blackgram, ** Include tori, rayo and groundnut, *** Include cauliflower, radish, turnip, mustard, leaf, onion, tomato, carrot, cabbage, beans

Wheat is relatively a newer crop compared to rice and maize in Nepal. And the beginning of increase in wheat cultivation in the country is co-terminus to the introduction of early GR wheat varieties developed in Mexico. Thus, the rate of adoption of improved wheat varieties is observed to be the highest among the cereal crops. However, the adoption of improved rice and maize varieties is low and the farmers still quite popularly grow traditional varieties of these crops.

Some of the most popular improved varieties grown by the farmers are still those that were released before the early 1970s, despite a significant number of new varieties released in the latter years. For example, among the 38 improved rice varieties introduced by 1991, CH-45 and Taichung-176 introduced in the 1960s and Masuli introduced in the early 1970s were among the most popular varieties grown by the farmers (Upadhyaya, 1996). A latter study in 401 wards representing the major rice growing areas of the country estimated the level of adoption of improved rice varieties in Nepal at 53% of which that of Masuli alone was 23% (Upadhayaya *et al.*, 1996) (Fig.1).

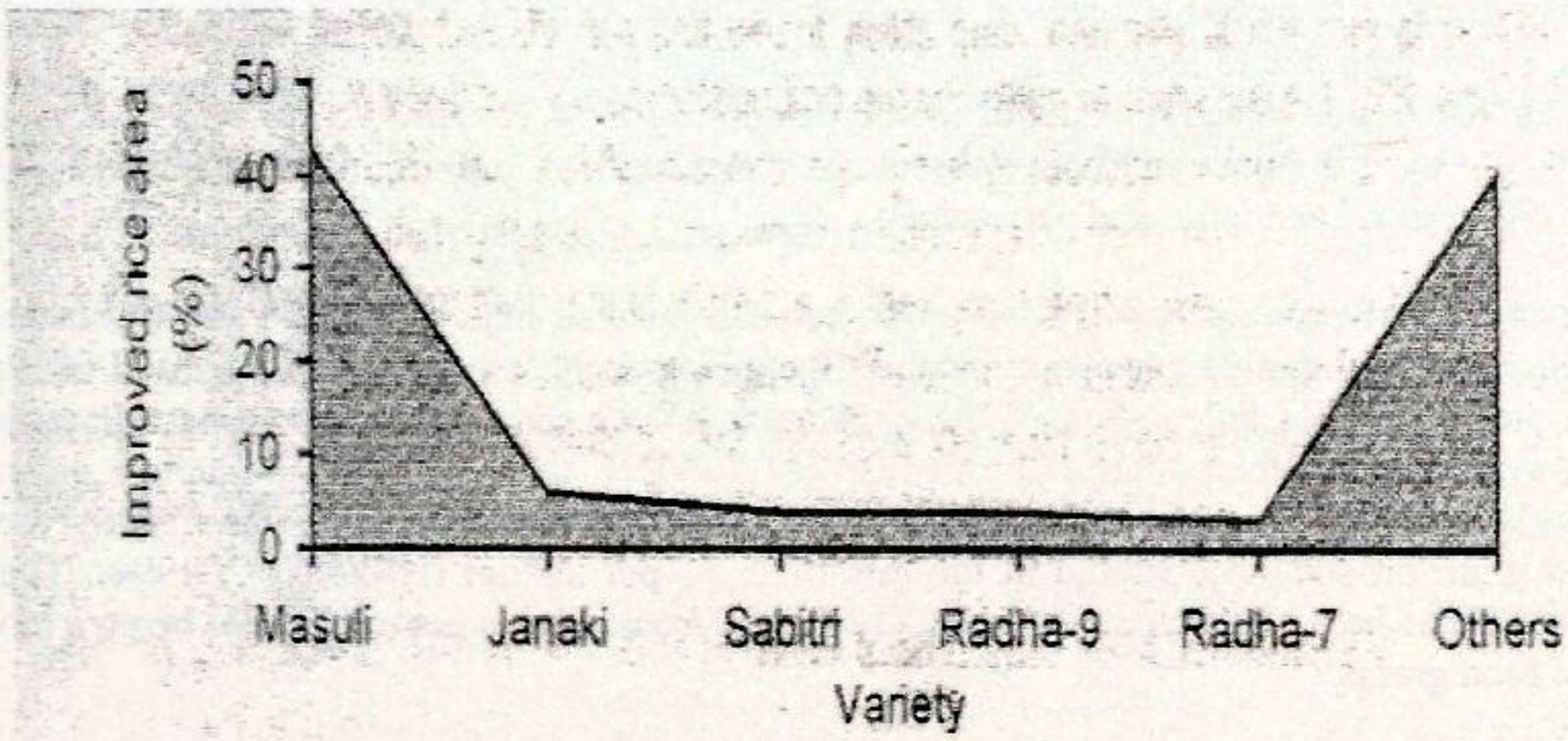


**Fig. 1. Variety-wise percentage share of total rice area under improved varieties, 1994/95**

A number of different factors may be responsible for the low adoption rates of improved varieties, and for the continued popularity of high yielding Masuli over other new varieties that have the proven records of yielding much higher than Masuli. Studies have shown that the lack of irrigation and water control facilities has critically determined that level of adoption of improved varieties (Upadhayaya, 1990 and Upadhayaya *et al.*, 1993). About two-thirds of the rice production occurs under rain-fed environment, where these varieties are not adapted. Furthermore, lack of irrigation increase production risk and reduces the profitability of investment in inputs, particularly fertilizer, further reducing the yield levels. Masuli continues to be popularly grown because its yield performance has been more or less stable even under moderately unfavorable production environments, which dominate the overall rice production environment in Nepal.

Significant efforts, at least in cumulative terms, have also gone into disciplinary research for example to identify improved agronomic and crop management practices and to control pests. The ultimate purpose has been to increase crop yields both through exploitation of potential yield and reduction of yield losses for the given variety and production environment. Again, the major cereal crops have received a very large share of all such research experiments on crops. There is no doubt that the past agricultural research has achieved positive results in several respects. Hence, whether the agricultural research has had any positive impact on the agricultural sector is not an issue addressed here. Rather, the magnitude of its impact on crop yields, which does not appear to be impressive by any measure, and the consequent impact on food security and poverty incidence in the country, is a relevant issue to be addressed.

## TRENDS IN AGRICULTURAL PRODUCTIVITY, FOOD SECURITY AND POVERTY

Food crops (rice, maize, wheat, barley and millet) account for nearly 90% of the cropped area (excluding vegetables, fruits and pulses) and 56% of all agricultural production (excluding livestock and fisheries). As such, greater research emphasis on these crops in the past appears to be logical. However, the impact of research on these crops, measured in terms of yield increase, has been far less than significant. As stated earlier, while its neighbors experienced a rapid growth in agricultural productivity and production during the period of GR, Nepal hardly retained its initial productivity levels of major crops. Consequently, Nepal's crop yield levels, which were the highest among the south Asian countries during 1961-63, have now become the lowest in the region.

Between 1961-63 and 1991-93, the overall annual growth rate of yields of major crops in Nepal was actually negative (-0.07%), while it was 2.71% in India and 1.59% in Bangladesh (HMG/NPC, 1995). During this priod, Nepal's rice and wheat yields grew annually at the rate of 0.54% and 0.29%, respectively. In contrast, the corresponding growth rates in India were 1.92% and 2.46%, and in Bangladesh, 1.55% and 2.59% respectively. Total production of food grain in Nepal has increased considerably during the period. However, it happened largely due to increase in the area under the food crops, rather than due to increase in their yield levels, which has been the case in other countries of the region. The trends in yields of major food crops during 1974/75-1997/98 are truly disappointing (Fig. 2). Not only have the yield levels remained low due to poor growth rates, their annual fluctuations have also been large and persistent.

Their poor growth of productivity of food crops has had adverse impact on food security in Nepal. Over the years, as further area expansion has become increasingly less feasible, the rate of growth of food grain production has fallen short of the population growth rate, resulting in reduced per capita food grain availability in the country. During 1980/81-1990/91, the food grain production increased annually at the rate of 2.3% while the population increased at the rate of 2.5%. Consequently, the per capita food grain production declined at the rate of 0.2% per annum (HMG/NPC, 1994). The net effect of all this has been that Nepal has gradually shifted from being a net exporter to being a modest importer of food grains.

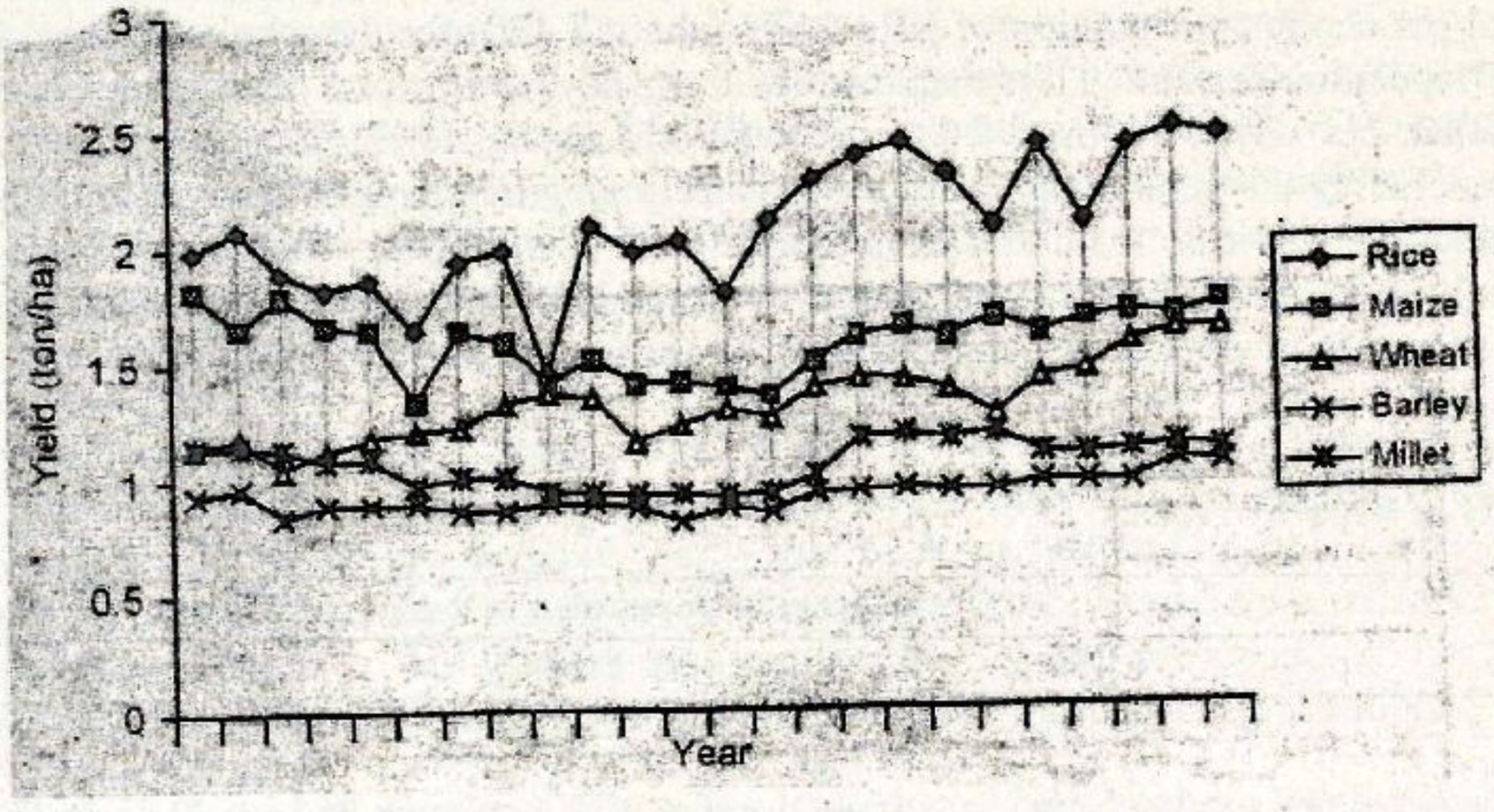


**Fig. 2. Trends in yields of major food crops, 1974/75-1997/98**

Figure 3 shows the trend in domestic food grain production, requirement and balance during 1981/82-1996/97. The gap between the domestic food grain production and requirement is rising, indicating the worsening trend in food self-sufficiency, and growing need for food imports.

As stated earlier, Nepal has an overwhelmingly agrarian economy, with a vast majority of its poor being either farmers or on-farm laborers. The effect of poor growth of the agricultural sector, therefore will not only worsen the food security situation, but also adversely affect the employment and income of the rural people, including the poor. The extent to which Nepal will be able to reduce its poverty level is greatly conditioned by its ability to promote agricultural growth. However, during the last decade, not only has the real growth rate of food grain production (net of population growth rate) declined, the growth rate of the agricultural sector, as a whole, has been low and highly unstable. This would mean a rising level of rural poverty in Nepal.

In deed, in view of the incidence of poverty at present, past efforts have apparently had little positive impact on poverty reduction. Poverty is extreme and widespread, especially in rural and remote parts of the country. The Ninth Plan (1998-2003) being implemented now has considered poverty alleviation as the most important goal, which is to be achieved not in one Plan period but in a much longer time covering at least four Plan periods (HMG/NPC, 1998). Evidently, poverty alleviation has been and will continue to be a serious challenge for the governments of Nepal.

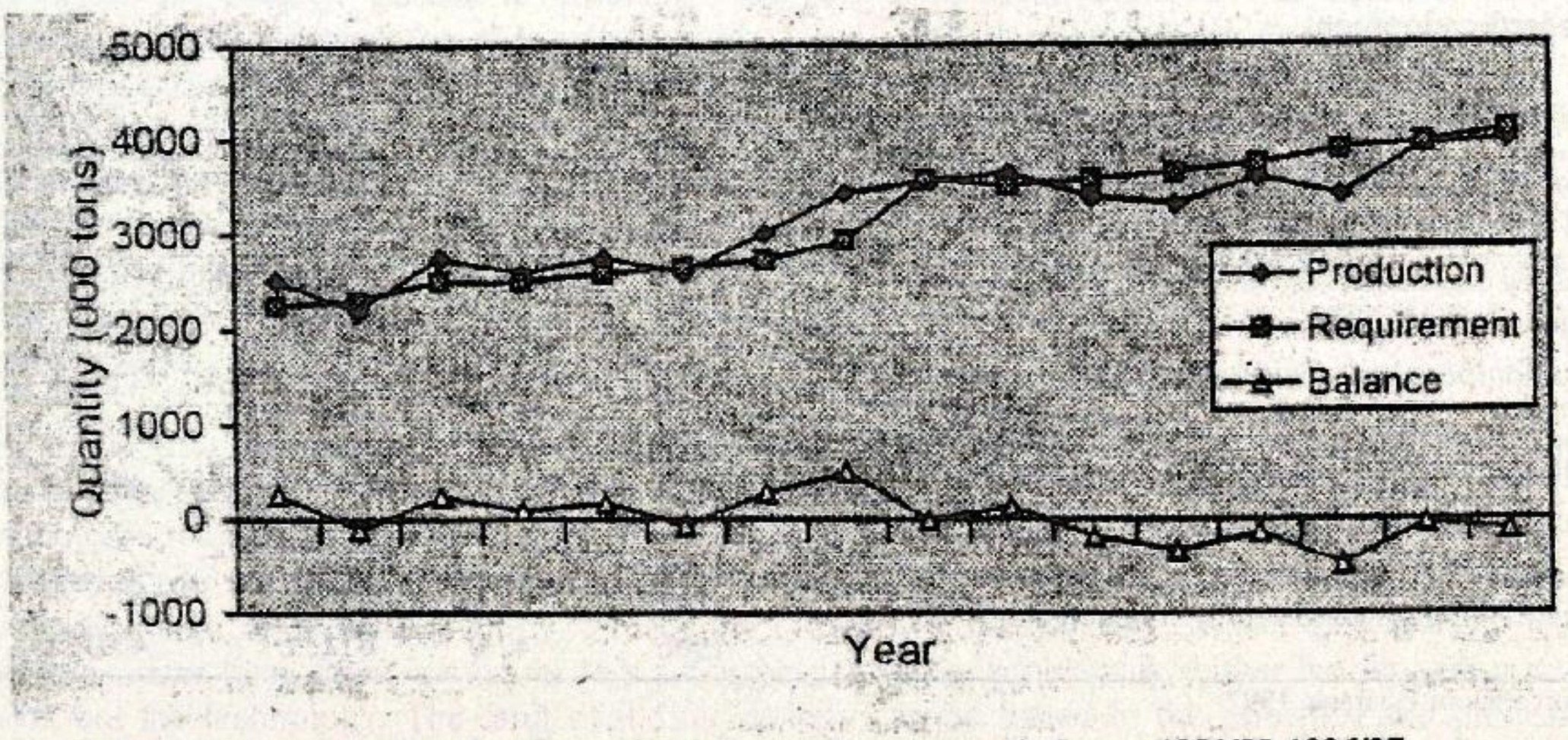


**Fig. 3. Trends in domestic foodgrain production, requirement and balance, 1981/82-1996/97**

The extent of poverty in Nepal is much higher by international comparison. The NLSS estimated an average annual per capita consumption of NRs 6,802 (about $ 130) for the whole country. About 53 percent of the population consumed less than one dollar per day, while those consuming less than one-and a half dollar per day comprised 76 percent (World Bank, 1997). The social indicators of development, including the gender gap, also present a very gloomy picture, literacy, lack of adequate health and sanitation services, malnutrition and illness are some of the common features of rural Nepal, especially in the remote parts. In general, women and children are more deprived of these basic services than men. The overall living conditions of a vast majority of rural population are poor and harsh.

**Table 2. Poverty in Nepal by region**

| Region | Percentage of population below poverty line | | |
|---|---|---|---|
| | Total | Poor | Ultra-poor |
| Mountains | 56.0 | 29.3 | 26.7 |
| Hills | 41.4 | 21.3 | 19.7 |
| Terai | 42.0 | 28.7 | 13.3 |
| Urban Nepal | 23.0 | 13.2 | 9.8 |
| Rural Nepal | 44.0 | 26.4 | 17.6 |
| Nepal | 42.0 | 24.9 | 17.1 |

Source: National Planning Commission, Ninth Plan (1997-2002).

The picture is even darker when disparities among regions and between the majority of the people and the few, who are well off, are considered. Poverty is deeper and more severe in rural areas than in urban areas, suggesting that poverty is largely a rural phenomenon. For example, the Kathmandu Valley has a poverty level of 4 percent while this level is as high as 72 percent in the mid and far-western hills and the mountains. In general, poverty levels are much higher in the mountains (56%) than in both the hills (42%) and the terai (41%). Thus, poverty is severe in rural than in urban areas, and most severe in the remote western parts of the country.

Estimates of poverty levels over time are not directly comparable due to difference in the methodology used. As such the trends in poverty level cannot be precisely judged. However, when the nutrition based poverty line criterion is applied to the data generated over the years, there is more or less a clear trend of rising poverty incidence, particularly in the rural areas of the country. As shown in Table 3, the percentage of rural population living below the poverty line appears to have risen from 37.2% in 1977 to 43.1% in 1985, and further to 47.0% in 1996. A careful observation and informed judgment also support that the poverty trend in Nepal is nowhere on the decline. Obviously, the situation is highly frustrating and discouraging to all concerned with Nepal's poverty and underdevelopment.

**Table 3. Trends of poverty incidence in Nepal**

| Source | Survey year | Rural Nepal | Urban Nepal | Nepal |
|---|---|---|---|---|
| Survey of income, consumption and employment conducted by NPC | 1977 | 37.2 | 170 | 36.2 |
| Multipurpose household budget survey conducted by NRB | 1985 | 43.1 | 19.2 | 42.6 |
| The eighth plan (1992-97) document prepared by NPC | 1992 | - | - | 49.2 |
| Monitoring micro impact of macro policies conducted by APROSC | 1992 | - | - | 49.0 |
| Nepal living standard survey conducted by CBS | 1996 | 47.0 | 23.0 | 45.0 |

Source: Guru-Gharana, 1997

Given that a vast majority of the Nepali population drew their livelihood from agriculture, the poor growth of this sector appears to be the main cause of growing incidence of poverty and food insecurity in the country. A number of factors may be associated with the pool growth of agriculture. Despite continued emphasis on irrigation development, only about two-thirds of the cultivated land of the country receives some form of irrigation. As a result, most of the agricultural production occurs in rain-fed conditions, and is subjected to high weather risk and uncertainties. In deed, in the past, weather fluctuations have caused fluctuations in the level of production, which in turn have resulted in poor and unstable growth rates of the sector as a whole.

The risky production environment reduces the profitability of investment in farm inputs, particularly fertilizer. Moreover, farmers often lack the capacity to self-finance their investment in such inputs and external financing is not easily available. Partly due to these factors and partly due to institutional problems leading to the unreliable supply of fertilizers, the level of fertilizer application to crops has been very low, except in a few pockets and commodities. There are concerns that the extension system has been weak and that the marketing opportunities for farm products are limited.

The cumulative effect of all the above factors has been that the productivity levels have remained low and the entire agricultural sector has remained largely subsistence-oriented. Understandably, it is outside the purview of the NARS to deal with all such factors through research. However, this does raise an important question concerning the appropriateness of the technologies generated by NARC and its predecessors.

Why are the adoption rates of these technologies low? Do the available technologies adequately respond to the problems and priorities of the farmers and their actual production environments? If not, why has research apparently failed to generate technologies that are readily accepted by the farmers? In more operational terms, all of the above inter-related questions can be lumped into one single question. What are the factors affecting the progress of NARC in developing the required type of technologies that promote economic growth, reduce poverty and increase food security? There may be no single and straightforward answer to this question. The associated factors may be many- and both internal and external to NARC.

## FACTORS AFFECTING THE PROGRESS OF NARC

### Inadequate research planning and priority setting

Research organizations-whether private or public are not immune from the need to achieve economic efficiency (Evensong *et al.*, 1996). This is particularly true for the public organizations in resource scarce economies where the limited resources can be put to several alternative uses to generate greater benefits to the society. Economic efficiency has two components. The first is technical or cost efficiency, which requires that the cost of producing a particular research product (knowledge) is minimized. The second is allocate efficiency, which requires that the product of research be of maximum value to the society. Both of these conditions require that research is adequately planned and the research problem areas are properly prioritized. However, in view of the observed trends in agricultural productivity, agricultural research in Nepal does not seem to have been adequately planned and prioritized to achieve economic efficiency. More specifically, given their low adoption rates, efficiency of resource allocation to the development of the large number of crop varieties over the years can be seriously questioned.

The issue of the low or non-adoption of new agricultural technologies by the farmers has since alone attracted the attention of biological and social scientists. Until the 1960s, the non-adoption was attributed to farmers' ignorance, and hence extension education was prescribed. A new notion emerged during the 1970s and the early 1980s: this time, the non-adoption was attributed to farm level constraints and the prescription was to make the farm more like the research station. However, over the years since then, there is more or less a consensus that the problem is neither the farmers nor the farm, but the technology. The fault of the technology can be traced to the priorities and processes

which generate it (Chambers *et al.,* 1993). The central theme of this new consensus is that the knowledge, problems and priorities of the farmers, rather than of the researchers, should form the basis for research planning and priority setting.

Nepal, not only has the agricultural research rarely planned and prioritized, the need to base research on farmers' needs and constraints has not also been fully realized. For example, why is that a rice variety introduced three decades ago is still popular while the farmers have not accepted many of the newer, reportedly higher-yielding rice varieties? Who determined the need for those latter generation varieties? How was rice chosen for research over other crops or commodities which the farmers produce? Measures such as monitoring tours, minikits and on-farm trials provided some opportunities for the scientists to understand the technology needs and concerns of the farmers. However, such measures were hardly adequate and effective to provide the basis for research planning and priority setting.

Administrative concerns and scientists' own knowledge and priorities have mainly determined the course of research the choice of commodities and of the specific research problem areas within a commodity. In effect, agricultural research in the past has largely followed a routing, without much careful analysis and evaluation of the value of its results. In the absence of adequate planning and prioritization, the agricultural research generally lacked the necessary focus. As a result, the limited research resources have been distributed too thinly and into a wide range of sectors, with little significant impact on any of them.

**Insufficient research resources**

The progress of agricultural research in Nepal is also constrained by inadequate resources. During 1981-85, Nepal's total agricultural research expenditure (incurred both within and outside NARC) was only 0.79% of its agricultural GDP (AGDP), while it was more than 1% in Bangladesh and Sri Lanka (HMG/NPC, 1995). NARC's annual budget in 1993/94 was 0.46% of the AGDP. This is far below the level of expenditure recommended by the World Bank of 2% of AGDP, and even below a much lower level recommended by the Food and Agricultural Organization (FAO) of 1% AGDP. Not only has the agricultural research suffered from resource constraint, but the available resources have also been disproportionately distributed among commodities.

Field crops contribute nearly 46% to AGDP, which received only 34% of NARC budget in 1998/99 (Fig. 4). Similarly, with 31% contribution to AGDP, livestock shared hardly 11% of the NARC budget for the year. In contrast, almost the same proportion of the budget has gone to fisheries, which contributes only 1% to the AGDP.

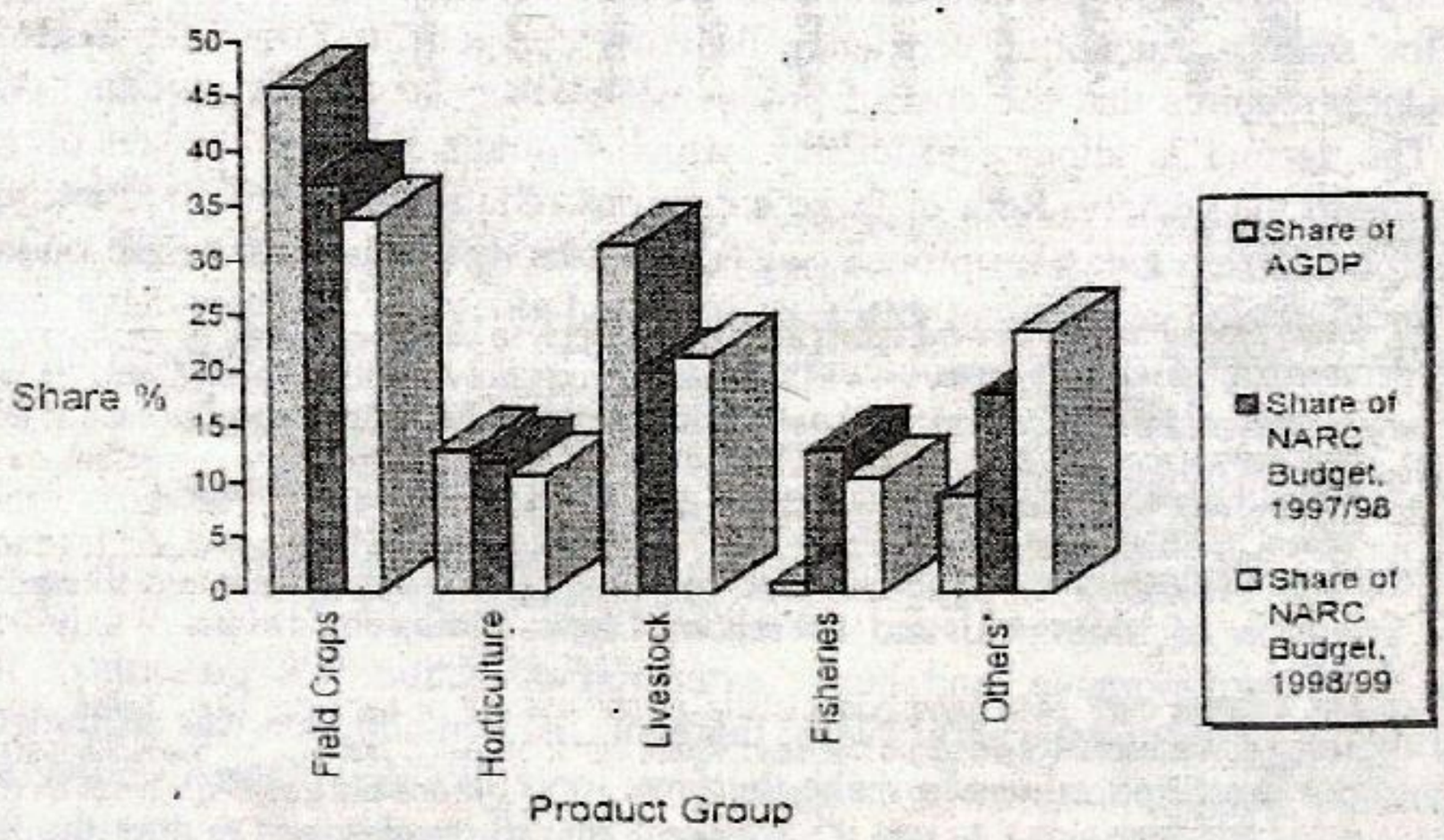


**Fig. 4. Product group-wise share of NARC budget and AGDP**

During the past one decade, the annual budget of NARC has remained more or less between 0.2% and 0.3% of the AGDP, with some fluctuations in some years (Fig. 5). For example, in 1990/91 and 1996/97, it has fallen below 0.2%. Overall, the annual budget has shown a declining trend during most of the decade. NARC being the single largest agricultural research organization of Nepal, its budget is far too small compared to the international norms to make any research break-through in the agricultural sector. It hardly allows creation of new scientific infrastructure and facilities. This may also have forced NARC, at least partly to stick to a set pattern of research followed in the past.

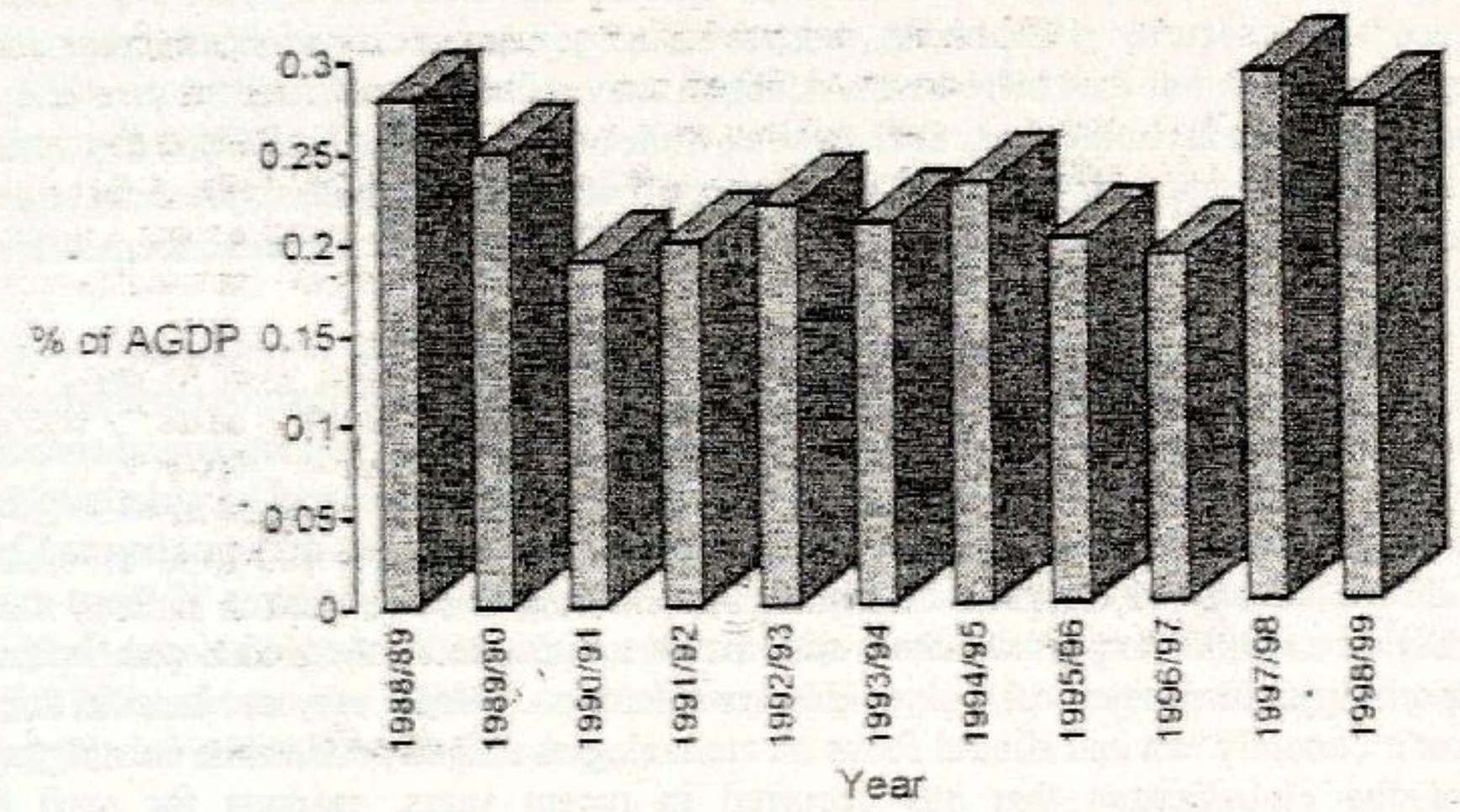


**Fig. 5. NARC budget expressed as percentage of AGDP, 1988/89 to 1998/99**

## Inadequate scientific environment and facilities

In the past, efforts to create a scientific environment for agricultural research in the country have been carried away by the need for new institutional structure. As a result, the NARS was frequently subjected to administrative reforms and changes in its structure-most of the time, led by donor or political interest. For example, the process of development of an independent research institution in the country, which led to the creation of the NARC, during 1985-1990, was largely led by the requirement of the Agro-enterprise and Technology System Project funded by the USAID. Insofar as its creation is concerned, it is consistent with the country's need for an autonomous agricultural research institution, based on the lessons learned from other countries of the region.

By design, NARC was expected to function as an autonomous body. In practice, however, it has hardly been left of its own. New research innovations require a high level of commitment, stability, professionalism and optimism of the researchers, which under the existing environment are becoming increasingly rare. The low level of financial incentives (staff salaries, allowances and other privileges) has further compounded the problem. This, however, is a typical problem of all public sector organizations in Nepal.

## Meeting the challenge some basic conditions for NARC

As the single largest organization representing the NARS of Nepal, the challenge faced by NARC is by no means small and easy to meet, especially in its present form and capacity. In particular, to meet the goal of poverty reduction and food self-sufficiency requires a strong, dynamic and efficient agricultural research, which Nepal is yet to develop the foundation for.

In the context of Nepal, the challenge is more serious in that much of the problem of food insecurity is caused by the widespread poverty, which largely originates from agriculture. Thus, the challenge for NARC is to be able to provide the technologies that promote agricultural growth in a manner that both increases farm incomes and ensures a higher level of food security. As it is now, the ability of NARC

to meet this challenge is greatly limited, unless a number of important reforms are introduced in its institutional orientation, scientific environment, and processes and priorities of research. Some of these basic conditions that must be fulfilled by NARC are given below.

***Poverty orientation is adopted.*** The focus of NARC has been largely on yield enhancing technologies, particularly of the main food crops ( e.g. rice, maize and wheat), which is at best an indirect focus on poverty reduction. More than two-thirds of the farm families, which include the majority of the country's population of the poor, operate less than half a hectare of land. From the perspective of food security and poverty reduction, increase in yields of these crops may lead to increase in production, but that increased production may still be insufficient to meet the household food and non-food needs. In the present context of widespread poverty, NARC needs to adopt a more direct poverty orientation, and this would require a shift of research emphasis from these cereal crops to crops and commodities that would generate enough farm production and incomes from limited farm lands.

Accumulated evidences from within the country indicate that it is possible to obtain high returns from limited lands from high-value agriculture (e.g. off-season vegetables) production and reduce the level of poverty and food insecurity (Upadhayaya, 1999). Such opportunities may be unique to the Nepal's diverse climatic and physiologic conditions and appropriate technologies may not be readily available from outside the country to exploit this natural comparative advantage. Even if these are available research may be required to identify their sustainable use in the context of Nepal. In this context, market opportunities also need to be given due consideration. NARC may not be able to create new markets, but it certainly can and should focus on technologies that respond to the existing markets. As a result of the globalization that has occurred in recent years, markets for such high-value commodities are opening and large. At present, even the domestic markets for agricultural products are not fully exploited. A recent study has indicated that many of the domestic agro-industries have to import their raw materials (agricultural products) while the domestic producers of these raw materials face market constraint. One of the reasons is that domestic products do not suit the specific need of the industries in terms of variety and quality.

Little efforts and resources have been allocated to livestock research in the past. Livestock production is an important part of the farming systems in Nepal. In view of its contribution to AGDP and the income opportunities offered by it particularly for the poorer households, the scope of its further promotion is promising. However, research efforts need to be directed towards finding out ways to promote livestock production in a more sustainable and environment-friendly manner. The 20-year Agricultural Perspective Plan (APP), being implemented by the government recently, has also identified livestock, horticulture and high value agriculture as the key output areas for promoting high agricultural growth, and for reducing poverty in rural Nepal.

***Research areas are planned and prioritized.*** No research can be effective and sustainable, if it does not target economic efficiency. And economic efficiency requires careful research planning and prioritization, so that research is able to produce results of maximum value at minimum costs. Farmers being the ultimate users of the research results and producers of the value of these results, adequate understanding of their specific production environments as well as of their problems, needs and priorities is crucial for research to achieve economic efficiency. Research priority setting among a large number of commodities and problem areas is a process that blends the scientists' assessment of the potential value of research and the probability of research success in solving a problem. It must also be seen as a dynamic process as the costs and benefits of research may change over time. Thus, the process must be institutionalized at a higher level of research administration.

In view the past trends in research NARC needs to institutionalize research planning and priority setting process as a policy priority. At the operational level, there are several ways to do this. One of these is to form an internal research panel, which will review and scrutinize the proposed research projects taking into account the need to both minimize the cost and maximize the value of research. The knowledge and ability of the panel members themselves will, however, condition the

effectiveness of this approach. Another way is to form a research panel consisting of anonymous members from both within and outside the NARC system. This is similar to the approach being presently followed by the Hill Agriculture Research Project (HARP) funded by the British Government's Department for International Development (DFID). There could be several other ways to do this.

In the present state of NARC to begin with the research prioritization, it may be desirable to carry out a detailed and systematic priority setting exercise considering all the sectors (e.g. crops, livestock, horticulture), all the commodities within a sector and all possible researchable areas within a commodity. Once this detailed exercise is completed, future priority setting exercises will be relatively less demanding of data and time, and can build on this. This will also help researchers, policy makers, planners, donors, and all others concerned with agricultural development to coordinate their activities in a consistent manner.

*Collaboration with NGOs and private sector agencies is developed and sustained.* Nepal's development needs and challenges are so complex and enormous that neither of the sectors- whether public, private or non-government alone can meets them in any significant manner. This applies equally well to the agricultural research. Moreover, some research activities (the benefits of which can be adequately appropriated) are more efficiently carried out by the private sector than by the public sector. Some types of research particularly the more adaptive and applied types, are more effectively and efficiently performed by the NGOs than either by the public or the private sector. NGOs can also serves as the link between the farmers and the researchers, so that farmers' needs and concerns are adequately reflected in the research priorities.

There is a need to carefully identify and delineate the specific role of NGOs and the private sector in research, and coordinate with them on the identified research priorities or the components there of on the basis of respective comparative advantage. An effective collaboration and coordination between NARC and the potential NGOs may help to ensure that NARC's research is farmer responsive, poverty-focused and sustainable. This can be done in several ways for example by signing a formal memorandum of understanding for collaboration in agricultural research and by including the representatives of the potential partner NGOs in research priority setting exercise.

*Adequate scientific environment and facilities are created.* High quality research output is often associated with a high level of scientific knowledge, which is difficult to attract and retain without adequate scientific environment and facilities. Adequate scientific environment has at least the following characteristics: a) scientific knowledge prevails and commands a high value, b) staff performance is judged by the quality of scientific output e.g. innovation, number of research publications and staff are rewarded on the same basis, and c) the administration is responsive to the needs and vision of the scientists. For any research organization to develop this environment, freedom from excessive government and political control and attractive incentive package for the staff may be the basic necessary conditions. NARC has lacked both these characteristics. It has been increasingly subjected to political influence, particularly in recent years, which may lead to erosion of scientific knowledge and interest of its staff.

Various internal and external review missions in different sectors have addressed problem to staff incentives and recommended substantial reforms in the present incentive structure. However, given the budgetary limitations it is unlikely that the government will ever be able to introduce such reforms and make the incentive structure at per with other neighboring countries. Perhaps, this problem needs to be largely dealt with other measures that would bring less financial burden to the government. One such measure may be to introduce a performance-based incentive system. In the context of NARC, it would mean higher incentives for better quality research outputs. Also, the scientists may be encouraged to access external sources of fund for research projects that fall within the priorities of NARC and within such fund a provision may be made for additional incentives to the concerned scientist through a well worked out and transparent policy.

***Structural reforms are affected.*** It may be difficult for NARC to meet the above basic conditions under its present structure. As stated earlier the Council is the supreme body for NARC, and is chaired by the Minister for Agriculture. The Council members include existing government officials (as ex-officio members of the Council) and other nominated by the government. The Council is empowered to appoint and replace the ED, and the ED has the power to appoint Directors and other key research administrator. As such, the present structure is essentially prone to a high degree of political and government influence. One way to reduce the possible political influence and control may be to restructure the Council to make it a professional policy making body at the top with broad based membership which will have the mandate to appoint the ED from the open market base on the ability to conduct research based on national priority and contact with national/international agency and donors. The Council will also review the research priorities of NARC and introduce necessary policy changes. Since the existing structure is backed by the Act under which NARC is established, these reforms may require amendment in the Act.

NARC may also need to review and rationalize the functions of its various disciplinary divisions, and redesign the mandate for regional research stations. At present, the regional research stations are engaged in a range of research activities, mostly in response to the need of the commodity development programs. These stations lack a clear research mandate of their own. Given the diversity of agro-ecological conditions under which farming is practiced in the country, the research needs are truly many and diverse, which NARC may not be able to meet with its present organizational infrastructure. One way to address this issue is to develop these stations into specialized regional agricultural research centers with the mandate of meeting the research needs of their respective regions. Each of these centers will develop its own set of research priorities and operate within the framework of decentralization and local self-governance.

## CONCLUSION

Nepal's development challenges are to achieve a high and sustainable economic growth, reduce poverty and attain food security. For this, agriculture is the engine and agricultural research fuels this engine. However, the growth of agriculture has been slow and unstable and the impact of agricultural research has not been impressive as reflected in the trends in yields of major crops. As a result the incidence of poverty appears to be rising and the level of food security declining in the country. Thus, the challenge faced by Nepal's national agricultural research system, which is represented by NARC, is becoming increasingly complex and difficult to meet.

The performance of agricultural research in the past has been seriously constrained by the lack of adequate research planning and priority setting. Administrative concerns and the scientists' own knowledge and priorities determined the research areas (commodities, specific problems within a commodity etc.) in the past. Actual knowledge, problems and priorities of the farmers within their given production environments were hardly incorporated. As a result, the research results very often failed to receive farmers' acceptance. Low or non-adoption of a large number of improved varieties of cereal crops introduced in the country is an example of this.

Agricultural research has also suffered from lack of adequate resources. Total agricultural research expenditure has remained mostly between 0.2% and 0.3% of the AGDP, which is farm below the recommended levels, and the levels observed in other countries of the region. Also, due to lack of focused priorities the available resources have been distributed too thinly and into a wide range of areas. Another major shortcoming of NARC has been that it has been subjected to frequent political and government intervention, often resulting in low morale and a sense of insecurity and instability among the research administrators and senior scientific personnel. The type of scientific environment required for high quality research has been lacking. The cumulative effect of all the and other factors has been that agricultural research in Nepal has largely remained a routine activity following a set and targeted precedence but to has of research resources and staff incentives.

In order for NARC to be able to meet the challenges of agricultural research, it must meet a set of basic conditions. It needs to sharpen its research focus and orientation towards poverty reduction which may call for a shift in emphasis from production to market oriented research and from food crops to high value crops and commodities. Research areas need to be adequately planned and

prioritized across sectors, commodities and problem areas within a commodity to achieve economic efficiency in the allocation of scarce resources. Similarly in order to attract and retain high quality researchers within NARC, efforts need to be directed towards creating a free and stable scientific environment and also towards introducing a performance based incentive structure for its staff. In this regards the present organizational and administrative structure of NARC needs to be reviewed and redesigned in order to minimize political influence. This may require amendment in its existing Act.

It is almost an impossible task for any single sector whether public, private or NGO to meet all the research needs of the country. Neither is it an efficient proposition. Thus, an effective collaboration and coordination among the NGOs and the private sector agencies can help NARC to plan and prioritize its research activities in a manner that will respond to the needs of the farmers and that will make research more market oriented. NARC also needs to review and rationalize the functions of its various disciplinary divisions. Finally, NARC needs to develop its own institutional capacity and regional infrastructure to function as the national apex agricultural research organization of the country. One way to strengthen its regional research infrastructure is to develop the existing regional research stations into specialized regional agricultural research centers with a clear mandate to meet the research needs of their respective regions.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# AGRICULTURAL DEVELOPMENT AND FOOD SECURITY IN NEPAL: CONSTRAINTS AND POTENTIAL

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## ABSTRACT

Politicians, planners and agricultural scientists are unanimous in making their position clear on agricultural development as the precursor of overall development in Nepal. The emotional plea usually comes out as a sound byte loud enough to be heard by any body who counts and one who can think in this country. And that's where it ends. The result of last forty years of planned development is in front of everybody to evaluate along with the rhetoric and some truth of giving agricultural sector top priority. Nepal is still one of the poorest countries in the world. The agricultural production has not kept pace with population growth and the productivity of major food grains has been stagnant. The country has become the net importer of food grain from the exporter status. Constraints, emerging trends, potential for increased productivity of cereals and strategy to secure food security in Nepal has been discussed.

## CONSTRAINTS

The unsatisfactory performance of agricultural sector continues at present. The main reasons of poor performance, which have been reiterated in various documents and sector studies, is lack lustre performance of lead public institutions namely Department of Irrigation (DOI), Nepal Agricultural Research Council (NARC), Department of Agricultural Development (DOAD) and Institute of Agricultural and Animal Science (IAAS) unable to discharge their responsibility leading to desired outputs. The lead institutions that have the mandate from the government for irrigation development (DOI), agriculture research (NARC), extension (DOAD) and training (IAAS) are so inefficient and marred with inherent problem that major restructuring and change in the work culture will be required before these institution can play a vital catalytic role. The mediocrity and complacency in above public institutions have resulted in poor performance of public sector irrigation schemes, failure in the generation of appropriate technology, chronic problem in delivery of inputs and services to the farmers.

In spite of the huge public investment in irrigation sector the percent area that can be irrigated for winter crops is less than 30% of projected command area of major irrigation projects. Contrary to privately managed schemes the major cause of poor performance of public undertakings can be attributed to deficient system design and neglect of tertiary and field channels, non-involvement of beneficiary farmers in planning design, construction and operation of the irrigation system as well as the culture of over emphasis on construction work and neglecting on software leading to suboptimal benefit to farmers.

The system of delivery of extension services and inputs are the most critical bottlenecks in accelerating agricultural growth rate. The institutions like DOAD and Agricultural Input Corporation

(AIC) involved in these important functions have an elaborate network of district and regional offices with their own turf to protect and cultivate. The grass root level extension agents have been termed as part of a welfare system where in the system has lost its effectiveness and purpose. The AIC, overburdened by subsidies and mismanagement is sinking under its own weight.

The Agricultural Perspective Plan (APP) has visualized the need of an efficient agricultural research system as a prerequisite to realize higher growth rate in agricultural sector. NARC's approach in accelerating the agricultural growth rate (AGDP) through relevant agricultural research is derived from the basic premise of transforming the apex institution of agricultural research into the cost effective, vibrant and responsive system capable of generating appropriate technologies to increase production productivity and farm income. The vital institution such as NARC is plagued by frequent change in leadership as the result of political interference as well as its inability to retain and motivate competent scientists. The institution is overstaffed with deadwood technicians and too many administrative lower level staff.

After two and half decades of cereal commodity (rice, wheat, maize) research in Nepal, the productivity has not increased appreciably in most farmers' fields. Yield gaps between research stations and farmers' fields have not been reduced appreciably. Food deficits, which occur frequently especially in low rainfall years, are the facts of life in the country. The available technologies are limited very much to irrigated, high-input agriculture, which does not represent most farmers' circumstances. Most of our efforts in the past have been spent (some scientists say it has been a waste of time and resources) testing breeding materials developed by international research centers (IRRI, CIMMYT). A cursory look of the improved rice varieties adopted by the farmers throughout the country reveals that IRRI cultivars have not been overwhelmingly popular.

## POTENTIALS

Fortunately, the technical know-how to increase food production and sustain at higher level is no secret. The major elements of which are: irrigation water availability at farmers' fields when they need it, availability of appropriate information on production technology/skills that the farmers can use and required inputs in the hands of farmers when they need it. Most important of all farmers must get assured returns on their investments so that they can meet their subsistence and other needs. To date, we have failed in realizing any of the above satisfactorily. But there is no reason why it can not be done now or in future, especially when there are no other alternatives.

The country is naturally endowed with favorable climatic conditions to produce rice, maize and wheat - the three important crops for food security. The total potential acreage under these three crops is approximately three million hectares. At present, the national productivity of rice, maize and wheat are 2.2, 1.7 and 1.4 ton/ha, respectively. The farmers yield level is nearly half of the researchers managed experiments. There is no technological obstacle as such to double the productivity at farmer's fields. A realistic target within 20 year of APP plan period will be to produce 12 million ton of food grain in the country.

## EMERGING TREND IN CEREAL CROPS VIS-A-VIS FOOD SECURITY

### Rice

Rice remains the choice staple food of 20 million Nepalese whose population is expected to double in the next 25 years. The priority of rice over other agricultural commodities is obvious for the foreseeable future. Among the basic food crops, rice occupies foremost importance. The importance of rice crop in the national economy and its role in sustaining the lives of Nepalese populace can hardly be overemphasized.

With the increase in irrigated area double cropping of rice is under increase. While the rice production can be expected to increase significantly new problems that have arisen due to increase in cropping intensity will need special attention from the research point of view.

However, in the national research system it seems that the rice program has not received the priority attention that it deserves. To meet the challenge of feeding the growing population through developing improved technologies to increase production and productivity, adequate resources must be ensured for the rice research program. At the same time we must improve the planning, management, and implementation of the rice research program such that in our drive to push improved high yielding varieties we still preserve that rich genetic diversity of rice in Nepal, which will have profound importance in future rice improvement.

**Maize**

Maize is the most important staple food for approximately ten million people in the hills of Nepal. It is grown in more than 600,000 ha in slopping un-irrigated terraces in the hills during April to October, entirely dependent on monsoon rain. The maize production practices is characterized by low yields (average 1.7 t/ha) as the result of frequent drought and heavily dependent on poor quality FYM for plant nutrient replenishment in the production system.

The sustainability of maize production system in the hill is under serious threat inherently related to increase in area of maize due to expansion in marginal lands and decline in yield- mining of nutrients, soil erosion, low input use and dwindling resources base.

Maize is emerging as an industrial crop in Nepal i.e. as corn oil, animal feed ingredients, glucose, corn flakes etc. Farmers are changing cropping pattern to include vegetable and other cash crops in their rotation in response to market forces and also to meet their cash needs. Due to degradation of forest and control of community forest for grazing animal availability and accessibility of fodder is decreasing. Consequently, as farmers move towards stall-feeding of livestock there is greater pressure for increased use of maize foliage as fodder for their livestock. Increased migration of men (for seasonal or permanent jobs outside the community) for augmenting cash income to household for bare minimum necessities resulting into increased role of women farmers and more work for women and children.

The future demand for maize in Nepal is expected to grow by 4% per year over the next 20 years driven by increase in demand for food and feed for livestock. The importance of maize in Nepalese hills can hardly be exaggerated for food security in the context of alarming population growth rate. Returns from rainfed Bariland maize based farming system in the hills of Nepal is pivotal for the survival of hill farm families. There is no alternative other than to improve and sustain the fragile rainfed Bariland maize production system.

**Wheat**

Among cereals wheat is a success story of growth and adoption by farmers in Nepal. Not only the area has expanded to more that 600,000 ha but also food patterns have changed. Consumption has also increased along with wheat-based industries in the last two and half decades. With the expansion of wheat in irrigated area in recent years, it has increased the cropping intensity resulting into severe decline in soil productivity. Because of the wide scale adoption of HYVs of wheat in their cropping patterns, the irrigated land is experiencing rapid declines in soil fertility and deficiencies in plant nutrients as a result of increased output. This coupled with low and unbalanced use of chemical fertilizers, low levels of compost or FYM use in part due to the use for fuel, the removal of plant residues from the field and the growing of more intensive, mainly cereal based cropping patterns, has posed a serious threat to the sustainability of the existing cropping systems. There can be no doubt that farmers are experiencing need for more fertilizer and nutrients to sustain existing yield level. The demand and use of fertilizer is restricted only by availability of fertilizer, cash and credit in time.

Introduction of HYVs with their high yield potential has accelerated the process of nutrient mining in accessible area.

The expansion of wheat area in the Nepalese Terai during the past two and half decade has resulted in a shift of traditional cropping system from rice-fallow and rice-legumes to that of rice-wheat. It is estimated some 4000000 ha of land area under grain legume or winter fallow are brought under wheat during the period. Such a massive change continuing to date has exerted pressure on non-renewable soil nutrient reserve such as phosphorus (P) and mineral cations.

The long-term fertilizer experiments at various NARC research stations have clearly demonstrated the unsustainability of rice-rice-wheat system due to extensive mining of the nutrients (macro as well as micro). Because of fixation and heavy uptake, P is becoming increasingly important for the sustainability of the rice-wheat system. The point of utmost concern is that the nutrient deficiencies occur in well-fertilized treatments also. The deficiency of P, K, Zn and Bo were critical. Soil analysis data after ten years under the rotation have indicated near zero available P in all the treatments except where FYM has been applied.

Any intervention, be it in the form of government policy, agricultural research or extension programs or targeted input delivery, must take into consideration the above trends to have meaningful impact on food security front.

## THE APPROACH FOR TECHNOLOGY GENERATION

Agricultural Perspective Plan (APP) is the first comprehensive blue print for agricultural development in the country adopted by the HMG. It has visualized technology generation as a primary input for accelerated growth in AGDP along with rural road, electricity and ground water utilization. It is not clear how the funding will be arranged for the implementation of the expensive APP programs.

NARC, after its inception has initiated positive steps through an institutionalized system of bottom-up research program planning that needs nurturing and continuity of efforts. NARC's approach in achieving the mandated goal is to build a sustainable research system that includes a balanced focus on:

a) Regional agricultural research to solve regional clients problems exploiting on specific agro-ecological advantage suitable for specific agro-enterprise. Emphasis will be placed on high value commodities, and productivity potential of the specific environments.

b) Commodity research with prime emphasis on priority commodity such as rice, wheat, maize and potato to meet the growing staple food requirement (short term import substitution and long term self sufficiency) and high value commodities such as milk and dairy products, citrus, apple, honey and silk for employment/income generation.

c) Disciplinary research to be one step ahead of commodity research to support regional and commodity research programs tailored according to the national needs and priorities. At the same time it must carefully avoid the realm of basic research, which the country may not be able to afford.

d) Outreach research as a driving force, to provide a powerful strategy for meeting the needs of farmers through direct linkage of researcher-farmers and technology transfer agents complimenting each other. Direct links with farmer contribute to the relevance of technology development by providing rapid feedback to researchers. Strong links with technology transfer agents (extension system) ensure effective dissemination of verified technologies to farmers. The main purposes of outreach research are to have (i) direct researcher-farmer links for more in depth diagnosis of farming problems and potentials, and ii) a functional interface with technology transfer agents (extension system) to ensure greater impact of technologies developed upon the end user, the farmers.

NARC must emphasize the priority research thrust areas envisioned by APP in its research programs and these must reflect in increased resource mobilization and number of scientists working under the projects. These priority areas of research are:

1. Soil fertility thrust concentrating on amelioration of soil fertility deterioration by increased fertilizer use and efficiency as well as by encouraging use of bio-fertilizer and agricultural by-products for organic manure.
2. Integrated pest management.
3. Farming system for high intensity irrigated agriculture.
4. Research on basic food crops such as rice, wheat, maize and potato for increase in productivity.
5. High value commodities such as buffalo and milk, citrus, apple, honey, silk, vegetables and other seeds, off-season vegetables etc.

The efficiency of commodity programs in generating appropriate technology will be the first crucial element in increasing productivity of cereal crops for food security. However, technology generation is not an end in itself. It must reach to the farmers and it must produce results at the farmers' field. That can only happen if other elements (such as irrigation and delivery of inputs and extension services) are in place and move forward simultaneously to benefit farmers.

## WHAT OUGHT TO BE DONE

The argument of Nepal, being a poor country, cannot afford its own research program and therefore it must borrow production technology from neighboring countries reverberate every now and then. Diverse and complex farming systems require specific varieties and agronomic practices to maximize returns. Poor soil fertility, less availability of organic manure, unavailability and low fertilizer use, inappropriate production technology, losses due to drought, diseases, pests and post harvest losses are the major constraints in realizing the potentials of HYVs at the farmers' field. All these problems are expected to be increased and their complexities will increase with intensification of agriculture. There will be very limited scope to solve those site-specific complex problems with borrowed technology. Furthermore, our ability to utilize borrowed technology will be very much limited in absence of our own research programs. There is no alternative than to have an output oriented, cost effective, national agricultural research institution responsive to the clients' need.

The prioritization of research programs is to be undertaken immediately. It must be reflected in the resource allocation, research programs and its implementation. The research challenge lies in giving more emphasis on rainfed and resource poor conditions and it must be reflected in the rice research program. The key here is to develop technologies for adverse conditions of rice production. Research to ensure a successful rice crop under adverse conditions (low rainfall year and/or late monsoon condition) should receive utmost importance. Similarly in maize, rainfed bariland production system should be the focal point of maize research.

Above all, NARC must ensure that competent agricultural scientists continue to be engaged in productive research. Presently, NARC scarce resources are under pressure because of large number of agricultural research stations it has to operate. There is an urgent need of rationalizing the number of research stations under NARC and the research programs being carried out by those research stations so as to make it relevant and avoid duplication of effort.

The irrigation sector not only should bring all possible areas under year round irrigation but also must ensure efficient distribution of irrigation water at farmers' fields. One way to achieve this will be to involve the beneficiary farmers in the management of public financed irrigation system right from the

planning phase to construction and operation of the system. Increased irrigated area under farmers owned and managed irrigation system will ensure optimal efficiency and use of irrigation water.

Extension services at grass roots are not at all functioning. At the grass roots level, the outreach sites under NARC and agriculture service centers under DOAD are functioning independently. Often the extension agents do not have relevant information to deliver to the farmers. Somehow the process of technology generation, verification and delivery to farmers is not in synchrony. An effective workable mechanism must be developed to bring together different actors at grass root to improve research extension farmers linkage and outputs based on common programs and incentives linked to performance. The researchers and extension agents must work in union at outreach sites to serve the clients.

What is urgently required is the integration of on-station and outreach research with agricultural extension complementing each other to enhance the relevance of each as well as providing exposure to on-station researcher on clients problems and opportunities. Such integration would provide much needed teeth to extension agents at grass roots with relevant research information. The on-station researcher as well as outreach researchers must work in their special niches to maintain dynamism in the whole process of research planning, implementation and generating outputs that can be used by the clients.

Unavailability of inputs in time and lack of skill and usable information suitable to specific farmer's circumstances are facts of life for the Nepalese farmers. The present system of input subsidy is not helping to get fertilizer input in the hands of farmers in time. To increase efficiency subsidy must revoked at least in accessible area and competitive input delivery system should be initiated.

Trained agricultural manpower will be in short supply in the light of complexities of future problems and needs. This is more so because of significant reduction in bilateral assistance for advanced studies outside the country. In future, production of trained agricultural manpower within the country will be inevitable. Looking at the present situation it is doubtful that IAAS will be ready to take the challenge. To jump start the process of cleaning, the institution (IAAS) must get rid of students and faculty leaders representing various political parties. An independent academician/scientists not branded to have affiliation with any political party should lead the institution at least for five years.

## CONCLUSION

Over the last few decades, solid groundwork has been completed and basic elements required for higher growth in agriculture is already present in the country. There is lot of competent agricultural scientist, available in the country. What is required is political will and trusting our own indigenous talent over high flying "know it all" expatriate consultants often pushed by donors to push their diplomatic agenda.

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# IMPROVEMENT OF STATUS OF AGRICULTURAL SCIENTISTS

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## ABSTRACT

Agriculture development in Nepal began about 95 years back. It was organized more scientifically in 1953. Since then, various kinds of agriculture development have taken place. Agriculture production is not increasing sharply as compared to population growth. Similarly, the status of agricultural scientists is not growing on line with other technical profession. Personal views are expressed here how they can be improved on observing the history of agriculture development of Nepal.

## INTRODUCTION

History of agricultural science in Nepal dates back to 1902, when a progressive and liberal minded Prime Minister Dev Shamsher J. B. Rana met a Japanese monk Rev. E. Kai Kawaguchi who was visiting Nepal and Tibet. He suggested that Nepal should learn many things from a Budhist country Japan. After overcoming many hurdles, 8 students were sent to overseas with a guide called Swami Giri and 17 servants reached Japan on 17 June 1902 when Chandra Shamsher J. B. Rana replaced Dev Shamsher only after 114 days. Dev Shamsher might have been impressed by the rapid Meiji transformation, the change of agriculture feudal society to an industrial nation as Japan established many cottage industries. Chandra Shamsher did not like the idea of universal education. Eight students Capt. Jan Narshing Rana, Capt. Bhakta Bahadur Basnet, Dev Lal Singh, Bichar Man Singh studied ammunition making, mining, agriculture, mechanical engineering, paper and soap making. Mr. Deep Narshing studied agriculture. He introduced Wisteria, Chrysanthemum, persimmon and big chestnut from Japan and he constructed Chandra canal in Sunsari and Saptari. Because of their high skill Chandra Shamsher posted them outside Kathmandu.

With slow modernization, an agriculture office was established in 1922. In 1927, Krishi Parisad was established. In 1948, two agriculture farms in Parwanipur and Singh Durbar and three horticulture farms in Balaju, Godawari and Kakani were established. In 1953, Agriculture Ministry and Department was established with various divisions. In 1967, different departments such as Department of Agriculture Research and Education, Department of Horticulture, Department of Fisheries, Department of Livestock and Veterinary, and Department of Agriculture Extension were opened. Nepal Agricultural Research Council (NARC) was established in 1991. Many hurdles have been passed during these 97 years of agriculture exploration in Nepal. The condition of agricultural scientists economically speaking deteriorated considerably. For example, when I was employed I was receiving Rs. 380 per month and I could buy two '*tolas*' of gold in Rs. 300 and met very comfortably monthly expenses in Rs. 80. But when I resigned in 1982, I was receiving salary of Rs. 1500 per month and the price of gold was about Rs. 1100 a '*tola*'. So we can analyze the living conditions, which was far lower than when I was hired. I think same condition is true at present time as the inflation continues to rise. I would like to discuss these issues from scientific and economic point.

## WAYS TO IMPROVE THE STATUS OF SCIENTISTS

### Good administration

If we want to know how people feel, what they experience and what they remember, what their emotion and motive are like, and the reason for acting they do why not ask them? With these basic things in mind I usually ask fellow agriculture researchers for the response. Most of the time I did not find encouraging responses rather felt a kind of frustration and helplessness in the system and in the leadership. Frustration is that condition which exists when goal response suffers interference. Therefore, agriculture administration and research should continually seek to simplify and standardize work methods, ranging from relatively simple operation of sorting in coming data or administrative information to the complex process of formulation of a work plan for efficient rice breeding program (for example) or organization of entire budgeting process for annual programme associated with other breeding system of the corps etc. Lack of good administration and leadership would always hamper progress in scientific field. Thus, scientific knowledge and scientist would suffer badly creating frustration. Administration at the top and below should see that well qualified right person for right job. This would certainly help for improving the status of agricultural scientists. Good reporting system is the key for good administration.

### Good education

In any organization well-educated force is always more productive in thinking and results. Thus, agricultural scientists should be given all opportunity for higher learning as far as possible to create a good team of expertise that can tackle problems. It is my feeling that good training would always make scientists more imaginative to tackle future agricultural problems. It they are well trained and well utilized this would not only help NARC but would benefit scientists themselves for their promotions, recognition and for their leadership quality. NARC should have some scheme to upgrade its scientific staff for higher education or for higher training before it becomes too late. The scientists should be competent enough to qualify for the benefits.

### Good performance

It is accepted that well educated scientists would perform better. They would understand the nature of the problems of country or regions by providing good project proposals for action. This would create a sense of competition among individuals and group. Thus, more scientific publication would benefit NARC and scientists personally as performance is the key to progress. Biding of scientific project proposal would help create competition and economically benefit many. Relatively NARC scientists are well qualified and well exposed in the international area.

### Good evaluation

In any system, evaluation is very important aspects of development. In agricultural research, it is key to new technology development. Evaluation can be done in many ways such as by number of publications, creation of new laboratories, field facilities creation, new breeds or varieties, new technologies, etc. There can be some kind of survey on peer's pressure and respect to reflect on leadership qualities of scientist. Research ethic should always be valued while evaluation is made. Common senses and imagination should be pointed out while evaluation is made that would very much help agricultural scientists for their betterment.

### Good economic preposition

This would depend on individual basis. There are scientists who use their knowledge for creating wealth as side job which certainly help economically such as mushroom cultivation horticulture, flowers, cut flowers, vegetable seeds, dealing in breeds of animal and plants, seed business etc. There can be some kind of network among the member of agriculture scientists. If you have studied

agriculture than you should be using that knowledge for producing different things. NARC should also create some kind of pool system, which can be used legally as bonus in many companies. Economical proposition can be made according to the regions, the level of scientists and technicians and other staff. Performance would depend on variety in unity, open system or closed system, function versus structure, qualification based status and other social values. To attract more scientists in this regards fringe benefit should be created with positive out look. Effective use of exchange system between scientists and research organization can help scientists monetarily and or scientifically. Economically speaking, best qualified scientist should lead the NARC as such good grader in B.Sc. (Agri.) should have preference in hiring. For this, if needed they should be hired at junior scientist or associate scientist level rather than in technical grade. This phenomenon is harming NARC distantly. NARC should create some revolving fund for family welfare as and when needed to protect their scientists.

At the end, I would emphasize that NARC "Peerage" should be created. This would help one of those rare individuals who has a good grasp of NARC as a whole perhaps the budget officer, perhaps bureau chief with many years of service and a sufficient variety of successive responsibilities behind him is likely to be drawn into the personal organization of the Executive Director (ED). Democratic theory stresses the unregimented evaluation of free association of scientists who speak for themselves. Since NARC is an autonomous body for the benefit of scientists and the country, autonomy should percolate to lower level as well for better performance. Autonomy should not be kept for few top scientists only. Voice of the union is another important aspect, which should be used for the progress of NARC, perhaps like Society of Agricultural Scientists (SAS).

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# MILK HOLIDAY BOTH A CHALLENCE AND AN OPPORTUNITY TO POVERTY ALLEVIATION PROGRAM IN NEPAL

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## INTRODUCTION

For the first time in Nepal's history, increased milk production has been a problem. The Government owned Dairy Development Corporation (DDC) is resorting to so-called Milk Holidays to conceal their mounting incompetence on the one end, and the dairy farmers are resorting to street protests to ensure necessary market for their expanding milk production on the other. What a big surprise to one who had experienced the critical situation of Nepal's Milk Market of 1970's and 1980's.

1970's were the days of World Food Program milk powder with some supplement of Skim Milk Powder procurement from New Zealand, Australia while 1980's were the days of US Aid milk powder with increased quantity of import procurement, including from Chernobyl. Those were days, one could hardly dream of such a thing like MILK HOLIDAY to take place in the Nepal's milk market of 1990's.

## HOW IT BEGAN?

Milk Holiday is rooted to accidental beginning. In one-way, Chernobyl issue has been a blessing in disguise. The Government's ultimate announcement to disgruntled general public to ban the import of powder milk and to assure the supply with local milk production to the consumer had virtually led the foundation of Milk Holiday. The then Agriculture Minister Mr. Hari Narayan Rajauria was forced to make this announcement to satisfy the general milk consumers to bring back the milk consumption to the normal.

Following this announcement, there was a speedy growth of milk market for local milk. Coincidentally, a large number of dairy plants came into operation in the private sector during 1980's and thereafter to meet the expanding market demand. Incidentally, a large number of banking institutions and finance companies also happened to come into operation during this period which became instrumental to support increased milk production. They saw much prospect of agriculture credit for milking buffaloes to small farmers in dairy sector and much agricultural credit went into it, especially in enhancing milk production.

From one angle, the Government should be congratulated for having created conditions ever dreamt before for the poor and non-poor farmers of the otherwise insular villages to take up dairying as a potential source for supplemental cash income and rural employment. It has resulted into a tremendous volume of cash flow from the urban to rural population creating enormous employment to the deprived rural poor which went beyond the imagination for the planners for poverty alleviation and rural employment generation.

## A PARADOX

One could have never imagined such a volume of cash flow from urban population to the rural community continuously- the annual cash flow amounts to 8 million rupees for every 1000 liters of milk daily collected from the rural community - not could have imagined the masses of the gender based and poverty based employment generated to the deprived rural community. But the paradox is that the same farmers are now up in arms against the Government protesting Milk Holiday.

## ANALYSIS

The fact is that unbalanced emphasis were laid on the milk production with the farmers all over the country with little or no attention to improve the capability of existing private dairies for increased milk processing and marketing in the country. This is the common mistake that Nepal always repeats in all agriculture production sectors because government just want to help farmers but not the agro-based private enterprises who drive the market for the farmers. Development of various process technologies and driving market in competition under the domain of private sector is required. Supporting them is to support production for the farmers. On the other side, building up the private sector is to build up the potential taxpayer, which forms the stronger backbone of the national economy.

Dairies in the private sectors have limited capability, limited technology and limited market. Today, excess milk production knows no technology for product diversification for market extension. Herein lies the role of NARC for poverty alleviation and employment generation in the dairy sector. But no such Dairy Division has been established in NARC for the study.

## BIAS OUTLOOK AND MALICIOUS INTENTIONS

The DDC, which hitherto has been the single largest milk processing facility in the country, used to look at the upcoming dairy plants in the private sector as its unwelcome competitors and the Government outlook till recent years for the private dairies as something undesirable profiteers against the Government owned DDC. Such an outlook fails to recognize the latter's potential as an upcoming dairy industries in the private sector to contribute to the common cause of dairy development and the milk market extension of the entire milk producing farmers in the country.

While the newly established dairies were struggling in the throes of survival due to severely limited access to investment, technology, training and equipment, the DDC, by far the biggest player in the field, tends to create unfavorable situation to drive several upcoming private dairies out of business.

Request for the rescue support to National Dairy Development Board (NDDB) for consideration in all impositions of all kinds of taxes (including VAT and income tax) to the Government to be able to stay in business have been a far cry in the wilderness so far. How can such feeble dairies in the private sector go to rescue the milk producer from Milk Holiday? However, a survey has revealed that dairies in the private sector have been doubling the amount of their normal milk intake while DDC has declared Milk Holiday. There were no such words as 'Milk Holiday' recorded so far in the books of private dairies. The milk producers in this case are the best judges.

Consequently, the market ratio of private dairies to DDC was 35:65 year before last. This year the ratio is down to 45:55. One can easily imagine what awaits the DDC after the year 2000.

## NDDB- A POLITICAL CIRCUS

The National Dairy Development Board (NDDB), which was created nearly a decade ago with the larger goal of promoting dairy development in the country, has remained more or less defunct and least interested in these problems faced by the private sector dairies, not to speak of their growth and expansion. It has only busied itself either in privatizing DDC or in creating and sustaining unfeasible programs like powder milk plant at Chitraban. Why should NDDB be so much interested in privatizing DDC or in establishing new powder milk plant at Chitraban than to strengthening all the dairies already in operation in the private sector?

Private dairies never supported privatizing DDC nor the dairy experts both national and international, including DANIDA have declared feasible to establish Chitraban Milk Powder Plant. DDC is still experiencing the sad consequences of such past undertaking of Biratnagar Powder Milk Plant, which produces skimmed milk powder at Rs. 170 per kg when the prevailing market price is Rs. 130 per kg. Private dairies are interested in building up their capabilities rather than privatizing DDC.

One of the pre-requisites for dairy development in Nepal is to have a strong and independent Dairy Development Board constituted of representatives of and accountable to producers, processors, and consumers of dairy products with provision of access to independent experts with vision and experience in the field. A body thus organized should be able to stay on the principles of sound dairy development footing.

At present, the Board is nothing more than a political circus. Every time the cabinet changes, the Board changes too as does the ED, irrespective of whether the new comers have the pre-requisite professional credentials for the purpose. If such is the tradition, no surprise Milk Holiday is the end result in the country.

## A LESSON TO LEARN FROM INDIA

It is about time for the fact to be recognized that private initiatives and investments have an important role to play in dairy development in the country, as has the DDC. While there is also some talk of milk cooperatives in recent times, there is no need to be easily carried away just by the Anand Model alone of India. Greater bulk of milk production and processing, and designing and production of dairy equipment and machinery continue to be in the private sector there.

After liberalization and entrusting of milk processing to the private sector in early 1992 apart from Amul, India today has been the number one milk producer in the world.

Nepal, as a matter of fact, has a valuable lesson to learn from the Indian experiences. Where there is the exploitation in production, there will be always good room for cooperatives to step in. Wherever there is high competition among private dairies, the margin become too small for the cooperatives to operate effectively. Compare the processing margin the private dairies are keeping with them with any cooperatives or private dairies in the outside world. No dairy could imagine that private dairies could be operational at that margin.

Their products become naturally more expensive as in Amul products and the private will gradually overtake cooperative in due course of time in free competition provided the milk cooperative are not subsidized or protected. But protection with subsidy is in one way a corruption for encouraging inefficiency at the cost of efficient production.

So long as the processing aspects of milk were confined to milk cooperatives only, the pace of development remained slow in India. But once it was opened to both cooperatives and private sectors

after 1991, the growth of dairy development took off speedily to its present height. No wonder India today is the largest milk producing country in the world. Thanks to the revision of the Government policy and thanks to the contribution of the private sector dairies in India to make it possible.

Their experiences teach us that milk production should be continued by the individual farm family on household basis as part of the farming system while milk collection should be done by milk cooperative in competition with the private collection. Processing and product diversification needs to be entrusted to the private sector for their talent, initiative and drive which would otherwise be slow and less effective. In the cooperative sector, the very core of development "the initiative" has been found to be weaker.

## A CHALLENGE TO THE NINTH PLAN

While milk production has already been established as one of the most effective tools of augmenting income of the poor and the deprived in rural Nepal, it is a sad thing to note that the processing and marketing capability has still remained stunted. If the necessary steps are not taken in time by the Government to build up the capabilities of the private dairies, it will be doubtful how the ambitious poverty alleviation targets of the Ninth Plan could ever be achieved.

According to the 20 years Agricultural Perspective Plan, the growth rate of the livestock sector is expected to accelerate from 2.9 percent to 6.1 percent in the next five years and its share in the agricultural GDP to rise from the current 31% to 45% during the same period. Given such ambitious targets, it is all the more incumbent on the Government to address the processing and marketing aspects of milk production on priority basis if the poor of the rural areas are to be genuinely benefited.

## REASONS TO IMPROVE THE CAPABILITIES OF PRIVATE DAIRIES

In order for Nepal's so-called Milk Holiday to end, think private and go private for the entire job of milk processing and marketing. Give real support to private sectors beyond speeches and seminars. Have faith on the hidden potentiality of the private sector.

In the present system, there is the missing link in the chain of dairy development and that is the third and the most potential partner- the private sector in addition to DDC and cooperatives. Their role has been ever undermined and demoralized in the name of profiteers. They are the source of national revenue from which Government supports to the cooperatives for the sake of social justice. It is high time for the Government to realize that if their revenue is good, then only they could think of social justice. Giving services to revenue generation is as important as doing social justice to the weak and invalids.

Let us now think how the Government could help private dairies to help the milk producers.

## AREAS TO IMPROVE THEIR CAPABILITIES

### Increase the capability of private dairies

Government should support private dairies to help themselves in following ways:

- Provide regular training for dairy processing and product diversification leading to the establishment of dairy training institute in Nepal.
- Develop easy access to soft credit for dairy machinery and equipment.

- Help private dairies to rehabilitate the existing dairy facilities to increase the processing capabilities.
- Help private dairies to establish milk collection centers with soft credit.
- Help private dairies to develop the market of milk and milk product.
- Help private dairies to explore the opportunity for the technology transfer and joint venture for export market.

**Collaboration between Nepal Private Dairy Association (NPDA) and NARC**

The collaboration should focus on:

- Improvement in the process technology.
- Local designing and manufacturing of common dairy equipment.
- Development of ready-made packages of cheese and butter factories.
- Diversification and development of other dairy products where surplus milk could be absorbed for import substitution.

**Collaboration among NPDA, NDDB and Livestock Services Department**

The collaboration should focus on:

- Promotion of cheese and butter factories in the mountain and development of the cold chain for the storage of cheese and butter.
- Development of domestic and export market of cheese and butter.
- Strengthening the capability of private dairies and rehabilitation.

**Participation and negotiation between NPDA and the Government**

The participation and negotiation should lead on:

- Review of tax, VAT and other impositions on processed milk and other dairy products.
- Review of purchase and sales price of milk.

**Collaboration between NPDA and Central Food Research Laboratory**

The collaboration should lead to establish a common quality management laboratory to make aware of the quality dairy products that are being produced, and to arrange quality management training to them.

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# BASELINE AND NEED INDENTIFICATION SURVEY OF AGRO-ECOLOGICAL RESEARCH SITES REPRESENTING FROM RIVER BASIN TO HIGH HILL DOMAINS IN WESTERN NEPAL

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## ABSTRACT

A baseline and need identification survey of agro-ecological research sites at Chambas, Maduwa, Chhahara and Bhakimli representing from river basin to high hill domains, respectively was carried out at different periods from February to May 1998. The participatory rural appraisal was the main technique of data collection. The survey results reveal that the sites are located not so far from road heads. Rainfall pattern is almost similar at all the sites with monsoon generally running from June/July to September/October. The ethnic composition at all the sites are mixed with dominance of Tamang (37%) at Chambas, Brahmin (40%) at Maduwa, Chhetri (32%) at Chhahara and Magars (83.5%) at Bhakimili. Higher proportion of farmers belongs to food sufficient group at Chambas (35%) and Maduwa (40%) whereas the deficit farmers are dominant at Chhahara (51%) and Bhakimli (55%). Selling of food is the main source of income among food surplus farmers, whereas majority of food sufficient and deficit farmers are engaged in off-farm activities. The male literacy level is high and decreases with lower food self-sufficiency levels. The level of educational attainment increases with higher levels of food self-sufficiency. The proportion of Bari land is high. Red soil is the most prevalent soil in types of lands. The Khet cropping pattern is rice-based whereas Bari cropping pattern is maize-based. Rice, wheat, maize, potato, millet and barley are the major food crops grown at all the sites. Buffalo, cattle, goats and fowl are the major livestock types. Forage (thatched grass) is the major source of feed item at Chambas (34%), Maduwa (42%) and Chhahara (60%), whereas crops residues (50%) are the main sources at Bhakimli. Tanki at Chambas, Bedulo at Maduwa, Phosro at Chhahara and Chuletro and Khanyum at Bhakimli are the major fodder trees. Blast in rice and yellow rust and sterility in wheat are the major diseases. Stem borer, white grub and red ant are the major pests in rice, maize and potato, respectively. FMD, infertility and mastitis are the major diseases in large ruminants and white diarrhea and ranikhet are in fowl.

## INTRODUCTION

Agricultural Research Station (ARS), Lumle the then, Lumle Agricultural Research Centre (LARC) is mandated to carry out farming systems research (FSR) in its research command area (RCA) to increase the production and productivity of agricultural commodities. The RCA consists of 11 hill districts of Western Development Region viz. Tanahun, Gorkha, Lamjung, Kaski, Parbat, Myagdi, Baglung, Syangja, Palpa, Gulmi and Arghakhanchi.

The environment of the RCA is so diverse that the technologies generated at ARS, Lumle cannot be generalized to the whole RCA. Taking this fact into consideration, ARS, Lumle since its inception has been conducting agricultural research at three different tiers viz. on-station, off-station and outreach research. But the off-station and outreach research had been carried out at sites operated under the concept of recommendation domains defined by arbitrary eco-zones based primarily on altitude (Vaidya *et al.*, 1997). So, to define more precise and comprehensive recommendation domains, a study

was carried out by Vaidya and Floyd (1997) which identified five recommendation domains viz. river basins (240-600 masl), low hills (600-1000 masl), mid hills (1000-1600 masl), high hills (1600-2300 masl) and mountains (above 2300 masl). The same study identified four off-station research sites: Chambas representing river basin, Maduwa representing low hills, Chhahara representing mid hills and Bhakimli representing high hills. These sites are called agro-ecological research (AER) sites.

This study was carried out as an activity under agro-ecological research management process of establishing benchmark information (bio-physical and socio-economy) of these on farm research sites and identifying the research needs of the farmers.

## METHODS

The baseline and need identification survey of the agro-ecological research sites was carried out by a team of multidisciplinary researchers at different periods from 8 Februrary to 14 May 1998.

Two different methods were used for data collection. Those included participatory rural appraisal (PRA) technique and data extracted from the secondary source viz. completed survey questionnaire of the recommendation domains by Vaidya and Floyd (1997).

The collected information were analyzed by using simple statistical tools like average, percentage and cross tabulation.

## RESULTS

This paper presents the joint results of surveys reported by Nepali *et al.* (1998a & b; 1999a & b).

### General features

The agro-ecological research sites viz. Chambas, Maduwa, Chhahara and Bhikimli are situated in Tanahun, Syangja, Palpa and Myagdi districts, respectively. The general features of the sites are summarized in table 1. The rainfall pattern is almost similar at all the sites with monsoon generally running from June/July to September/October.

**Table 1. General features of agro-ecological research sites**

| General features | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Recommendation domain | River basin | Low hill | Mid hill | High hill |
| Altitude range | 440-550 masl | 840-1050 masl | 1100-1500 masl | 1300-2300 masl |
| Aspect | Flat-eastern slope | North-eastern slope | South-eastern slope | North-eastern slope |
| District | Tanahun | Syangja | Palpa | Myagdi |
| Village Development Committee | Bhanu | Chilaunebas | Amalabas | Bhakimli |
| Walking distance from road head | 0 hour | 25 hour | 0 hour | 4 hour |
| Nearest local market | Turture | Jugle | Chhahara | Beni bazar |
| Climatic conditions | Sub-tropical | Suip-tropical | Sub-tropical to sub temperate | Cold temperate |
| Rainfall | May-Sep. (80%) | May-Sep. (83%) | July-Sep. (73%) | July-Oct. (67%) |
| Maximum | August (27%) | August (27%) | August (26%) | August (19%) |
| Hailstone occurrence | May-June (64%) | June (64%) | March-April (46%) | May (35%) |
| Frost occurrence | Dec.-January | - | Dec.-January | Dec.- Jan. (30%) |

## Ethnic composition

All the sites have mixed ethnic composition with dominance of Tamang at Chambas, Brahmins at Maduwa, Chhetries at Chhahara and Magars at Bhakimli. Table 2 illustrates the distribution of ethinic groups by AER sites.

**Table 2. Ethnic composition by agro-ecological research sites**

| Ethnic groups | Agro-ecological research sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Chambas | | Maduwa | | Chhahara | | Bhakimli | |
| | n | % | n | % | n | % | n | % |
| Brahmin | 11 | 13 | 31 | 40 | 31 | 17 | - | - |
| Chhetri | 13 | 16 | 14 | 18 | 59 | 32 | 10 | 8.7 |
| Gurung | - | - | 14 | 18 | - | - | - | - |
| Tamang | 31 | 37 | - | - | - | - | - | - |
| Magar | - | - | - | - | - | - | 96 | 83.5 |
| Newar | 14 | 17 | - | - | 14 | 7 | - | - |
| Occupational castes | 14 | 17 | 19 | 24 | 53 | 29 | 4 | 3.5 |
| Others | - | - | - | - | 28 | 15 | 5 | 4.5 |
| **Total** | **83** | **100** | **78** | **100** | **185** | **100** | **115** | **100** |

## Food self-sufficiency

During the survey the farming households were classified into three wealth groups viz. food surplus group (food enough ≥ 12 months), food sufficient group (> 6 ≤12 months) and food deficit group (≥ 6 months) on the basis of level of food security established from their own product. At Chambas and Maduwa, higher proportion of inhabitants belongs to food sufficient groups, whereas majority of inhabitants at Chhahara and Bhakimli belong to food deficit groups (Table 3).

**Table 3. Percentage distribution of food self-sufficiency by agro-ecological research sites**

| Food self-sufficiency groups | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Surplus group | 34 | 22 | 20 | 20 |
| Sufficient group | 35 | 40 | 29 | 25 |
| Deficit group | 31 | 38 | 51 | 55 |
| **Total** | **100** | **100** | **100** | **100** |

## Income generation

Cereal is the main source of income supplemented by vegetables and fruits among food surplus farmers in all the sites except Bhakimli where service and pension stand as the major source. In the case of food sufficient and deficit farmers, food crops are the main source at Chambas and Bhakimli AER sites. On the contrary, service and pension are the main sources at Maduwa and Chhahara AER sites. In the case of service and pension, farmers from food surplus group are involved in government service, teaching and other services, whereas farmers from food sufficient and deficit groups are involved in foreign services viz. in Gulf countries, Indian armies, etc. (Table 4).

## Educational status

The male literacy status is high at all the sites and decreases with lower food self-sufficiency levels (Table 5). Majority of men from food surplus group at Chambas and Maduwa have attained primary education, whereas majority of men from food sufficient and deficit groups are literate without schooling. In the case of Chhahara and Bhakimli the literacy situation has increased with the higher levels of food self-sufficiency (Table 6). High proportion of women belonging to food surplus group has attained primary education. Except in Chhahara, high proportion of women from both food self

sufficient and deficit groups are literate without schooling (Table 7). However, formal education attainment was always highest in food surplus group.

**Table 4. Percentage distribution of sources of income by food self-sufficiency at agro-ecological research sites**

| Sources of income | Agro-ecological research sites | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chambas | | | Maduwa | | | Chhahara | | | Bhakimli | | |
| | Sur. | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. |
| Food crops | 60 | 39 | 32 | 50 | 30 | 15 | 44 | 33 | 25 | 40 | 40 | 50 |
| Livestock | 10 | 10 | 9 | 15 | 14 | 10 | 8 | 16 | 15 | 0 | 10 | 20 |
| Service/Pension | 30 | 34 | 20 | 25 | 29 | 20 | 40 | 49 | 30 | 60 | 40 | 10 |
| Business | 0 | 4 | 0 | 0 | 4 | 0 | 8 | 2 | 0 | 0 | 10 | 0 |
| Daily wage | 0 | 11 | 35 | 0 | 11 | 35 | 0 | 0 | 30 | 0 | 0 | 10 |
| Prist work | 0 | 2 | 0 | 10 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Occupational work | 0 | 0 | 4 | 0 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 10 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 5. Percentage distribution of literacy status by food self-sufficiency at agro-ecological research sites**

| Literacy status | Agro-ecological research sites | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chambas | | | Maduwa | | | Chhahara | | | Bhakimli | | |
| | Sur. | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. |
| Male | 95 | 85 | 60 | 95 | 75 | 25 | 48 | 35 | 25 | 49 | 60 | 41 |
| Female | 90 | 70 | 40 | 80 | 50 | 7 | 44 | 19 | 21 | 28 | 48 | 33 |
| Both sexes | 92.5 | 77.5 | 50 | 85 | 62.5 | 16 | 46 | 27 | 23 | 38 | 55 | 37 |

Sur: Surplus, Suff: sufficient, Def: Deficient

**Table 6. Percentage distribution of literacy status by food self-sufficiency for male population at agro-ecological research sites**

| Educational attainment | Agro-ecological research sites | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chambas | | | Maduwa | | | Chhahara | | | Bhakimli | | |
| | Sur | Suff. | Def. | Sur | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. |
| Literate but no schooling | 24 | 48 | 65 | 24 | 66 | 72 | 55 | 60 | 53 | 58 | 75 | 69 |
| Primary education | 55 | 37 | 25 | 37 | 27 | 28 | 23 | 20 | 23 | 36 | 20 | 24 |
| SLC | 12 | 10 | 6 | 23 | 7 | 0 | 14 | 10 | 17 | 6 | 5 | 5 |
| Higher education | 9 | 5 | 4 | 16 | 0 | 0 | 8 | 10 | 7 | 0 | 0 | 2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Sur, : Surplus, Suff: sufficient, Def: Deficient

**Table 7. Percentage distribution of literacy status by food self-sufficiency for female population at agro-ecological research sites**

| Educational attainment | Agro-ecological research sites | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chambas | | | Maduwa | | | Chhahara | | | Bhakimli | | |
| | Sur. | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. | Sur. | Suff. | Def. |
| Literate but no schooling | 39 | 57 | 65 | 25 | 60 | 71 | 44 | 29 | 21 | 28 | 50 | 49 |
| Primary education | 41 | 31 | 29 | 44 | 40 | 29 | 12 | 10 | 8 | 30 | 20 | 17 |
| SLC | 12 | 9 | 3 | 21 | 0 | 0 | 6 | 4 | 3 | 1 | 0 | 1 |
| Higher education | 5 | 3 | 3 | 10 | 0 | 0 | 4 | 3 | 2 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Sur: Surplus, Suff : sufficient, Def: Deficient

## Land type

The proportion of Bari land in comparison to Khet land is high in all the sites with relatively more land holdings at Maduwa AER site (Table 8).

**Table 8. Distribution of land types by agro-ecological research sites**

| Land types | Agro-ecological research sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Chambas | | Maduwa | | Chhahara | | Bhakimli | |
| | Size (ha) | % | Size (ha) | % | Size (ha) | % | Size (ha) | % |
| Khet land | 14.2 | 30 | 43 | 43 | 14 | 13 | 8.25 | 22.5 |
| Bari land | 33.2 | 70 | 57 | 57 | 86 | 87 | 27.50 | 77.5 |
| Total | 47.4 | 100 | 100 | 100 | 100 | 100 | 35.75 | 100 |
| Average Khet land holding | 0.20 | 0 | 0.55 | - | 0.1 | - | 0.15 | - |
| Average Bari land holding | 0.40 | - | 0.75 | - | 0.5 | - | 0.50 | - |

## Cropping pattern

Rice followed by wheat is the principal cropping pattern in Khet land in all the sites except Chambas where potato is grown more widely than wheat (Table 9).

**Table 9. Percentage distribution of khet cropping patterns by agro-ecological research sites**

| Khet cropping pattern | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Rice-Wheat-Fallow | 26 | 59 | 59 | 66 |
| Rice-Potato- Fallow | 33 | 13 | - | 13 |
| Rice-Mustard-Fallow | 14 | 15 | - | 4 |
| Rice-Fallow-Maize | 27 | 13 | - | - |
| Rice- Fallow- Fallow | - | - | 41 | 17 |
| **Total** | **100** | **100** | **100** | **100** |

In Bari land, maize is the principal crop across the hills, followed by black gram mostly at Chambas, millet mostly at Maduwa, toria, bean and wheat equally at Chhahara and millet followed by barley mostly at Bhakimli. Upland rice is grown only at Chambas (Table 10).

**Table 10. Percentage distribution of Bari land cropping patterns by agro-ecological research sites**

| Bari cropping pattern | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Maize-Millet-Fallow | - | 61 | - | - |
| Maize -Millet-Barley | - | 15 | - | 55 |
| Maize -Millet-Pea- Fallow | - | 24 | - | - |
| Maize - Tori | - | - | 25 | - |
| Maize+Legume-Barley | - | - | - | 11 |
| Maize-Legume- Fallow | - | - | - | 11 |
| Maize-Blackgram-Fallow | 50 | - | - | - |
| Maize+Potato-Buckwheat/Mustard | - | - | - | 7 |
| Potato-Buckwheat/Mustard | - | - | 25 | - |
| Maize+Bean+Soybean-Wheat | - | - | 25 | 16 |
| MaizeWheat/Barley-Fallow | - | - | 25 | - |
| Upland-Rice-Fallow | 50 | - | - | - |
| **Total** | **100** | **100** | **100** | **100** |

## Crop productivity

The productivity of rice, wheat, maize and millet is highest at Maduwa and lowest at Chhahara, whereas the productivity of barley and potato is highest at Bhakimli (Table 11).

**Table 11. Average productivity (kg/ha) of major crops by agro-ecological research sites**

| Crop varieties | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Rice | 4200 | 5400 | 1139 | 1242 |
| Wheat | 1600 | 2400 | 250 | 927 |
| Maize | 2200 | 4300 | 1124 | 2551 |
| Potato | 1800 | - | - | 10828 |
| Millet | - | 2833 | 488 | 1482 |
| Barley | - | 1000 | 1350 | 2800 |
| Soybean | - | - | - | 880 |
| Upland rice | 2300 | - | - | - |
| Blackgram | 900 | - | - | - |

## Livestock

Buffalo, cattle and goats are the important animals raised in all the sites, followed by fowl. The population of buffalo, cattle, goats and fowl is highest at Chhahara (Table 12).

**Table 12. Livestock population by agro-ecological research sites**

| Livestock types | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Buffalo | 112 | 207 | 555 | 211 |
| Cattle | 180 | 76 | 415 | 460 |
| Goat | 240 | 123 | 520 | 61 |
| Sheep | - | - | - | 20 |
| Rabbit | 22 | - | - | 42 |
| Pig | 21 | - | 11 | - |
| Chicken | 750 | 295 | 1000 | 810 |
| Duck | 15 | - | - | 45 |

The major diseases of large ruminants at the sites are FMD, mastitis and infertility (in buffalo) and parasites are liverfluke and timpani. The major diseases of fowl are white diarrhea and Ranikhet.

## Fodder and forage situation

Livestock feed includes rice straw, maize stalk, maize husk, maize thinning, millet straw, wheat straw, fodder tree cuttings, thatched grasses and other biomass collected from public forest wherever accessible. The use of fodder trees, forage, straw crop residues and biomass from public forest as feed resources is highest at Chambas, Chhahara and Bhakimli, respectively (Table 13).

In addition to above feed types, lactating buffaloes are sometimes fed concentrated feed like oilseed cake, rice bran, maize flour, wheat flour mixed with water. Fodder trees and their ranking based on use are given in Table 14.

**Table 13. Percentage distribution of feed types by agro-ecological research sites**

| Feed types | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Fodder (tree cutting) | 33 | 19 | 25 | 25 |
| Forage (thatched grass) | 34 | 42 | 60 | 17 |
| Straw and crop residues | 33 | 39 | 15 | 50 |
| Biomass from public forest | - | - | - | 8 |

Taki (*Bauhinia purpurea*) followed by Ramsing (*Garuga pinnata*) and Badahar (*Artocarpus lakoocha*) are the most commonly preferred fodder trees at Chambas, Bedulo (*Ficus clavata*) followed by Bans (*Dendrocalamus strictus*) and Kutmiro (*Litsea monopetala*) at Maduwa, Phorso (*Grewia optiva*), followed by Phulchus and Khanyum (*Ficus semicordata*) at Chhahara and Khanyum followed by Bans and Bedulo at Bhakimli.

**Table 14. Ranking of fodder trees by agro-ecological research sites**

| Fodder trees | Agro-ecological research sites | | | |
|---|---|---|---|---|
| | Chambas | Maduwa | Chhahara | Bhakimli |
| Arkhalo *(Quercus spicata)* | - | 13 | - | - |
| Badahar *(Artocarpus lakoocha)* | 2 | - | - | - |
| Bains | - | - | - | 3 |
| Bans *(Dendrocalamus strictus)* | - | 2 | 4 | 2 |
| Bedulo *(Ficus clavata)* | - | 1 | 4 | 2 |
| Chuletro *(Brassaiopsis sp.)* | - | 5 | - | 1 |
| Dudhilo *(Ficus nemoralis)* | - | 9 | - | - |
| Jhigano *(Eurya acuminata)* | - | 15 | - | 6 |
| Kavro *(Ficus lacor)* | - | - | 5 | - |
| Khanyum *(Ficus semicordata)* | 6 | 9 | 3 | 1 |
| Koiralo *( Bauhinia variegata)* | 4 | 7 | 5 | 5 |
| Kutmiro *(Litsea monopetala)* | 3 | 3 | - | - |
| Nimaro *(Ficus roxburghii)* | - | 6 | - | - |
| Painyu *(Prunus cerasoides)* | - | 12 | - | 3 |
| Pakhuri *(Ficus glaberrima)* | - | 8 | - | - |
| Phulchus | - | - | 2 | - |
| Phorso *(Grewia optiva)* | - | - | 1 | 4 |
| Rai Khanyin *(Ficus semicordata)* | - | 10 | - | 1 |
| Ramsing *(Garuga pinnata)* | 2 | 11 | - | - |
| Gidari *(Premma barbata)* | 7 | - | - | - |
| Taki *(Bauhinia purpurea)* | 1 | - | - | - |

**Pests and diseases**

Blast and stem borer are very common problems in rice grown at all the AER sites (Table 15). Similarly, yellow rust, sterility and *Phalaris minor* in wheat, white grub in maize, stem borer and black beetle in millet are other problems. Red ants infestation in vegetable, potato and radish is crucial.

Diseases like FMD, infertility (in buffaloes) and mastitis and parasites like liverfluke and timpani are the major problems in large ruminants. In fowl, Ranikhet disease is problematic.

Table 15. Pests and diseases by agro-ecological research sites

| Sector | Sub-sector | Agro-ecological research sites | | | |
|---|---|---|---|---|---|
| | | Chambas | Maduwa | Chhahara | Bhakimli |
| Crops | Rice | Disease-Blast<br>Pest-Stem borer | Disease-Blast<br>Pest-Stem borer | Disease-Blast<br>Pest-Stem borer | Disease-Blast<br>Pest-Stem borer |
| | Wheat | Disease-Yellow rust, Sterility | Disease-Yellow rust | Disease-Yellow rust | Disease-Yellow rust |
| | Maize | Pest-White gurb | Pest-White gurb | Pest-White gurb | Pest-White gurb |
| | Millet | - | Pest-Stem borer, Black beetle | Pest-Stem borer | Pest-Stem borer, Black beetle |
| | Potato | Pest-Red ant | Pest-Red ant | Pest-Red ant | Pest-Red ant |
| | Radish | Pest-Red ant | - | - | - |
| Livestock | Buffalo & Cattle | Disease-FMD, infertility, Mastitis<br>Parasite-Liver fluke | Disease-FMD, infertility, Mastitis<br>Parasite- Liver fluke | Disease-FMD, infertility, Mastitis<br>Parasite-Liver fluke | Disease-FMD, infertility, Mastitis<br>Parasite-Liver fluke, Timpani |
| | Fowl (chicken) | Disease-White diarrhoea | Disease-Ranikhet | Disease-Ranikhet | Disease-Ranikhet |

## Needs of the farmers

The needs of the farmers across the western hills are high yielding and early maturing varieties of wheat, upland rice, black gram, tasteful and disease/pest resistant varieties of potato, treatment of infertility in livestock and control of diseases like FMD, mastitis. Improved pigs and rabbits for raising and saplings of fodder trees have been desired by the farmers (Table 16).

Table 16. Need of the farmers by agro-ecological research sites

| Sector | Sub-sector | Agro-ecological research sites | | | |
|---|---|---|---|---|---|
| | | Chambas | Maduwa | Chhahara | Bhakimli |
| Cereal crops | Wheat | Early Variety | High yielding varieties | High yielding varieties | - |
| | Upland rice | High yielding, early maturing and less shattering varieties | - | - | - |
| Legumes | Black gram | High yielding varieties | - | - | - |
| | Cowpea | Prakash variety for seed multiplication | | | |
| Tuber crops | Potato | High yielding, tasteful and disease, insect pest resistant varieties | High yielding and tasteful variety | High yielding, tasteful and disease insect pest resistant varieties | High yielding and tasteful varieties |
| Livestock | Large ruminants buffalo and cattle | Cross and exotic breeds | Treatment of infertility in buffalo | Treatment of infertility in buffalo and cattle | Treatment of infertility in buffalo, control of FMD, anthrax and timpani<br>Development of local buffalo breeds |
| | Small ruminants | Improved buck | Rabbit rearing for meat and wool | Rabbit rearing for meat and wool Improved pig and goat | - |
| | Fodder and forage | Saplings of Gidari, Kavro, Phosro, and Bamboo | Saplings of Badahar and Kutmiro | Saplings of various fodder trees | Sapling of Badahar and Khanyum |

## DISCUSSION

The AER sites have been established to provide representative environments (biophysical and socio-economic) in which demand led research activities are carried out to generate appropriate technologies that are most likely to meet the farmers' needs. So, it is essential that the sites ought to be the representative of the major environments in the RCA of the station. In connection to this, discussion is presented in line with the recommendation domains as defined by Vaidya and Floyd (1997).

All the sites are easily accessible as compared to other villages whose average distance from road head is 4.80 hours for river basin, 4.91 hours for low hills, 8.59 hours for mid-hills and 22.39 hours for high hills (Vaidya and Floyd, 1997). Thus, from accessibility point of view the sites are suitable for technology generation and dissemination to other villages.

The distribution of food self sufficiency reveals that the economic status of the inhabitants at Chambas and Maduwa is relatively better than other villages in river basin and low hills where on an average 43 % and 48% households respectively fall under food deficit group (Vaidya and Floyd, 1977). In the present study, the food deficit household percent was 31 at Chambas and 38 at Maduwa.. But in the case of Chhahara and Bhakimle the economic status of the farmers is relatively low compared to other villages in mid hills and high hills where 46 and 43% households belong to food deficit group respectively (Vaidya and Floyd, 1997). In the present study, the food deficit household percent was 51 at Chhahara and 55 at Bhakimli. Thus, Chambas and Maduwa could serve as suitable sites for generating agricultural technologies leading to commercial farming. At the same time, it will be worthwhile to consider the proportion of population by food self-sufficiency while generating agricultural technologies for identifying the target groups.

Hill farming is largely subsistent and unremunerative so that overall off-farm sources of income contribute significantly (66%) to the total household income. The contribution of off-farm sources is even more important as level of food self-sufficiency decreases (Vaidya and Floyd, 1997). In the present study, the average contribution of off-farm sources for all three groups food surplus, sufficient and deficit was found 50%, while it was 56% for food deficit group. Thus, commercial and highly remunerative agricultural technologies are to be introduced so that the hill farmers will be attached more to on-farm activities.

The literacy situation of all the sites except Chhahara are relatively high as compared to the national status of 54.5% for male, 25% for female and 39.6% for both sexes (CBS, 1995). However, better-off families have more access to educational attainment, which decreases with lower food self-sufficiency situation.

Khet land declines and Bari, grazing and forests land increase with increasing altitude (Vaidya and Floyd 1997). But the sites locating at increasing altitude have not followed the same pattern due to variation in availability of irrigation sources. The average land holdings, both khet and bari land at the sites are relatively higher than other villages located in the respective agro-ecological regions. This can be seen when compared with the findings of Vaidya and Floyd (1997). The present study from average land holding point of view suggests that Maduwa is suitable for khet land research while Chhahara for bari land research.

The Khet cropping pattern is rice-based at all the sites as the river basin with dominance of rice-potato-fallow (33%), low hills with dominance of rice-wheat-fallow system (59%), mid hills with dominance of rice-fallow-fallow system (59%) and high hills with dominance of again rice-wheat-fallow (66%). Thus, the sites are suitable for rice-based research

The Bari cropping pattern is maize-based at all the sites, followed by different crops as in river basin with dominance of maize-blackgram-fallow (50%), low hill with dominance of maize-millet-fallow (61%), mid hills with equal distribution of maize-tori, maize+potato-buckwheat, maize+beans-wheat

and maize-wheat/barley-fallow and high hills with dominance of maize-millet-barley (55%). Thus, the sites are suitable for maize-based research.

The average productivity of cereal crops at Maduwa is relatively high when compared with other sites. Thus, from production and productivity points of view Maduwa is suitable for research in rice-wheat, maize and millet, Chambas for upland rice and blackgram, and Bhakimle for potato and barley.

Buffalo and cattle are kept in all the sites. Vaidya and Floyd, (1997). reported that 97% villages in RCA had buffalo and cattle. The highest population of buffalo, cattle, goat and chicken at Chhahara could be because of more number of households. Thus, it would be worthwhile to focus research on these livestock.

The contribution of straw as the feed source is high at all the sites except Chhahara. Also, in other villages in RCA straw has been reported to contribute 30.8% to the total feed supply (Vaidya and Floyd, 1997). The low contribution of straw and crop residues at Chhahara could be due to low production and productivity of cereal crops. At the same time, the use of fodder trees is more or less similar at all the sites. So, it would be worthwhile to focus research on fodder trees being commonly preferred.

Disease and pest problems in crops are almost same at all the sites. Besides, drought and lack of agricultural inputs have been considered as the major problems at all other locations in the RCA (Vaidya and Floyd, 1997). Thus, research on plant protection and low input technologies should receive attention. Disease and parasites in livestock production are the major problems and the problem types are almost some at all the sites and also in other locations in the RCA. Animal health, animal feed, lack of improved breed etc. have been identified as the major constraints.

## CONCLUSION

In conclusion, the AER sites provide representative environments in terms of biophysical and socio-economic conditions. The technologies developed and tested under the same conditions are most likely to meet the farmers' needs. The problems and needs raised by the farmers are valid to the extent of their persistence. The needs of the farmers require due consideration in order to get participation in agricultural technology generation, verification and dissemination.

## ACKNOWLEDGEMENTS

The authors acknowledge the support of Dr. R.P. Sah, the station chief of ARS Lumle. This project was funded by His Majesty's Government of Nepal and partly by Department for International Development (DFID) of the British Government through Hill Agriculture Research Project (HARP).

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# ECONOMICS AND DIVERSITY OF RICE-BASED PRODUCTION SYSTEMS IN NEPAL'S CENTRAL TERAI

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## ABSTRACT

Rice production systems in Nepal Terai is complex and diverse. This complexity and diversity is the result of inherent heterogeneity of farmers' resource endowments, sociocultural and agroecological diversity of the rice production environment. This study attempts to capture this essence of diversity and complexity of rice production systems through economic analysis, yield gap, production constraints and production systems characteristics in order to address the areas for rice technological intervention and improvement. The study from selected villages/outreach research sites of RARS, Parwanipur, central Terai conducted in 1996 and 1997 reveals that farmers' resource endowments, rice varieties, cropping pattern, yields, yield gaps and economic return from rice differ between production systems (Bhadaiya and Agahani) and agroecosystems (upland, mid-wet-land, and lower wet-land). Farm level input use, rice yields and return are higher in Aghani system and resource rich farm group. Sizeable yield gaps and production constraints such as drought, adverse soils, unavailability of fertilizer and improved seeds were observed in both types of rice production systems. Finally this study suggests to fully recognize the inherent diversity in the farmers resource endowments, rice production systems, constraints and production environments in designing meaningful operational research strategies for rice crop in Nepal Terai.

## INTRODUCTION

Research relevance and effectiveness of the technology development depends on the fundamental understanding and analysis of the farmers socioeconomic and agroecological environments, production systems, and resource endowment of farm households. Such detail understanding and analysis help prioritize research programs based on the needs, priorities and resource constraints of the target farmers in their given recommendation domains (Gauchan *et al.*, 1997).

Broadly, agricultural research and developmental interventions in Terai area of Nepal is considered as one recommendation domain (homogenous in terms of agroecology and socioeconomic settings). However, at the micro level, Terai is not uniform as seen from outside (macro level) from rice production perspectives (Gill, 1996; Gauchan *et al.*, 1997). Wide diversity exist in farmers' resource endowments, production objectives, sociocultural and agroecological diversity within the Terai, which have resulted in significant variations and complexity in rice production systems and farmers' demand for technologies.

Presently, rice research program has focused variety development work recognizing only the agroecological diversity of environment, land types and surface hydrology ignoring socioeconomic diversity. Upadhayaya *et al.*, (1996), recognized both agroecological and socioeconomic diversity, where recommendation domains were classified basically based on ecological (three rainfall class and four altitude regimes) criteria relatively at meso-level for research planning and rice biotechnological initiatives. However, within this classification in rainfall and altitude, there exist significant micro-level variations in the Terai based land type, moisture regime, soil types and household resource endowments that may have important research and development implications.

Since presently we lack adequate information to address the needs, constraints and potentials specific to farmers socioeconomic circumstances, production system and resource endowments at the micro-level, this study attempts to describe, assess and capture aforesaid diversity of rice agro-ecosystems, farm resource endowments, and rice based production systems of the case study villages in central Terai. It analyzes agroecosytems, and socioeconomic diversity through agroecological, social and economic analysis, production constraints, and yield gaps in order to address the areas for rice technological intervention and improvement. The specific objectives are:

- Analyze the diversity of agroecosystems, farm resource endowments and production systems
- Characterize rice production systems and assess their economics
- Identify production constraints and yield gaps by ecosystems and production systems
- Suggest implications of diversity to target rice research and development in the Terai

## MATERIALS AND METHODS

### Literature review and study planning

Available secondary sources of information were reviewed to conceptualize the problems and develop understanding on economics and diversity of rice production systems. Research protocol, checklists and questionnaire were developed and updated through interaction with concerned rice scientists and knowledgeable people.

### Informal interaction, direct observation and focus group discussions

A multidisciplinary team involving both social and biological scientists was involved in the study site selection, focus groups discussions and household interview. Concerned rice scientists, outreach research staff, extensionists and knowledgeable farmers were consulted for the selection of villages, agro-ecodomains, and research hypothesis refinement.

Farmers' house, their rice fields, sheds, storage and local input and output market were visited to observe, understand and gain insights on actual field understanding of rice agroecosystems, production systems, cropping patterns and marketing system. Focus group discussions were held with different groups of farmers and women groups on rice production practices, rationale for adoption of diverse production systems, variety use, economics and production constraints.

### Household survey

*Sampling methods.* A purposive two stage sampling technique was employed for field survey. For this, major rice production areas of three districts of central Terai such as Bara, Parsa and Rautahat under the research command areas of Regional Agricultural Research Station (RARS), Parwanipur were purposively selected. Within these districts, villages with different agroecosystems (upland, mid-wetland, lower-wet land and irrigated and rainfed) were selected. Some of the selected villages are Outreach Research Sites of RARS, Parwanipur and neighbouring villages. They are

(1) Sugauli Village Development Committee (VDC) - Bara Irrigated (irrigated lower wet land/ mid-wet land)
(2) Belwa VDC - Parsa Rainfed (rainfed mid-wet land/ upland)
(3) Santapur VDC - Rautahat Rainfed (rainfed upland/mid-wet land)

*Selection of rice farm households.* Within each production environment households were stratified based on resource /economic status. Voter lists were obtained from the VDC office and rice growing

farm households were selected and categorized into three groups based on economic/wealth status using key informants. The criteria for farm groupings are presented below:

- Resource rich: Ownership of large rice land (>2 ha), equipment (tractors, thresher or tube wells), cart, cattle with better human resource (educated members) and other assets.
- Medium resource: Ownership of medium land size (0.5-2 ha), draft power with medium human resource (literate family members) etc.
- Resource poor: Small rice farm size (<0.5 ha), tenant with no draft power, poor human resource (illiterate family members) and no other capital assets.

*Household interview.* The selected farm households based on resource categories (n=40) and production environments were interviewed using pretested questionnaire. The data and information collection included farm household's socioeconomic characteristics, relevant rice production systems by environments, input use, farm production, economics, yield gaps and farmers' on-farm technical and socio-economic production constraints including problem solving practices, gender issues, off-farm activities and food security considerations.

## RESULTS

### The agro-ecosystem diversity

At the micro-level, the study sites in the Terai are diverse with immense micro-agroecological variations from the rice production point of view (NARC/ATSP, 1993; Gauchan and Yokoyama, 1999). Both structural and functional diversity are high in these agroecosystems. Based on land, soil types, water regimes and limitation to agricultural production, they can be classified into three agroecosystems namely lower wetland, mid-wetland and upland / dry land (Table 1).

**Table 1. Types of rice agro-ecosystems and their characteristics in central Terai, Nepal**

| Agro-ecosystems | Moisture regime | Soil types | Land types | Limitation to rice production system |
|---|---|---|---|---|
| Lower wetland (Sarihan, Nichha, *Agahani khet*) | High water retention, poorly drained | Clay-loam to loam | Wetland | Flooding and ponding in monsoon season |
| Mid-wetland (*Ucha Bhadaiya khet*) | Medium to poor water retention | Loam | Upper and mixed wetland | Occasional flooding and ponding |
| Upland / Dry land (*Bhitta, Danda khet* ) | Drought prone, well drained | Sandy loam | Dry land fans | Mositure scarcity, dry soils, wind erosion |

Source: Field surveys (1996 and 1997), NARC/ATSP (1993), and Gauchan and Yokoyama (1999)

### Socio-cultural diversity

The socio-cultural variables such as ethnicity, gender role, existing tenancy pattern, farmers' resource access and livelihood systems are related with farmers' resource endowments and consequently in the adoption of diverse rice production systems (Table 2).

Unlike resource rich households, resource poor farms have nuclear family types with high women involvement in farming and non-farming operations. Since they hardly produce adequate food for 3-6 months, they involve in off-farm wage labour activities for their major source of income and employment. There was positive relationship between farmer's social caste (ethnic) and wealth status/resource access. For instances, majority of higher ethnic/caste groups such as Brahmin, Chhetri, Kayastha were found in resource rich group while Dhangar and Mushar ethnic groups were resource poor.

## Diversity in farm resource endowments

Farm households are of with diverse resource endowments such as land, labour, capital and livestock (Table 3). Resource endowments of the farm households e.g. farm size, livestock size, capital assets, household size, literacy rate, family members involved in farming are higher in large and medium resource farm households. Average total rice farm size and landholding are higher in resource rich and medium groups. Resource poor households lack irrigated land, assets such as tractor, bullock cart and farm machinery and own only few heads of livestock. However, in comparison to resource rich and medium farm groups they have greater proportion of family members in off-farm activities. Resource poor farmers live in rainfed environment and tend to have smaller family size (nuclear family), small land holding and low productivity of the land.

**Table 2. Socio-cultural diversity of the sample farm households in the study sites, central Terai**

| Socio-cultural diversity | Resource poor | Medium resource | Resource rich |
|---|---|---|---|
| Ethnic types | Dhanger, Mushar | Yadav, Tharu, Muslims | Kurmi, Kayastha, Tharu, Brahamin, Chhetri |
| Family types | Mostly nuclear | Nuclear/Joint | Mostly joint |
| Gender role | High women involvement | Medium women involvement | Low women involvement |
| Food sufficiency level | Very low (3-6 months) | Low (6-9 months) | Surplus (> 9 months) |
| Livelihood strategies | Less farming, more off-farm wage labour | Mostly farming | Business, farming and services |
| Production objectives | Food security | Food security | Food security and sell |
| Land tenancy types | Tenant, share croppers | Owners | Owners and Land leaser |
| Resource access (credit, labor, water) | Very less | Medium | High |
| Access to support, information, technology | Less | Medium | High |

Source: Field surveys (1996 and 1997)

**Table 3: Resource endowments characteristics (diversity) of the sample farm households, central Terai**

| Resource endowments | Resource poor | Medium resource | Resource rich |
|---|---|---|---|
| Total farm size (ha) | 0.35 | 1.7 | 3.25 |
| Rice farm size (ha) | 0.15 | 1.2 | 2.57 |
| Irrigated farm size (ha) | 0 | 0.4 | 1.2 |
| Household size (No.) | 7.14 | 7.80 | 7.52 |
| Agriculture labour force (No.) | 2.4 | 4.1 | 3.1 |
| Off-farm labour force (No.) | 3.1 | 1.2 | 1.59 |
| Literacy level (%)* | 15 | 65 | 85 |
| Livestock holding (No.) | 2.1 | 5.3 | 5.5 |
| Bullock cart (No.) | 0 | 0.5 | 0.7 |
| Tractors, pumpsets (No.) | 0 | 0 | 0.5 |

*Literacy level (%) is used as proxy for quality human resource base., Source: Field surveys (1996 and 1997)

## Diversity in rice production systems

Farmers practice diverse rice production systems to fit in farmers' existing farming and livelihood systems due to availability of wide growing seasons, cultivars and internal and inherent heterogeneity of agroecosystems, sociocultural settings, and diversity in farmers' resource endowments. In addition, availability and access to modern technology, inputs, markets and prevailing policy environments also influence maintenance of wide diversity of rice production systems. Table 4 presents inherent diversity in rice production systems that are found in central Terai. Presently, rice production systems mainly

categorized into three types: spring (*Chaite*), early (*Bhadaiya*), normal (*Agahani*) season (Gauchan, 1997). Basically, all of these systems are named based on time of maturity. These systems are practiced either in the form of traditional subsistence oriented or in semi-commercialized forms.

## Cropping intensity and cropping pattern

Cropping pattern and cropping intensity varies with land types. The cropping intensity was found higher (237%) in mid-wetland as compared to 126% in lower wetland and 75% in upland environment (Table 5).

**Table 4. Diversity in production systems, cropping pattern and cultivated rice varieties, central Terai**

| Production systems | Agro-ecosystems | Rice production season | Cropping pattern | Rice varieties |
|---|---|---|---|---|
| *Bhadaiya* * | Mid-wetland | June - September | Rice-Lentils/Tori<br>Rice-Vegetables | Chinaboro-4, Phillips, Sathia |
| *Agahani*** | Lower wetland | July/Aug - Nov/Dec | Rice-Wheat/Fallow | Masuli, Radha-7, IR-71, Sabitri |
| *Chaite**** | Mid-wetland/ Irrigated upland | April/May - June/July | Rice-Rice-Wheat<br>Rice-Rice-Fallow | Chaite-1,Chaite-2, Chinaboro-4 |

Source: Field survey (1997) and Gauchan *et al.* (1997)

*Bhadaiya (early) system consists of the cultivation of short duration rice varieties in upland / mid-wetland under rainfed or partially irrigated conditions planted in June and harvested in October. **Normal season (Agahani) rice system includes cultivation of normal to late season varieties in rainfed lower wetland where rice is transplanted on July and harvested on November / December. *** Chaite is a spring rice transplanted in March /April and harvested in June in irrigated conditions.

**Table 5: Cropping pattern diversity, percent area, households and cultivar use by agro-ecosystems**

| Cropping pattern | Total rice area (%) | Percent households | Rice varieties cultivated |
|---|---|---|---|
| Mid-wet lowland | 100 | 100 | |
| Rice-Rice-Wheat | 24 | 14 | Phillips(Bhadaiya) in first crop and Masuli / Sabitri in the second |
| Rice-Wheat | 48 | 52 | Masuli, Radha, Sabitri etc. |
| Rice-Lentil/Oil seeds | 18 | 28 | Phillips, Chinaboro (Bhadaiya) |
| Rice-Potato-Vegetable | 10 | 6 | Bhadaiya (Phillips) |
| Lower wet lowland | 100 | 100 | |
| Rice-Wheat | 28 | 79 | Agahani rice e.g. Basmati, Masuli |
| Rice-Fallow | 72 | 21 | Agahani rice e.g. Basmati, Kamod |
| Rainfed upland | 100 | 100 | |
| Rice-Potato/Vegetables | 22 | 18 | Phillips, Chinaboro |
| Rice-Fallow | 78 | 82 | Sathia, Phillips, Chinaboro, etc. |

Source: Field surveys (1996 and 1997)

About 24% of the total area in mid-wetland was with triple cropping mainly double crop of rice followed by wheat in sequence. Rice-potato-vegetable was a principle cropping pattern in irrigated condition. In lower wetland, rice–fallow was a predominant pattern. The cropping intensity was low because of excess moisture, which inhibits cultivation of second crops in sequence. Rice-lentils or oilseeds was common after Bhadaiya rice varieties in mid-wetland field. In upland field, rice-fallow occupied largest area due to scarcity of moisture for second crop.

## Input use and rice productivity

Seeds, chemical fertilizers, organic manure (FYM/compost), labour (human and bullock) were the main inputs used by the farm households. Most farmers used their own seeds or seeds borrowed from neighbour farmers. Farmers use short duration varieties and low rate of fertilizer in *Bhadaiya* as compared to *Agahani* rice. Between the production systems, total labour and fertilizer use and productivity is higher for *Agahani* rice. This is because of use of cultivars, which takes long growing seasons, environment and better management conditions in *Agahani* crop (Table 6).

**Table 6. Input use and productivity (kg/ha) of *Bhadaiya* (early) and *Agahani* (normal) central Terai**

| Production system | Variety | Fertilizer NPK | Labour use (days) | Average yield (kg/ha) |
|---|---|---|---|---|
| *Bhadaiya* rice system | Phillip,Chinaboro | 40:30:10 | 163 | 1.3 |
| *Agahani* rice system | Masuli, Radha 7 | 60:45:30 | 172 | 2.1 |

Source: Field surveys (1996 and 1997)

## Economics of rice production

Economic viability/profitability of the rice farming differs with production systems and farm household resource types. It is explicit from the data that yield, return and benefit-cost ratio from rice production is higher in Aghani systems and resource rich farm groups despite their high total costs of rice production. The high yield and higher benefit from rice farming is due to use of higher yielding varieties and improved management practices in resource rich group (Table 7).

**Table 7. Rice area, yield costs, return by agro-ecosystems of the sample farm households, central Terai**

| Production systems/ Farm groups | Rice yield | Gross value | Total costs | Net return | Benefit-Cost ratio |
|---|---|---|---|---|---|
| Production system | | | | | |
| *Agahani* | 2100 | 15750 | 7180 | 8570 | 1.83:1 |
| *Bhadaiya* | 1300 | 8450 | 5580 | 2870 | 1.51:1 |
| Farm resource groups | | | | | |
| Resource rich | 2650 | 19875 | 10560 | 9315 | 1.88:1 |
| Medium resource | 2300 | 17135 | 9880 | 7255 | 1.73:1 |
| Resource poor | 1500 | 9750 | 5900 | 3850 | 1.65:1 |

Source: Field surveys (1996 and 1997)

## Economics of rice varieties

Farmers cultivate various types of rice varieties in the survey area. The data show that a course variety B-44-B has the highest yield but the lowest market price, as compared to Masuli and Basmati. Masuli, a medium texture variety is a medium yielding and gets medium price per kg of output. Local landrace Basmati (a fine textured aromatic variety) is the lowest yielding but its farm gate price is the highest in the survey area (Gauchan *et al.*, 1996). Economic analysis of these three different group of rice varieties reveal that net return and cost-benefit ration from traditional fine (Basmati type) rice variety is higher than that of medium (Masuli) and coarse type (e.g. B-44-B) despite the fact that Basmati has lowest grain yield (Table 8).

Table 8. Comparative economics of rice varieties in low input *Agahani* production systems

| Rice Varieties | Rice yield (kg/ha) | Price (Rs) | Gross value(Rs) | Total costs(Rs) | Net return(Rs) | Benefit-Cost ratio |
|---|---|---|---|---|---|---|
| Coarse type(B-44-B) | 2789 | 5.75 | 16036 | 9560 | 6476 | 1.67:1 |
| Medium type (Masuli) | 2378 | 7.00 | 16646 | 9650 | 6996 | 1.72:1 |
| Fine type (Basmati) | 1841 | 10.75 | 19790 | 8990 | 10800 | 2.20:1 |

Source: Field surveys (1996 and 1997), Gauchan *et al.* (1996).

## Yield gaps

Yield gap differs with the agro-ecological environments, production systems and farmers' socioeconomic conditions. Within the same production system and environment, the gap is observed higher in upland and *Bhadaiya* system as compared to mid-wetland and *Agahani* conditions. Lack of adequate water availability and control and economic incentives in terms of price, marketing, input supply and technology are important for such high yield gap (Upadhyaya, 1994; Gauchan *et al.*, 1997).

The percentage yield gap is 31% in *Bhadiaya* as compared to 22% in *Agahani* rice. Similarly the gap is higher in upland rice (60%) than mid-wetland (25%) in the survey area. This gap is lower than the 74% yield gap in reported by Upadhyaya (1994) in Nepal. The relatively low yield gap in the study site could be probably due to better production environment (e.g. favourable rainfed) and market accessibility of the survey area (Table 9).

Table 9. Average and potential on-farm rice yield and yield gap in east and central Terai

| Production system and agro-ecosystems | Average yield (kg/ha) | Potential yield (kg/ha) | Yield gap (%) |
|---|---|---|---|
| Production systems | | | |
| *Bhadaiya* Rice | 2.05 | 2.96 | 31 |
| *Agahani* Rice | 2.59 | 3.30 | 22 |
| Agro-ecosystems | | | |
| Upland | 1.10 | 2.80 | 60 |
| Mid-wet land | 3.06 | 4.10 | 25 |
| Lower-wet land | 2.69 | 3.85 | 30 |

Source: Field surveys, (1996 and 1997) and Gauchan *et al.* (1997)

### Production constraints

Production constraints are classified basically into two groups: bio-physical (technical) and socioeconomic (Gauchan *et al.*, 1997; Upadhyaya, 1994) (Table 10).

### Bio-physical constraints

Biophysical constraints include both biological and physical that limit rice yields and are distinct from socioeconomic constraints. Many of them are potentially solvable through genetic improvement of rice. Drought (moisture stress), adverse soils, weeds, diseases and insects are the major constraints to higher rice yields perceived by the farm households. Farmers perceive drought as the number one constraint (45%) followed by weeds (25%) and adverse soils (15%) (Table 10). Even under *Agahani* systems, poor rice yield due to drought are commonly observed. Weeds are more problematic in early and dry seeded rice. Adverse soils (poor fertility, acidic etc.), *Khaira* disease (zinc deficiency) and insects are more critical in *Agahani* systems as compared to *Bhadaiya*.

### Socio-economic constraints

The major socioeconomic constraints to high rice yield in order of importance as perceived by farm households are unavailability of fertilizers (31%), improve (HYV) seeds (22%), followed by low market price of rice (18%), technical information (18%) and credit unavailability (14%) (Table 10). Previous

studies also report institutional constraints such as lack of timely and reliable supply of fertilizer and improved seed as the most critical to high rice productivity in various production systems and environments (Gauchan *et al.*, 1997; Bania *et al.*, 1997, ORD/NARC, 1997).

**Table 10. Farmers' perception on various biophysical and socioeconomic constraints to rice production**

| Biophysical constraints | Rank (in percent) | Socioeconomic constraints | Rank (in percent) |
|---|---|---|---|
| Drought | I (45 ) | Fertilizer unavailability | I (31%) |
| Weeds | II (20) | Improved seeds unavailability | II (22%) |
| Adverse soils | III (15) | Low rice market price | III (18%) |
| Diseases | IV (12) | Credit unavailability | IV (15%) |
| Insects | V ( 8) | Lack of technical information | V (14%) |

Source: Field surveys (1996 and 1997) and Gauchan *et al.* (1997)

## CONCLUSION AND RECOMMENDATIONS

The synthesis of the findings shows that farmers practice diverse type of rice production systems in different seasons to fit in their farm production and livelihood system. The diversity of rice production systems is the result of inherent heterogeneity of farmers' resource endowments, livelihood strategies, and sociocultural and agroecological diversity of the production environment. Choice of rice varieties, cropping pattern, yields, yield gaps and economic return from rice differ between agro-ecosystems, production systems and farm resource categories. Farm size, literacy level, input use, rice yields, return and household income are higher in *Agahani* as compared to *Bhadaiya* systems. Yields, input use, economics, yield gaps and production constraints differ between production systems. Rice yields, labour and fertilizer use is higher in *Agahani* (normal season rice) and resourceful farmers. Yields and profit from rice production are high in mid-wetland ecosystems and resourceful farm categories due to better farming environment, resource access, ownership's and availability of technologies. Under low input rainfed small-scale farming context, traditional fine rice (Basmati type) is economically more profitable to medium (Masuli) and coarse type (e.g. B-44-B) in spite of the very low yield of Basmati rice.

Two major production constraints such as biophysical and socioeconomic are critical to higher rice yields. Among biophysical constraints farmers perceived drought, adverse soils and weeds as the important ones. The important socioeconomic constraints perceived and ranked by the farm households are unavailability of fertilizer and seeds in time. Sizeable yield gaps were observed in both types of production systems and environments. However, it was large in early season rice and rainfed environment. Financial (cash, credit) constraints are important for resource poor farm categories, while labour is a main constraint for resource rich farmers.

The present findings imply that need for research and technological development for rice will vary according to the rice agro-ecosystems, production systems, socio-economic settings and constraints. The inherent diversity in the farmers' resource endowments, production systems and agro-ecological environments have to be fully recognized in designing meaningful operational rice research strategies. Technological development should be targeted according to the farmers' resource endowments and socio-cultural needs in addition to prevalent agro-ecosystems. In designing such a strategy, the farmer must be placed in the center of the place.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# EFFECT OF RHIZOME SEED SIZE AND PLANT SPACING ON GINGER YIELD

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## ABSTRACT

A field experiment was carried out in 1997 and 1998 at Ginger Research Program Kapurkot, Salyan (1480 masl) to find out the cost effective seed rhizome size and spacing for planting to get the maximum yield. Both the factors, spacing and seed size caused the significant difference on crop yield. Economic analysis for marginal rate of return indicated that planting rhizomes 30 cm apart between and within row was found appropriate spacing for mid-hill conditions. Seed to yield ratio was found decreasing with the increase in seed size. The highest yield (41.8 t/ha) was obtained from the large size seed rhizomes (90 gm), whereas marginal rate of return was minimum (44.7%) when planted large size rhizomes. The result clearly revealed that spacing 30 cm X 30 cm and seed size of 60 gm gave the highest marginal rate of return (79.6%). Therefore, the seed rate of ginger for Salyan cultivar, 6.0 t/ha was found cost effective for mid-hill conditions.

## INTRODUCTION

Ginger (*Zingiber officinale* Rosc.), one of the important spices is grown usually during summer in rainfed condition in Nepal. It is a medicinal crop and generally used for Aayurvedic medicine. Ginger contains volatile oil and oleoresin, which is important for perfume and food preservation, respectively. Its cultivation is widely distributed throughout the country, particularly in mid hills. It is grown in 6000 ha in Nepal. There is tremendous scope to increase present national average productivity (11 t/ha) with proper refined package of practices because production potentiality of the available cultivars in Nepal has been found higher than the present national average. Annually, 60% of the total production of ginger is exported to India as fresh or dry.

Seed management is one of the major existing problems for ginger growers. Ginger is generally propagated by cuttings of the rhizome in small bits. Seed rhizome is required in huge amount. Various size of seed rhizome, weighing 20-40 gms, and planting in 15-20 cm X 20-35 cm or 38 cm X 38 cm has been found effective in yield increase in India (Singh and Singh *et al.,* 1996). Growing ginger is one of the labour and capital intensive practices mainly due to heavy amount of seed requirement (40-80% of total cost of cultivation). It has been observed that farmers use 2-10 t/ha of ginger rhizome seed, which goes up to 15 t/ha in some places of Nepal. Such a large variation in seed rate is caused by mainly planting practices (plant density and mother rhizome retrieval), seed size and availability. This study was carried out to find out cost effective seed rhizome size and plant spacing and increase productivity.

## MATERIALS AND METHODS

An experiment was conducted in 1997 and 1998 at Ginger Research Program (GRP), Kapurkot (1480m masl). The experiment was carried out in factorial RCB design with three levels of spacing

and three levels of rhizome seed size. Promising local cultivar Salyan was planted with three replications in 1997 and 1998 (last week of March). Farm yard manure (FYM) 30 t/ha and fertilizer N: $P_2O_5$ : $K_2O$ @ 75:50:50 Kg/ha and dry forest leaves 20 t/ha were given to the crop. All FYM, $P_2O_5$ and 1/2 of $K_2O$ were applied as basal. While 1/2 N was applied 30 days after germination (DAG) and remaining N and $K_20$ were applied 60 DAG. Mulching was done immediately after planting and repeated later as required. Seed rhizomes were treated with the solution of 0.25% Indofil M-45 and Bavistin 0.1% by dipping for one hour and allowed for drying under shade prior to planting.

## RESULTS AND DISCUSSION

Plant height of ginger was found increasing with the increase in plant density as affected by closer spacing but tillers per clump were decreased with high population. Vigorous plant growth with tall plants and increased tillering was obtained with large rhizome seed size.

Rhizome seed size and plant spacing showed significant effect on rhizome yield in both years (Table 1). Closer spacing (30 x 20 cm) was superior than wider spacing which produced 39.2 tons rhizome yield per hectare and comparable with 30 x 30 cm but seed to crop ratio obtained by 30 x 20 cm was less than 30 x 30 cm. Seed size of 90 gm was found superior (41.8 t/ha rhizome yield) followed by 60 gm (34.8 t/ha) and 30 gm (25.8 t/ha). But seed to yield ratio was found greatly decreasing with increasing seed size.

Ginger yield was also affected by growing year. But interaction effect among spacing, seed size, and growing years was not significant, which indicate that effect of seed size and spacing variation on ginger yield was consistent.

Economic analysis was also performed. Among the plant spacing, the highest marginal rate of return (MRR) of 70.6% was obtained when 40 x 30 cm spacing was changed to 30 x 30 cm. But it was below than the acceptance level (40%). In the case of seed size, highest MRR (79.6%) was recovered when rhizome seed size was changed from 30 to 60 gm but it was increased only by 44.7% for changing seed size from 60 to 90 gm (Table 2).

The result clearly revealed that the seed rate of 6 t/ha as affected by 30 x 30 cm plant spacing. Rhizome size seed of 60 gm has been found cost effective and profitable for ginger growing farmers of mid-hills of Nepal.

Table 1. Effect of plant spacing and seed rhizome size on ginger yield (1997 and 1998)

| Factors | Affected seed rate (t/ha) | Plant stand/ha ('000) | Plant height (cm) | Tillers /clump | Mother rhizome recovery (t/ha) | Fresh rhizome yield (t/ha) | | | Seed to crop ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1997 | 1998 | Mean | |
| A. Spacing (cm) | | | | | | | | | |
| 40 X 30 | 4.5 | 70 | 65.7 | 8.7 | 3.8 | 17.4 | 41.6 | 29.5 | 6.6 |
| 30 X 30 | 6.0 | 93 | 66.4 | 7.7 | 4.2 | 21.4 | 46.4 | 34.1 | 5.7 |
| 30 X 20 | 9.0 | 125 | 67.5 | 7.6 | 6.5 | 26.5 | 51.9 | 39.2 | 4.4 |
| B. Seed size | | | | | | | | | |
| 30 gm | 3.25 | 95 | 59.8 | 7.3 | 2.7 | 12.9 | 38.7 | 25.8 | 7.9 |
| 60 gm | 6.50 | 95 | 67.1 | 8.5 | 5.4 | 23.4 | 46.2 | 34.8 | 5.4 |
| 90 gm | 9.75 | 98 | 70.6 | 8.1 | 7.0 | 29.4 | 54.2 | 41.8 | 4.3 |
| CV% | | | | | | 17.8 | 8.5 | 11.5 | |
| F test A | | | | | | ** | ** | ** | |
| B | | | | | | ** | ** | ** | |
| A X B | | | | | | NS | NS | NS | |
| Y (year) | | | | | | | | ** | |
| Y X A | | | | | | | | NS | |
| Y X B | | | | | | | | NS | |
| LSD (A,B) (0.05) | | | | | | 3.9 | 4.0 | 5.64 | |

**Table 2. Analysis of marginal rate of return (MRR) for ginger seed rate evaluation**

| Factors | Affected seed rate t/ha | Total variable cost (Rs in '000) | Marginal cost (Rs. '000) | Gross benefit (Rs. in '000) | Net benefit (Rs. in '000) | Marginal net benefit (Rs. '000) | MRR % |
|---|---|---|---|---|---|---|---|
| A. Spacing (cm) | | | | | | | |
| 40 X 30 | 5 | 102 | | 320 | 168 | | |
| | | | 34 | | | 24 | 71 |
| 30 X 30 | 6 | 136 | | 375 | 192 | | |
| | | | 68 | | | 27 | 40 |
| 30 X 20 | 9 | 204 | | 474 | 220 | | |
| B. Seed size (gm) | | | | | | | |
| 30 | 3 | 74 | | 267 | 143 | | |
| | | | 74 | | | 59 | 80 |
| 60 | 7 | 148 | | 400 | 202 | | |
| | | | 74 | | | 33 | 45 |
| 90 | 10 | 222 | | 507 | 235 | | |

Note: 1. Non variable cost has taken NRs. 50,000.00 per hectare.

2. In variable cost, NRs. 20/kg of seed rhizome, seed treatment cost and interest on seed cost @ 16% for nine months was added.

3. Farm gate price was calculated as NRs. 20/kg for seed amount and NRs. 8/kg (Average of two years).

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# ENVIRONMENT FRIENDLY AND SUSTAINABLE RICE PRODUCTION

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## ABSTRACT

Hardinath Agriculture Farm (HAF) in Nepal practiced *Sesbania cannabina* (Dhaincha) as pre-rice green manure annually in 20 ha for more than 20 years. Besides, the recommended doses of phosphorous and potassium, the total nitrogen requirement was fulfilled by using 50% of chemical nitrogenous fertilizer plus Dhaincha as pre-rice green manure. The average national productivity of paddy in Nepal is 2.4 t/ha whereas, the HAF's was 3.75 t/ha. The HAF on an average was producing 120 metric tones of foundation paddy seed annually with better agronomic practices for the last 20 years with more than 1:2 ratio of revenue. Such type of practical long-term experience of integrating chemical fertilizer with the pre-rice green manure in irrigated lowland fields of Tarai (93 masl) is the model practice for others. This can be practically said as environment friendly plus sustainable, low-cost successful story and can be replicated in other parts of the world having similar agro-ecological zones.

## INTRODUCTION

Rice, main diet of the Nepalese people, is the most important food crop of Nepal. Rice farming dominates the agricultural sector of Nepal, which itself dominates the economy. It is, therefore, the single most important industry in the country, contributing approximately one-fourth of the GDP and occupying 1.5 million hectare with 3.7 million tonnes production and productivity is 2.4 t/ha in 1998/99. With all these facts Agricultural Perspective Plan (APP) has identified rice as one of the priority commodities.

Fourty-two varieties of paddy with complete package of practices have been released so far in Nepal after the successful research results by Nepal Agricultural Research Council (NARC). The coverage of modern varieties of paddy in Nepal is 61% (1996/97).

The increase in population has forced us to raise the productivity as well as production of cereal crops. This can be done either by increasing the cultivable areas, which is not possible because there is no scope of increasing the cultivable lands. Now, we have to increase the productivity per hectare per day by any means. The total food grains can also be increased by increasing the cropping intensity. The "Green Revolution" technologies have helped us to increase the total food grains. However, in this technology the more emphasis was given for using modern varieties of rice, maize and wheat, chemical fertilizers, pesticides, etc. By doing so, we forgot to use bio-fertilizers as practiced by our ancestors. Thus, now, the organic matter of our soils has depleted, ultimately decline in the productivity of major cereal crops. The majority of soils in Nepal are deficient in nitrogen and organic matter thus any measure of improvement must involve the problem of increasing nitrogen and other nutrients supplied in the soil.

Now, the thrust has to be given on generating sustainable environment-friendly technologies like integrated plant nutrition system (IPNS) and integrated pest management (IPM). For this, searching locally available supplementary sources of fertilizers and other inputs has become necessary.

During the last few decades, organic manure took a back seat in many nations in favour of chemical fertilizers. But in the face of a continuing world energy crisis and increasing fertilizer prices, organic manures are once again gaining popularity. Farm yard manure (FYM) and green manure are commonly used organic manners. However, FYM is limited in supply and thus green manure opens up an interesting prospect as a potential source of organic manure and nitrogen.

As the imbalance use of chemical fertilizers alone eventually leads to productivity decline and organic matter depletion in the soil, interest in organic fertilization like green manuring and other forms of biological nitrogen fixation (BNF) has risen sharply in the recent years. Through exploitation of this technology, farmers can grow their own nitrogen and reduce dependence on costly fertilizers, especially in remote areas.

Several types of leguminous green manure (LGM) crops have been used as nitrogen sources for rice. *Sesbania cannabina (*Dhaincha) and *Crotalaria juncea* (Sunhemp) are outstanding nitrogen fixers and are the most acceptable to Asian farmers. Other potential green manuring plants include root and stem nodulating species like *Sesbania rostrata, Aeschynomene* sp. etc.

There is no fertilizer factory in Nepal and we have to import from foreign countries. Thus, source, timely availability and right kinds of fertilizers are not guaranteed. If we don't get chemical fertilizers then what will be the fate of our life saving soils?

## FIELD OBSERVATIONS

Hardinath Agriculture Farm (HAF), which was previously under the Department of Agriculture (DOA) and now under Nepal Agricultural Research Council (NARC) as Rice Research Program, Hardinath had practiced *Sesbania cannabina* (Dhaincha) as pre-rice green manure annually in 20 ha for more than 20 years.

The recommended doses of nitrogen and phosphorous is fulfilled through 50% of chemical fertilizer plus Dhaincha as pre-rice green manure. The recommended dose of nitrogen for modern paddy variety is 100 kilograms per hectare after harvesting wheat crop in Terai (93 masl). The *in situ* pre-rice green manure is used to incorporate at the time of puddling and before transplanting monsoon season rice. The Dhaincha is ready to incorporate after 50-60 days of emergence. The total fresh biomass of Dhaincha used is usually 25-30 metric tonnes per hectare. Thus, the pre-rice green manure of Dhaincha is taken between wheat and rice crop in Terai and similar agro-climatic conditions.

The optimum time of sowing for seed production and as green manures is the middle of March to the end of May. This period lies between harvesting of wheat and transplanting of main season paddy. Incorporation of Dhaincha for green manuring is done one week before transplanting main season paddy. The paddy can be transplanted even after one day of Dhaincha incorporation if it is succulent. For green manure, the foliage can be brought from other areas as green leaf manuring and it can also be grown even on the paddy bounds. It can be grown as inter-cropped or alley cropping, too.

The results of the replicated long-term soil fertility trials (10-12 years) at Hardinath Agriculture Farm also pointed out that the use of nitrogen, phosphorous, potash plus compost, and green manures (bio-fertilizers) are must, to get higher productivity of rice and wheat on sustained basis (Basnet, 1988).

The average national productivity of paddy in Nepal is 2.4 t/ha but the average productivity of paddy at HAF is 3.75 t/ha. Hardinath Agricultural Farm on an average produced 120 metric tonnes of foundation paddy seeds annually for more than 20 years. The revenue was more than 1:2 ratios. Such type of practical long-term experience of integrating chemical fertilizer with the green manure *(S. cannabina)* with rice in irrigated lowland fields of Terai is the model for others. This can be said as environment-friendly plus sustainable successful story of using Dhaincha as a pre-rice green manure.

## OTHERS' WORKS

Previous works carried out in Nepal revealed that green manuring of Titepati, Dhaincha and *Azolla* have improved the crop yields by 4.54%. A 3-year experiments conducted at Tarahara Agriculture Station (at present RARS, Tarahara) in the eastern Terai reported that green manure alone or in combination with nitrogenous fertilizer significantly increased rice yield and was economically profitable. The green manure crop used was *Sesbania aculeata*, which contributed about 50 kilograms available nitrogen per hectare to the subsequent rice crop.

The International Rice Research Institute (IRRI), Bangladesh Rice Research Institute (BRRI) and the Senegal (where *S. rostrata* was originated) have reported that *S. rostrata* as a pre-rice green manure can harness 200, 252 and 267 kg atmospheric nitrogen (equivalent to 600 kg of Urea) per hectare, respectively. Dhaincha has other uses like firewood, gunpowder charcoal, gum preparation etc. It is also reported that the grain yield produced by the application of Dhaincha as green manure plus 25 kg N/ha is equal to the grains yield produced by 75 kg/ha nitrogenous fertilizers alone.

## OTHER BENEFITS

Leguminous GM crops supply P and K plus some micro-nutrients, besides N. The benefits of green manuring are hard to quantify as this effects are often long-term in nature. They should not be seen solely in terms of nutrients supply to the following crops. Green manures have a very important role in the design of rotations for organic systems. Not only do they help to retain and in some cases accumulate nitrogen and other nutrients, thus reducing leaching losses, they also maintain ground cover, protecting the soil from erosion, and can make a contribution to pest and weed control.

## CONCLUSION

The use of locally available different plant materials as nutrient source is a traditional practice of the hill farmers in Nepal. However, dwindling supplies of these plant materials preclude their continued use as a source of green manure. Also, the use of Dhaincha as a green manure crop is common in the Terai and inner Terai regions of Nepal. This is the species of green manure available in Nepal since 1960. The practical long-term experience of HAF in Janakpur for using Dhaincha in irrigated lowland rice has a great implication for extending in other parts of Nepal having similar agro-ecological zones. Moreover, *Sesbania rostrata* (New Dhaincha), introduced first time in Nepal in 1985 as a versatile plant with twin (root and stem) abilities of fixing atmospheric nitrogen, has shown a great array of hope in some of the agricultural farms/stations as the potential supplementary source of nitrogen fertilizer in rice. Various results indicate that about 50 kg nitrogenous fertilizers per hectare can be saved by using Dhaincha as green manure.

Therefore, a greater promotion to " Nitrogen Farming " in the country like Nepal is a must because biological nitrogen fixation remains of vital importance for the existence of life on earth.

## ACKNOWLEDGEMENTS

I would like to thank all the staff of Hardinath Agriculture Farm who helped in one way and other, during my tenure, for the successful launching of Dhaincha as pre-rice green manure on long-term basis.

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# ETHNOBOTANY AND DIVERSITY OF TARO IN NEPAL

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## ABSTRACT

Taro (*Colocasia esculenta*) is an important traditional vegetable crop throughout the hills and plains of Nepal. It is generally grown on marginal land of almost all households by different ethinic groups for its nutritious leaves, petioles, flowers and tubers either in fresh or processed form. Taro cultivars are generated and selected by farmers and they are the main custodians of both genetic and cultural diversity. Though the crop is common in both home garden as well as larger agro-ecosytem,. it is uniquely adapted to home garden conditions where the crop provides the need of food security. Different types of taro are cultivated for the use of different parts and according to relative use value, farmers use local name annexing *karkalo* or *pidalu*. Considering the separate names given by farmers and phenotypic look of tubers there is need for further identification test using farmers' perception, agromorphologic traits and isozyme test.

## INTRODUCTION

Taro (*Colocasia esculenta* Schott) is an important vegetable crop in the hills of Nepal (Pandey *et al.*, 1998). Since this crop is well adapted to marginal lands and harsh environments, it is widely cultivated on bari land of almost all households for vegetable purpose. Almost all parts of the crop are utilized either in fresh or processed form. Taro is a traditional crop predominates in areas where improved or exotic technologies are either unavailable or unsuitable because of various reasons such as remoteness, ignorance, environmental stresses etc.

In Nepal, it is uniquely adapted to home garden conditions where the crop provides the need of food security. Because of its multi-purpose uses, farmers, particularly women, prepare different kinds of local products for cash generation. Taro is common in both home garden as well as larger agro eco-system of mid hills because it is easy to cultivate, propagate, and store easily for much longer period than any other tuber crops.

Concerning consumer's acceptance, taro is an important staple food of developing countries mainly in Africa, the West Indies, the pacific region and Asia. According to FAO production statistics of 1997, area under taro cultivation is 988,915 hectares and the production is 574,8015 mt. Taro corms are high in carbohydrates, some minerals such as calcium and phosphorus and low in fat. The leaves and petioles also contain greater amount of carotene. In Nepal, taro has multi-purpose uses. The aerial leafy part of taro is called '*karkalo*' and underground part is known as '*pidalu*'. Different types of taro are cultivated for the use of different parts. In general, underground part (corms and cormels) is used immediately after harvest as vegetable and also stored for later consumption. *Pidalu* is grown primarily for its underground corms, which contain lot of starch, a little bit of sugar and some protein (Heiser, 1990). Some taro landraces have high levels of calcium oxylate crystals, which irritate the mouth and throat but farmers posses indigenous knowledge to distinguish such varietal differences in quality. The crystals are generally destroyed by boiling (Hancock, 1992) but there are some varieties that can be eaten as green salads or pickles.

## MATERIALS AND METHODS

### Participatory rural appraisal (PRA)

Taro is one of the key species selected in the *in situ* project supported by IPGRI. Initial diversity was assessed by rapid diversity assessment used during site selection for PRA in Kaski, Bara and Jumla districts (Rijal *et al.*, 1997; Khatiwada *et al.*, 1998 and Paudyal *et al.*, 1998). Though the crop was reported from Bara and Jumla sites, its diversity was much higher in Kaski site. In Kaski, 22 villages were surveyed.

### Diversity fair

Diversity fair was organized at Begnas village of Pokhara valley. A total of 15 farmer groups took part in competition. The farmers' description on morphology and use value was collected during the fair. Underground part (corms and cormels) and some processed items were exhibited in the fair.

### *In situ* characterization

Landraces exhibited in the diversity fair were again verified in the farmers' field. Morphological characterization was done in the farmers' field with the help of farmers.

### On-station characterization

All the landraces exhibited in the diversity fair were collected and planted at Agricultural Research Station (Horticulture), Malepatan for characterization and to verify the characters given by the farmers. Morphological characters were documented. All aerial and underground parts were minutely described and compared with the farmers' classification.

## RESULTS AND DISCUSSION

Taro is widely distributed and traditionally cultivated but little studied vegetable crop in Nepal. It is commonly cultivated in the vegetable gardens and home gardens among many ethnic minorities but no importance has given for research and development.

### Farming systems and indigenous knowledge on taro cultivation

Farmers have been growing taro for generations in wider agro-ecological domains of plain Terai (≤ 600 m), mid-hills (600-1600 m) and high hills (1600-2500 m). Taro cultivation is more preferred in the upland than lowland and area is small and grown in home garden. It is grown in two distinctive agro-ecosystems of mid hills: first commonly in home gardens around the compost pits or shady areas, where in some areas taro is grown on newly cleared forest land or intercropped with ginger and maize. Landraces found around the homestead loves high fertility, high moisture and adapted to shade conditions. Few races are also adapted to wet conditions. Wild types are commonly found in wetlands. Usually the medium sizes of cormels or cut pieces of corm having at least one growing bud are selected for propagation. Farmers use organic fertilizer only in order to maintain good quality of taste. Mulching is common practice for moisture conservation and weed control. No chemicals and irrigation are applied. Leaves of edible landraces can be harvested from as early as mid July to the end of September. The tuber-eating taro can be harvested from October to December.

### Uses

According to relative use value, farmers use local name annexing either *karkalo* (aerial part) or *pidalu* (underground part). Aerial part (leaves, petioles and inflorescence) is used as fresh vegetable and also dried for off- season use. Underground part (corms and cormels) is used immediately after harvest and

also stored for later consumption. There are some landraces that can be eaten as green salads and pickles. Different ethnic groups have their own way of preparing cuisine from taro and there are special occasions and festivals when the products of taro are relish. Women farmers use taro in different forms and most of its products are prepared in such a way that they can be stored longer and meet the need of off-season scarcity. From aerial parts of taro four types of processed vegetable are commonly made by housewives. They are locally known as *gava*[1], *tandre sukuti*[2], *pate khasaura*[3] and *masaura*[4] and their preparation, choice of variety, cooking style and eating time vary with ethnicity and geographic distribution.

Taro is an excellent example, which demonstrates that conservation of crop genetic resources are possible through use. Some varieties have multiple uses whereas some varieties are maintained for specific purposes. *Dudhe karkalo*, literally means milky white taro, is famous for its best quality for pickle and salad. This variety must have low level of calcium oxylate crystals, which does not irritate the throat even if it is eaten as salad or pickle. The *Kalo karkalo* is also good for pickle preparation. Taro varieties preferred for underground part are highly valued because they can be easily cooked and have multipurpose uses. Corms of these varieties are boiled with black gram or prepared curry soup with *gundruk*[5]. Petiole of these varieties is good for preparing *sukuti*, whereas leaves are good for *gava* and *pate khasaura*. There are many wild types of taro, which are often used as fodder and vegetable. A wild type taro *phyause* is highly valued for pig fodder whereas another type like *jaluka* is edible. *Jaluka* that is used as green vegetable is harvested earlier in May-June.

**Types and diversity of taro**

Different types of taro were observed including petiole (petiole eating) type, single corm type, multi corm type and multi cormel type. Pandey (1995) reported that Nepal is rich in diversity of taro varieties among indigenous vegetables. There is no research report available in Nepal except one publication from Lumle Agricultural Research Station (GC and Subedi, 1997). They evaluated a total of 17 taro varieties from the Western Development Region at two locations: Rising Patan (475 m) in Tanahu district and Lumle (1400 m) in Kaski district. Taro germplasms were evaluated on the basis of yield potential, easy cooking, non-irritating types and tolerant to grub ( *Papuana* sp.). In Nepal, farmers recognize and classify taro varieties by corm types, leaf and petiole morphology, colour of petiole, local adaption and type of uses.

Diversity fair was organized at Begnas village (600-1200 m asl) of Pokhara valley, Kaski. "Diversity Fair" described herein, has been unique event as it has exclusively focused on indigenous crops and vegetables including taro and their landraces with farmer's knowledge base. A total of 15 farmer groups took part in the competition. Farmers grow a range of taro landraces as high as 18 *in situ* crop conservation villages. The number across participating groups ranged from 3 to 18. On the basis of landraces exhibited in the diversity fair number of landraces planted and agromorphological characters were verified in the farmer's field during crop growth. A total of 19 landraces were identified in the farmer's field during the visit. All these 19 landraces have been collected and planted at the Agricultural Research Station at Malepatan and *in situ* site as a block. Identification test using further farmer's perception, agromorphological traits and isozyme test of all landraces has been planned. Table 1 shows the literal translation of the varieties, which indicate varietal descriptions.

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[1]Half portion of leaf is rolled, boiled and sun-dried and preserved at room temperature before preparing curry.
[2]The petiole of taro is cut vertically into small noodles like tendrils, weaves like ladies hair, hanged in front of window to dry and preserved for off-season cuisine.
[3]Dried leaves packed for eating off-season.
[4]Chopped petioles are mixed with blackgram flour paste and balls are made and dried.
[5] A typical fermented dried vagetable prepared from leaves of cruciferae family.

Table 1. Name of taro landraces and its description

| Local variety name | Translation that match taro description and use |
|---|---|
| Lahure Pidalu | Multi-cormel type, only cormels are used. |
| Burmeli Pidalu | Similar to Lahure. |
| Hattipau Pidalu | Multi-corm type, corm shape looks like to elephant's foot. All parts are used, grown specially for underground part. |
| Bhaisi Khutte | Multi-corm type, similar to Hattipau. |
| Khujure | Multi-cormel type, many cormels attached to the corm. All parts are used, grown specially for underground part. Leaf green, petiole white and corm white. |
| Khujure Red | Similar to Khujure, but corm is red. |
| Khujure White | Similar to Khujure, but petiole is purple. |
| Khujure Black | Similar to Khujure, but petiole is purple black. |
| Gante | Similar to Khujure, but corms are round shaped. |
| Panchmukhe Pidalu | Multi-corm type, five corms attached each other. All parts are used, grown specially for underground part. |
| Panchmukhe White | Similar to Panchmukhe Pidalu |
| Khari Pidalu | Multi-corm type, long corm, excellent for corm use. All parts are used, grown specially for underground part. |
| Rato Pidalu | Multi-cormel type, many cormels attached to the corm. All parts are used, grown specially for underground part. Top portion of corm is red in colour. |
| Ratomukhe | Similar to Rato Pidalu. |
| Chhatre | Multi-cormel type, petiole purple, cormels attached all around the corm showing round umbrella shaped. All parts are used. |
| Thadomukhe | Multi-cormel type, whole petiole black. All parts are used. |
| Satmukhe | Multi-corm type, leaf margin petiole purple. All parts are used. |
| Dudhe Karkalo | Single-corm type, milky colour. Only petiole is used as pickle. |
| Kalo Karkalo | Single-corm type, milky colour. Only petiole is used as pickle. |
| Jaluka Karkalo | Wild type. Leaf and petiole used as green vegetable in early stage of plant growth. |

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# HISTORY OF NO-TILL (SURFACE/RELAY) WHEAT PLANTING IN NEPAL

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## ABSTRACT

Wheat cultivation using no-till technique was first started at the bank of Ridi Khola in Palpa district. Even before the initiation of wheat research, no-till wheat cultivation was practiced by the farmers of Bhaktapur district. Research on no-till wheat cultivation was initiated at Janakapur and Bhairahawa during mid seventies to minimize yield loss because of late planting.

No-till (surface/relay) seeding of wheat was found one of the most prominent technologies for timely planting of wheat and for bringing rice-fallow under rice-wheat system. The adoption of this technology in the farmers' fields in large plots was practically impossible because of covering of wheat seed after seeding with FYM/soil. Relay seeding of wheat, five days before rice harvesting produced higher yield. Relay seeding 3 days before rice harvesting and covering seed for about a week with rice harvest produced the highest wheat yield.

Delayed application of fertilizers particularly N, improved grain yield and nitrogen use efficiency (NUE). Among the wheat crop establishment techniques, no-tillage showed superior over farmer's practice irrespective of wheat genotypes-Bhrikuti, BL 1135, Achyuta. Bhrikuti and BL 1473 did comparatively better in farmers' practice under late planting condition. Longer stubble had positive effect on wheat yield. Zero-tillage (surface seeding) was the best in grain yield irrespective of any management options. In on-farm crop establishment studies, Chinese seed drill and surface seeding produced significantly higher yields than farmers' practice. Yields from no-till (surface seeding) were unstable over the years indicating its sensitivity to management.

## INTRODUCTION

Wheat is the third most important crop in acreage and production. Its area has increased from 0.1 million hectares in mid-sixties to more than 0.6 million hectares at present. Similarly, its production and productivity have been going up with slower rate. More than 84% of wheat area is after rice. Wheat is cultivated in roughly one third of the total rice area.

About 30% of wheat area is under late planting. The principal causes of late planting are excess/low soil moisture, long-turnaround time, late maturing rice varieties, poor draft power, poor animal health, inappropriate agricultural implements, and unavailability of labor during rice harvesting. There exists negative correlation between wheat yield and late planting. An optimum planting date has been reported as mid-November and deviation from this date results nearly (30-50 kg/day/ha) reduction in yield depending on climatic conditions.

Agricultural land has been encroached by modernization such as construction of buildings and roads etc. and natural calamities such as erosion (wind, water), flood, landslide etc. So improvement in productivity has to come through better technologies (crop management/cultivars) or crop intensification. Therefore, on-station and on-farm studies were undertaken to develop better technologies for timely planting of wheat and to convert rice-fallow-fallow to rice-wheat-fallow.

## MATERIALS AND METHODS

### Effect of tillage methods on wheat grain yield

This trial was designed in randomized complete block design with four replications and conducted at Janakpur and Bhairahawa Agriculture Farm. The treatments were: (i) line/broadcast sowing after usual plowing (UP), (ii) line sowing (LS)/broadcasting (BC) onto non-tilled field (NT) and (iii) covering seed with farm yard manure (FYM)/fine soil (FS).

### Effect of the duration of wheat relay in rice with different N levels

The experiment was conducted in split plot design with four replications. Main plot treatments were duration of wheat at 0, 5, 10 and 15 days before rice harvest (DBRH). Nitrogen levels- 40, 80 and 120 kg/ha were allotted as sub-plot treatments. Soaked seeds were relayed. Half dose of N and full dose of $P_2O_5$ and $K_2O$ were applied at planting time and remaining N was applied after first irrigation at 25 days after seeding (DAS). Weeds were controlled. Data on yield and yield components were collected.

### Response of wheat yield to different management options under surface seeding and conventional tillage

Management options studied were soil solarization, deep tillage, application of FYM (10 t/ha). These options were alone or in combination with other options with optimum management. Deep tillage up to 50 cm was done with Chisel plow. For solarization, experimental plots were covered by white polyethylene sheets for one month. In farmers' practice, four plowings followed by planking after each plowing were done. Seeding was simultaneously done in surface and farmers' practice.

### Effect of time of N application on the yield of surface seeded wheat

This field experiment was conducted at lower wetlands from 1993/94 to 1996/97 winter season at Regional Agricultural Research Station (RARS), Bhairahawa in randomized complete block design (RCBD) with four replications. It consisted of 10 treatments (Table 1). The soil was silt loam in texture with pH 8, low in organic matter and nitrogen (N) and medium in phosphorus ($P_2O_5$) and potassium ($K_2O$). The fertilizer rate was 100:50:25 kg N:$P_2O_5$:$K_2O$ /ha. Nitrogen as per treatments and full dose of $P_2O_5$ and $K_2O$ were applied at basal through urea (46:0:0), single super phosphate (0:16:0) and murate of potash (0:0:60), respectively. Wheat varieties Nepal 297 at the rate of 120 kg seed/ha was used. Seed soaked in water for 10 hours were treated uniformly with fresh cowdung to minimize bird damage. Treated seed kept under shade for another 10 hours enhanced crop establishment.

In the field, where footprints were observed while walking, irrigation was not given. Pre-irrigation was given in the case of inadequate soil moisture. Water stagnation in the field could rot seed and was avoided. Seeds were broadcasted in late afternoon to keep moist and accelerate germination. Nitrogen was also applied in late afternoon to minimize loss through volatilization. Irrigation was given as per need. Isoproturon was sprayed at 30 DAS to control weeds and the remaining were hand weeded. Five crop cut samples, each of 1 square meter were taken randomly from each experimental plot and yield was calculated at 12% moisture. The data on yield and yield components were recorded and analyzed.

NUE was calculated by subtracting the grain yield (Y) without N from the yield (Y1) with N and dividing the remainder by respective N level, i.e. (Y1-Y)/N rate.

### Interaction between seed soaking of wheat and mulching with rice harvest under relay seeded condition

This experiment was conducted in RCBD with four replications. It comprised of seed soaking (dry seed, seed soaked for six and 12 hours) and duration of seed cover with rice harvest (0, 3, 6, 9 day). Seed of UP 262 wheat variety at the rate of 120 kg/ha was soaked as per treatment, treated with fresh cowdung and relayed on the standing rice crop in the late afternoon 3 days before rice harvest at

National Wheat Research Program, Bhairahawa. Whole plots were harvested, uniformly covered with the same rice harvest and rice harvest was removed as per treatments. Relay seeding of wheat could help plant wheat in time, establish good plant stand and protect crop from severe moisture and heat stresses during post anthesis period. Fertilizers @ 50:50:25 and 50:0:0 N:$P_2O_5$:$K_2O$/ ha were applied at 12 and 30 DAS, respectively. Isoproturon was applied to control weeds particularly *Polypogon* sp., a noxious weed in lower wetlands. Field was irrigated as per need. Observations were made similar to the previous experiment.

**Response of wheat genotypes to crop establishment techniques**

Several wheat genotypes (BL 1022, BL 1135, Bhrikuti, BL 1473, NL 683, UP 262 and Achyuta) were tested to see genetic variability under different crop establishment techniques (relay, surface seeding and farmers' practice) in lower wetlands. Same methodology as in relay/surface seeding was used to plant wheat. In farmers' practice, four plowings followed by two plankings after each plowing were done, and yield and yield components were compared among the treatments.

**Effect of stubble height on wheat grain yield under surface seeded condition**

This experiment was conducted in RCBD with four treatments (5, 15, 30 and 45 cm stubble height) replicated four times. The main objectives were to conserve soil moisture and protect seed from birds. Other methodologies were similar to surface seeding.

**Effect of rice culture on subsequent wheat grain yield**

The experiment was conducted in RCBD with three main plot treatments - dry seeded rice (DSR), wet seeded rice (WSR) and transplanted rice (TPR). In wheat, each experimental unit in rice was splitted into three subplots - surface seeding (SS), seeding by Chinese seed drill (CSD) and seeding by farmers' practice (FP) and assigned randomly. In surface seeding, seeds were soaked for 10-12 hours, treated with fresh cowdung, incubated for another 8-10 hours in shade, and sown in the late afternoon onto the soil having excess soil moisture. In Chinese seed drill, 50:50:25 kg N:$P_2O_5$:$K_2O$/ha was first applied and wheat seeding and planking were done simultaneously. The remaining N was top-dressed after first irrigation, i.e. 25-30 DAS. In case of conventional tillage, three repeated plowings were done followed by planking. Fourth plowing was used to incorporate seed and fertilizers into soil. It was also followed by planking to give good seed soil contact. Data on yield and yield components were collected and analyzed.

**Tillage and crop establishment in rice-wheat system**

This experiment was conducted in split plot design with three replications at D-Block of RARS, Bhairahawa since 1997 rice season. Main plot treatments were deep tillage and normal tillage. Rice establishment methods-DSR and TPR were sub-plot treatments and wheat establishment techniques-SS and CSD were kept as sub-sub-plot treatments. After rice harvesting, whole experimental area was irrigated. In surface seeding, wheat seeds were soaked for 0 -12 hours, treated with fresh cowdung, kept in shade for another 8-10 hours and broadcast seeded onto nearly water saturated rice field in the late afternoon. Half N and full $P_2O_5$ and $K_2O$ @ 50:50:25 kg/ha were applied at 20 DAS and remaining 50 kg N was top-dressed at 30 DAS. In Chinese seed drill treatment, top-dressing was done at 25 DAS. Integrated approach was applied to control weeds. Experimental field was irrigated as per water requirement.

**On-farm crop establishment methods**

On-station research results of wheat establishment techniques were disseminated to the farmers' fields of Rupandehi, Kapilvastu and Nawalparasi districts. The methods used were similar to on-station surface/relay seeding. In the farmers' fields, surface seeding, Atchison zero-till drill, Chinese roto-tiller and Chinese seed drill were tested, evaluated and compared with farmers' practice.

### On-farm fertilizer evaluation

Crop establishment techniques were also evaluated with different fertilizer doses - recommended fertilizers (100:50:25 kg $N:P_2O_5:K_2O$/ha) and farmers' fertilizer dose (60:30:0 kg $N:P_2O_5:K_2O$/ha). Surface seeding was done earlier to catch up the residual soil moisture followed by Atchison seed drill, Chinese roto-tiller, Chinese seed drill. Farmers' practice was delayed by 10-20 days depending on the soil moisture. In the beginning, surface seeding and farmers' practice were seeded at the same time.

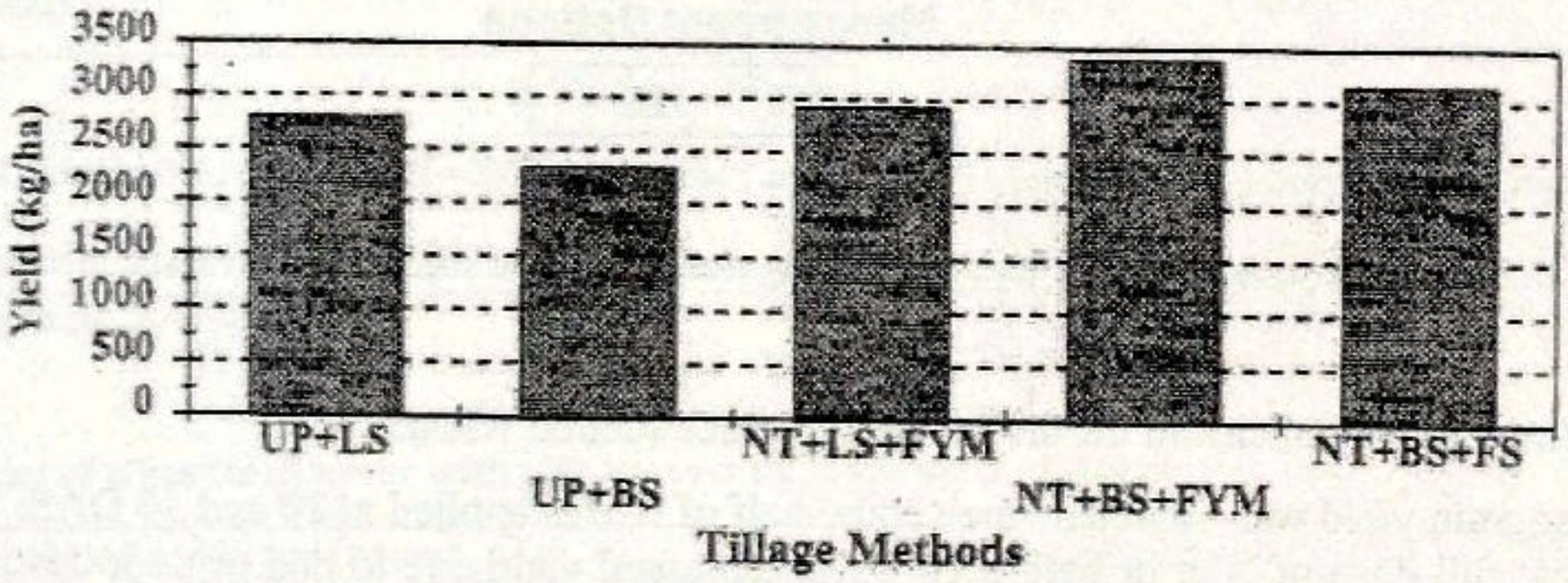
### On-farm demonstrations on surface seeding

Interested farmers from Rupandehi, Nawalparasi and Kapilvastu district were selected for the demonstration. Non-participating farmers were also invited for visit, suggestion and comments. Field days were organized during the crop season. Yield data from crop cut and other data were recorded, analyzed and reported.

## RESULTS AND DISCUSSION

### Effect of tillage methods on wheat grain yield

Broadcast seeding of wheat onto unplowed field and covering seed with FYM (NT + BS + FYM) produced the highest grain yield (Fig. 1). It was followed by broadcast-seeding of wheat onto non-tilled field and covering the seed with fine cultivated soil. Broadcast-seeding of wheat on normal land ready for seeding and incorporating seed and fertilizer into soil was least productive.




UP – usual plowing, LS – line sowing, NT – non-tilled field, BS – broadcasting, FS – fine soil, FYM – farm yard manure

**Fig. 1. Effect of tillage methods on wheat grain yield**

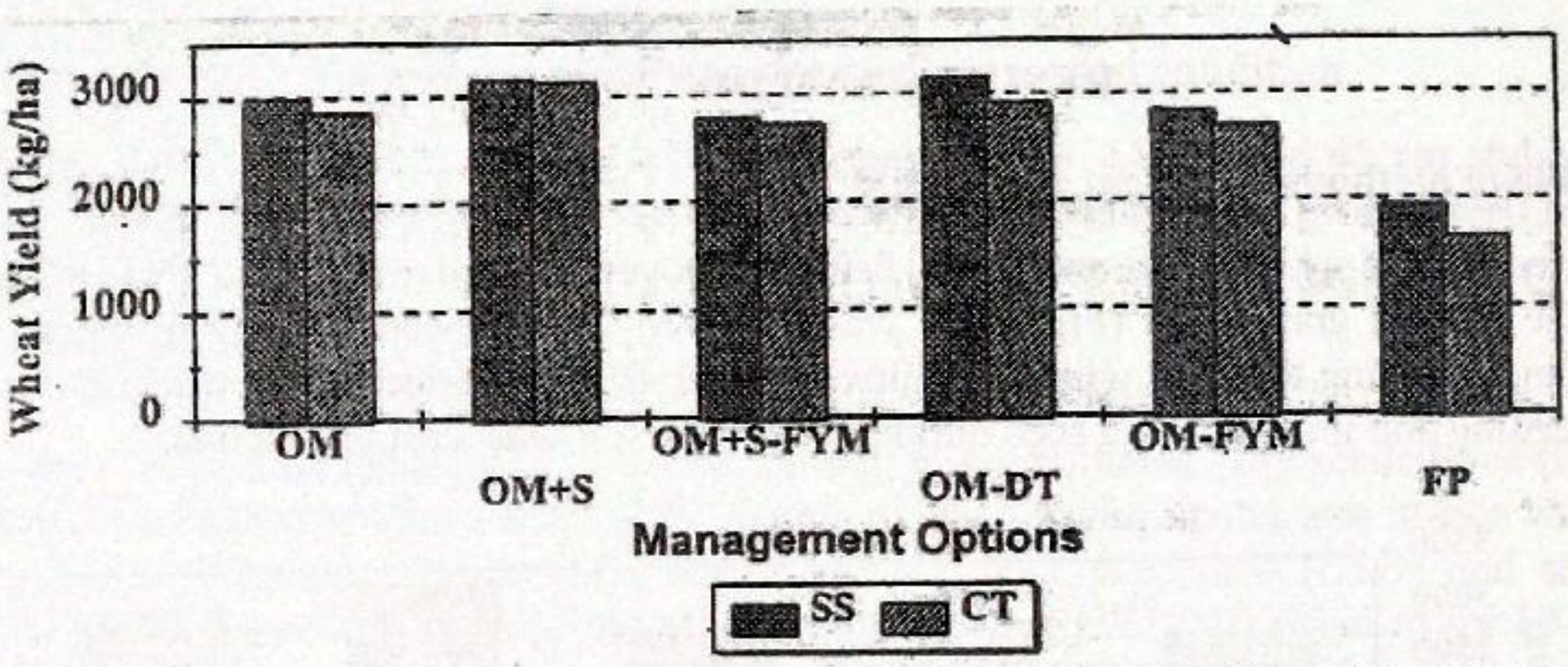
### Effect of duration of wheat relay in rice with different N levels

Relaying wheat 5 days before rice harvest (DBRH) produced the highest grain yield (Fig. 2) followed by surface seeding (0 DBRH). Relay seeding of wheat more than a week before rice harvest was not productive. Effect of N was also pronounced when wheat was relayed 5 DBRH and it was followed by surface seeding (0 DBRH). Amount of N applied had positive effect on wheat yield irrespective of treatments.

### Response of wheat yield to different management options under surface seeding and conventional tillage

Wheat yield from surface seeding was superior to conventional practice irrespective of different management options (Fig. 3). This clearly indicated its superiority even when seeding was done simultaneously. The reason could be uniform plant establishment in surface seeding as compared to conventional practice in which some seeds could not germinate due to more depth or being on the soil surface.

**Fig. 2. Effect of duration of wheat relay in rice on wheat yield**




OM = Optimum management; S = Solarized ; FYM = Farm Yard Manure; DT = Deep tillage ; FP = Farmers' Practice

**Fig. 3. Wheat yields at different management options - surface seeding vs. farmers' practice**

### Effect of time of N application on the yield of surface seeded wheat

The highest grain yield was obtained when equal half of N was applied at 20 and 30 DAS. The results revealed that full dose of N at or before 10 DAS depressed yield due to non or poor development of roots in wheat seedlings and the proliferation of residual weeds during early growth stages of crop. Full dose of N at 20 DAS and split application in equal half at 10 and 20, and 10 and 30 DAS produced comparative yields with 20 and 30 DAS (Table 1). Application of N at the most active growth stage benefited the crop and improved NUE.

### Effect of seed soaking

The combined analysis of grain yield data from 1994/95 to 1996/97 revealed non-significant differences among the treatments over the years except the third year (Table 2). The inconsistency/unstability in grain yields over the years indicates its sensitivity to management and environmental factors. This also indicates excess soil moisture as the most critical factor for the success of no-till wheat cultivation even under relay seeded condition.

### Mulching wheat with rice harvest

Covering of wheat seed with rice harvest for 3-9 days produced grain yield superior to non-covered (Table 3). Due to seasonal variation, the effect of seed cover on yield was, however, not consistent over the years. Relay seeding of wheat in rice produced more grain yield compared to surface seeding due to soil moisture conservation that produced more effective tillers/$m^2$.

Table 1. Grain yield, yield components of wheat and NUE as affected by the time of N application in surface seeded condition (Pooled analysis 1993/94-1996/97)

| Treatments | Spikes/m$^2$ | Grains/spike | TGW (gm) | BMY (kg/ha) | Grain yield | |
|---|---|---|---|---|---|---|
| | | | | | (kg/ha) | (kg/kg N) |
| Check (No N) | 203d | 25b | 44.1bc | 3805e | 1516e | |
| All N- basal | 203d | 30a | 45.3b | 5461d | 2430d | 9.1 |
| All N- 10 DAS | 237c | 29a | 45.7a | 5743cd | 2700cd | 11.8 |
| All N- 20 DAS | 269ab | 30a | 44.7abc | 6344abc | 2931ab | 14.1 |
| Half N- basal and half N- 10 DAS | 237c | 31a | 45.1a | 6542ab | 2897ab | 13.8 |
| Half N-basal and half N-20 DAS | 232c | 30a | 45.4ab | 6064bc | 2879ab | 13.6 |
| Half N- basal and half N- 30 DAS | 249abc | 29a | 44.2bc | 6634ab | 3021ab | 15.05 |
| Half N-10 DAS and half N-20 DAS | 252abc | 29a | 45.3ab | 6549ab | 3079a | 15.6 |
| Half N-10 DAS and half N-30 DAS | 256abc | 31a | 43.6c | 6741ab | 3065ab | 15.4 |
| Half N-20 DAS and half N-30 DAS | 273a | 30a | 44.5abc | 6896a | 3232a | 17.1 |
| "F" test | HS | HS | HS | HS | HS | |
| CV% | 11.55 | 10.20 | 2.9 | 12.6 | 13.49 | |

TGW = Thousand grain weight, BMY = Biomass yield, DAS = Days after seeding, HS = Highly significant
Data are an average of four replications over four years. Means are separated by DMRT at 5% level of significance. Means with the same letter in the column do not differ significantly.

Table 2. Effect of wheat seed cover with rice harvest on grain yield of wheat

| Duration of relayed seed cover (days) | Grain yield (kg/ha) | | | Mean |
|---|---|---|---|---|
| | 1994/95 | 1995/96 | 1996/97 | |
| 0 | 3204 | 2581 | 2992b | 2926 |
| 6 | 3250 | 2622 | 3235a | 3035 |
| 12 | 3264 | 2539 | 3201ab | 3001 |
| F test | NS | NS | S | NS |

NS = Non-significant, S = Significant

Table 3. Effect of wheat seed cover with rice harvest on grain yield of wheat

| Duration of relayed seed cover (days) | Grain yield (kg/ha) | | | Mean |
|---|---|---|---|---|
| | 1994/95 | 1995/96 | 1996/97 | |
| 0 Days | 3020b | 2465b | 3050 | 2845b |
| 3 Days | 3205ab | 2589ab | 3255 | 3016a |
| 6 Days | 3400a | 2584ab | 3054 | 3013a |
| 9 Days | 3333a | 2685a | 3210 | 3076a |
| F test | S | S | NS | S |
| CV% | 7.09 | 8.24 | 10.38 | 8.82 |

Data are an average of four replications over four years. Means are separated by DMRT at 5% level of significance. Means with the same letter in the column do not differ significantly. S = Significant, NS = Non-significant

**Response of wheat genotypes to crop establishment techniques**

Testing of wheat genotypes under different crop establishment showed superiority of relay seeding to surface seeding and farmers' practice. Wheat yields from relay and surface seeding were superior to farmer's practice by 58% and 27%, respectively (Table 4). Yield increment in relay seeding ranged from 29 to 105% and in surface seeding from 2 to 46% over farmers' practice.

Wheat variety Bhrikuti produced the highest grain yield (3371 kg/ha) followed by Achyuta, UP 262 and BL 1135 in relay seeding. Yield obtained from relay seeding of BL 1135 was superior to farmers'

practice by 105% and was followed by Achyuta (77%), UP 262 (76%), NL 683 (60%) and Bhrikuti (41%).

In surface seeding, BL 1135 produced the highest yield followed by Bhrikuti, UP 262 and Achyuta. The superiority of BL 1135 in yield was 87% to farmers' practice. Similarly, NL 683 produced 46% more yield followed by UP 262 (41%), Achyuta (25%), BL 1022 (10%), Bhrikuti (9%) and BL 1473 (2%) compared to farmers' practice (Table 4). Bhrikuti, BL 1473 and BL 1022 did fairly well even in late planting condition under farmers' practices.

**Table 4. Response of wheat genotypes to different crop establishment techniques on wheat grain yield (kg/ha)**

| Establishment Techniques | Wheat genotypes | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|
| | BL 1022 | BL 1135 | Bhrikuti | BL 1473 | NL 683 | UP 262 | Achyuta | |
| Relay seeding (RS) | 2696a | 3126a | 3371a | 2883a | 2517a | 3176a | 3309a | 3011a |
| Surface seeding (SS) | 2238b | 2855b | 2609b | 2284b | 2222b | 2429b | 2343b | 2426b |
| Farmers' practice (FP) | 2035c | 1526c | 2389c | 2240b | 1571c | 1717c | 1868c | 1907c |
| Superiority of RS to FP % | 32 | 105 | 41 | 29 | 60 | 76 | 77 | 58 |
| Superiority of SS to FP (%) | 10 | 87 | 9 | 2 | 46 | 41 | 25 | 27 |

## Effect of rice stubble height on wheat yield under surface seeded condition

Positive correlation was observed between rice stubble height and wheat yield (Fig. 4), i.e. longer the rice stubble, the higher the yield. Longer rice stubble in the field conserved soil moisture, protected seed/young seedlings from desiccation and contributed to higher grain yield. However, longer stubble tempted rodents and needed effective control measures.

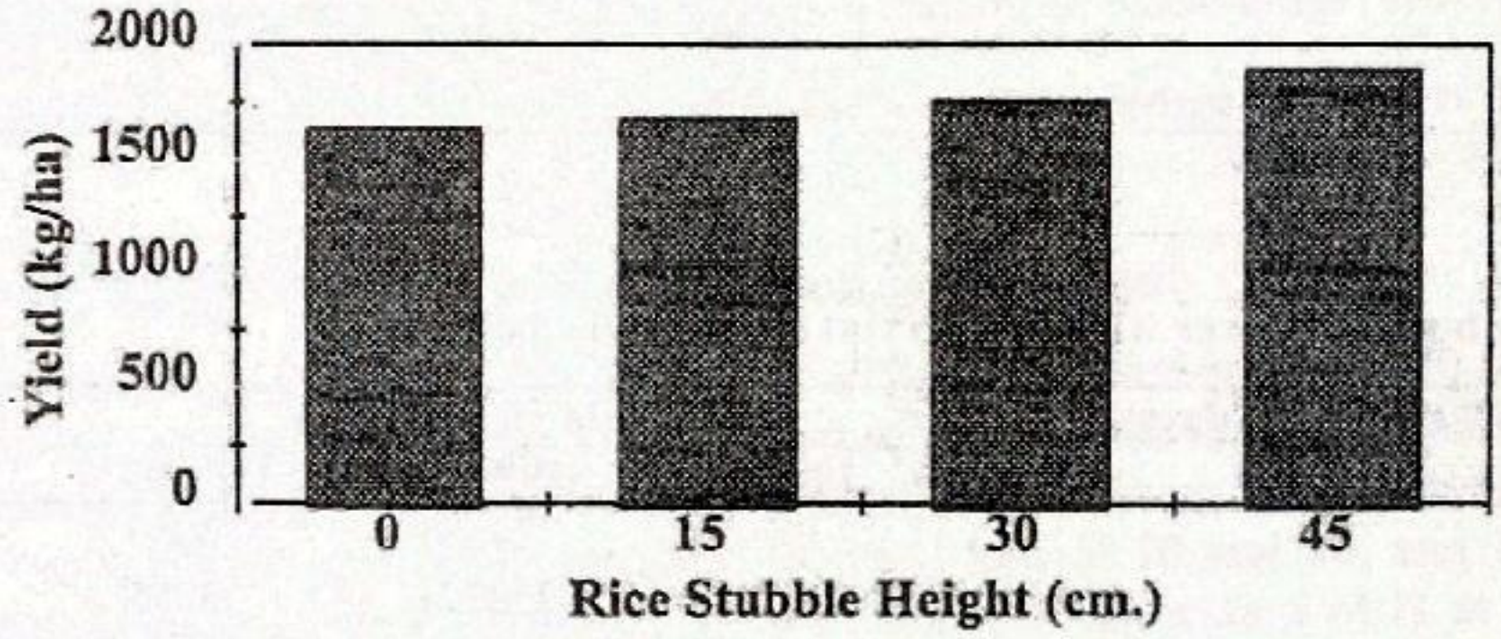



**Fig.4. Effect of rice stubble height on wheat yield under surface seeding**

## Effect of rice culture on subsequent wheat grain yield

Chinese seed drill produced the highest grain yield compared to farmers' practice, but did not differ significantly from surface seeding (Table 5). The higher yield was mainly attributed to timely planting of wheat.

Partial budgeting reflected the highest net benefit with Chinese seed drill (Table 5) and lowest with farmers' practice. The lowest net benefit with farmers' practice was due to its high cost of land preparation. Surface seeding was more economical than farmers' practice and thus could be an alternative for wheat establishment in wetlands.

Table 5. Partial budget for wheat establishment techniques

| Particulars | Wheat establishment techniques | | |
|---|---|---|---|
| | Surface seeding | Chinese seed drill | Farmers' practice |
| Wheat yield (kg/ha) | 2775 | 2831 | 2314 |
| Adjusted wheat yield (kg/ha) | 2497 | 2548 | 2083 |
| Gross yield benefit (Rs. /ha/) | 12484 | 12740 | 10415 |
| Land preparation cost (Rs./ha) | 0 | 600 | 2300 |
| Cost of labor (Rs./ha) | 100 | 50 | 50 |
| Total cost that vary (Rs./ha) | 100 | 650 | 2350 |
| Net benefit (Rs./ha) | 11485 | 12090 | 8065 |



Surface seeded wheat was not adversely affected by unusual rainfall in the first week of December. This rainfall (about 120 mm) delayed wheat planting by Chinese seed drill by 40 days. So surface seeded wheat escaped from desiccation during post anthesis period while the wheat seeded with Chinese seed drill suffered from heat stress and yield reduction was significant (Fig. 5). This shows the importance of surface seeding over conventional tillage or Chinese seed drill when soil has excess moisture and seeding by other techniques is not possible.

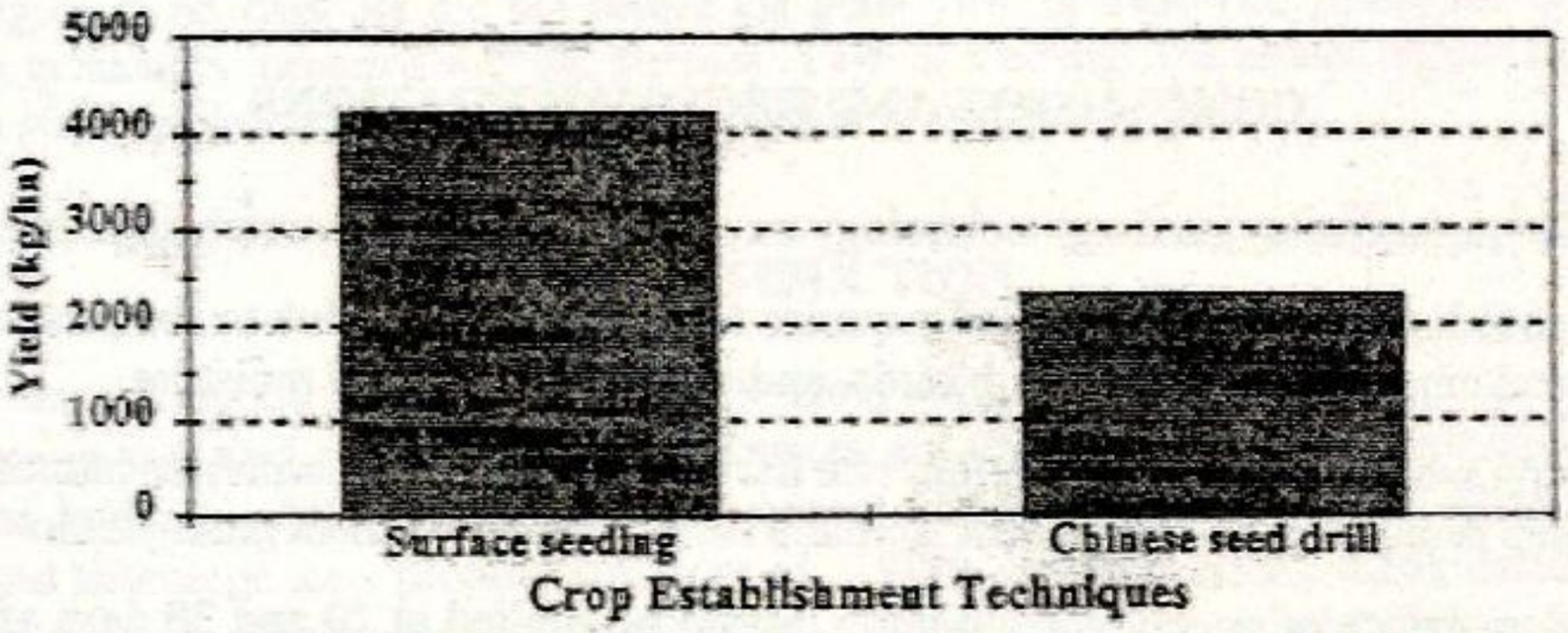



Fig.5. Effect of crop establishment techniques on wheat grain yield

## On-farm crop establishment method

Chinese seed drill produced the highest grain yield and it was followed by surface seeding and farmers' practice. It performed very well for timely planting of wheat and attracted many farmers due to its multiple uses (seeding and reaping of both rice and wheat crops, pumping irrigation water, threshing wheat, lentil, transportation of goods, tilling fields, winnowing rice, wheat and other crops, etc.). The performance of surface seeding was excellent at mid/lower wetlands where either wheat was not planted in time or the field was left fallow due to excess soil moisture. It also gave more net benefit than farmers' practice. Excess soil moisture was the first prerequisite for the success of surface/relay seeding at time of planting. Surface/relay seeded crop is very sensitive to management and thus should be handled carefully.

## On-farm fertilizer evaluation

Fertilizer evaluation was made under surface seeded condition in the farmers' fields. Yields from recommended fertilizers (100:50:25 kg $N:P_2O_5:K_2O$/ha) were compared to farmers' practice (60:30:0 kg $N:P_2O_5:K_2O$/ha). The former out yielded the latter one (Fig. 6).

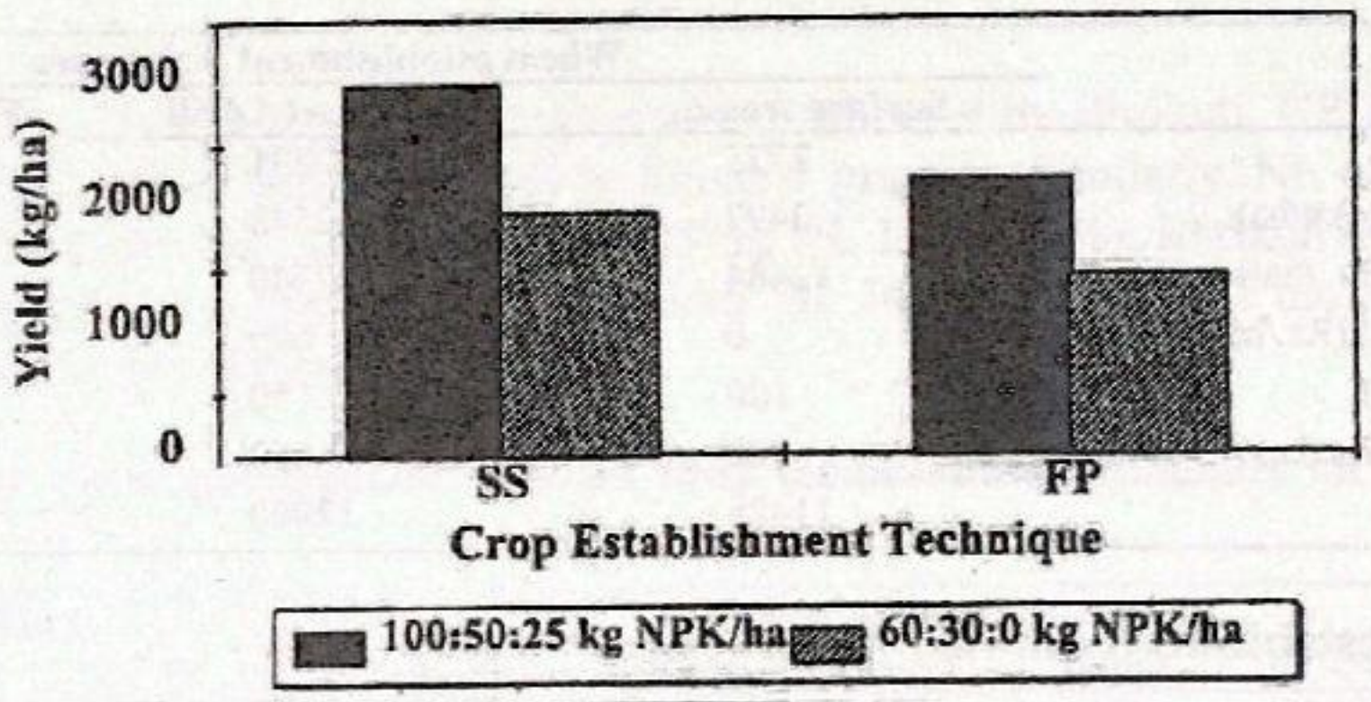



**Fig. 6. Crop establishment techniques and fertilizer affected grain yield**

### Demonstration on surface seeding

Demonstrations on surface seeding were done in large plots. Visits of farmers from different parts of the country were arranged. Results on surface seeding demonstrations were encouraging.

## CONCLUSION AND RECOMMENDATIONS

- No-till (surface/relay seeding) technology on wheat can facilitate timely planting.
- Relay seeding of wheat was found superior to surface seeding due to the protection of wheat seed and emerging seedlings from birds, and conservation of soil moisture.
- Relaying wheat seed 3-5 days before rice harvest, covering seed with rice harvest for 6-9 days and then removing the rice harvest from the fields improved wheat grain yields.
- N under surface/relay seeding condition should be applied at 20 and 30 days after seeding in equal split.
- Excess soil moisture is the "pre-requisite" for the success of surface/relay seeding. Pre-irrigation is important for good establishments in the case of low soil moisture.
- Bhrikuti, BL 1135, Nepal 297, Achyuta, UP 262 performed equally well under relay/surface seeding condition.
- NARC, Department of Agriculture, Department of Irrigation and participating farmers should be involved for sharing of ideas/experiences with other farmers for the quick dissemination of the technology

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# INFLUENCE OF AGE OF SEEDLING ON PRODUCTIVITY OF RICE UNDER RAINFED LOWLAND CONDITIONS

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## ABSTRACT

Field experiments were conducted during the rainy season of 1994, 1995 and 1996 at the Rice Research Program, Parwanipur under rainfed lowland conditions with the objective to find out the effect of seedling age on grain yield of three rice genotypes Radha 11, RP 1017 and RD 21. Seedling up to 65 days old did not reduce the grain yield of these rice genotypes. Days from seeding to maturity increased with the increase in age of seedling. The results suggest that farmer can use older seedling of these genotypes under rainfed lowland conditions.

## INTRODUCTION

Drought occurs worldwide in almost all rainfed ecosystems at sometime during the rice season and can also occur in irrigated rice if irrigation resources are insufficient to meet demand. About half of the 38 million hectares of the rainfed lowland ecosystem has been classified as either drought-prone or drought and submergence - prone (Garrity *et al.*, 1986). In these areas, water deficit limits yields to less than 2 t/ha in at least five years out of ten. Drought also occurs in other areas of rainfed lowland ecosystem, but with less frequency.

In general, rice growth and yields are directly proportional to the total amount of transpired water by the crop. The ratio of rice grain yield to transpiration is about 1:1000 i.e. to produce 1 kg of rice; 1 ton of water is needed (Yambao and Ingram, 1988). On an area basis, to produce 10 t/ha of rice requires 1000 mm of rainfall if all the water is used for transpiration only. Rainfed lowland rice cannot be grown where seasonal rainfall is less than 800 mm (Ingram, 1988).

In Nepal, rice is grown as rainfed in 72.21% of the total rice area. Rice occupies 60% of the total cultivated area mainly in the Terai, contributing about one fourth of the gross domestic product of the country. Delayed rains necessitate transplanting of overage seedlings. Other constraints to timely planting are non-availability of inputs, agricultural labourers and irrigation water. So, farmers are forced to transplant older seedlings. Thus, this experiment was conducted to find out the optimum age of seedlings for promising genotypes such as Radha 11, RP 1017 and RD 21.

## MATERIALS AND METHODS

Experiments were conducted at Rice Research Program, Parwanipur, Nepal during the normal (rainy) season of 1994, 1995 and 1996 to study the effects of seedling age for three rice genotypes Radha 11, RP 1017 and RD 21 under rainfed lowland conditions. The experiments were conducted in split plot design with four replications. The treatment comprised the genotypes as main plot and age of seedlings (25, 35, 45, 55 and 65 days) as subplot. Seedlings of the above mentioned five ages were

obtained by sowing seeds at different dates. The crop was transplanted on July 30 (1994), August 5 (1995) and July 31 (1996) with a spacing of 20 x 20 cm. Fertilizer was applied at the rate of 70, 30 and 30 kg of N, $P_2O_5$ and $K_2O$, per hectare, respectively. Half of N was applied as basal and remaining at tillering and panicle initiation stages in two equal splits. The soil of the experimental site was sandy loam with 6.4 pH. In this study the crop received the total mean rainfall of 610.3 mm, 772.7 mm and 564.4 mm with 23, 23 and 37 numbers of rainy days during 1994, 1995 and 1996, respectively from transplanting to maturity.

## RESULTS AND DISCUSSION

Effect of age of seedling on grain yield was not found significant in 1994 and 1996 but highly significant in 1995 (Table 1). The interaction between age of seedling and varieties was also found insignificant all over the years. In all three years, 65 days old seedlings produced higher yield than 25 and 35 days old seedling. This confirms the findings that there was no reduction in grain yield of Handiphuol and Masuli while using 65 days old seedlings (Mallick and Singh, 1976; Mathema, 1979). Also, Chandra and Manna (1988) found that using 30 or 60 days seedling did not affect mid-August transplanting yield; 60 days old seedling was significantly superior to 30 days old seedling with mid-September transplanting. Venksteswarlu (1979) reported that age of seedlings up to 65 days in normal rice season was not a constraint in obtaining optimum yield.

Besides increased grain yield, days to maturity also increased with the increase in seedling age (Table 1). In the 1994 and 1995 experiments, plant height was also increased with the increase in seedling age, but not in the 1996 experiment.

**Table 1. Grain yield and other agronomical traits**

| Age of seedlings (days) | Grain yield (kg/ha) | | | Days to maturity | | | Plant height (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1996 | 1994 | 1995 | 1996 | 1994 | 1995 | 1996 |
| 65 | 3837a | 3153a | 3805a | 166 | 159 | 156 | 108 | 100 | 104 |
| 55 | 3825a | 3250a | 3782a | 158 | 149 | 152 | 109 | 102 | 102 |
| 45 | 3624a | 3136a | 3883a | 151 | 142 | 147 | 105 | 104 | 102 |
| 35 | 3626a | 2657b | 3662a | 143 | 136 | 141 | 102 | 100 | 102 |
| 25 | 3626a | 2070c | 3590a | 137 | 130 | 133 | 99 | 95 | 100 |
| F test | NS | HS | NS | HS | HS | HS | HS | HS | NS |
| CV% | 9.7 | 13.5 | 10.1 | 0.9 | 1.2 | 2.9 | 4.4 | 4.2 | 7.5 |
| SED | | 320.80 | 343.26 | 1.22 | 1.33 | 3.3 | 4.25 | 3.85 | |

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.
NS = Non-significant, HS = Highly significant

Increased grain yield with longer maturity period was probably due to the fact that the aged seedlings start with higher dry matter content and greater assimilatory system (with more leaves). Also, older seedlings have more carbohydrate accumulation than the younger seedlings. This combination is an advantage for higher tiller production per unit time.

In the 1995 experiment, the older seedlings yielded much higher than the younger seedlings (25 and 35 days) when compared with the 1994 and 1996 experiments. This could probably be due to the damage of younger seedlings by heavy rains that occurred just after transplanting. This result supports the findings of Chandra and Manna (1988) that older seedlings are capable of withstanding heavy rains. According to Rasid *et al.* (1990), 40 and 60 days old seedlings had higher survival rate than 20 days old seedlings.

In conclusion, farmers can use seedling up to 65 days of the genotypes Radha 11, RP 1017 and RD 21 to get satisfactory yield under rainfed lowland conditions.

## ACKNOWLEDGEMENTS

The authors are very much thankful to Mr. G. P. Koirala, Director, Regional Agricultural Research Station, Parwanipur for providing facilities and giving valuable suggestions. We would like to thank Mr. T. P. Pokhrel, Chief Agronomist and Dr. N. Rajbhandari for their help at project formulation level. We also like to thank Mr. R. B. Prasad, Mr. S. P. Khatiwada, Mr. T. Akhtar and Mr. A. R. Ansari for statistical analysis and their constructive paper on the paper. Thanks are due to Messers G. Chaudhary, M. P. Sah, S. Sah, G. Thakur, S. Yadav, D. Shrestha, H. M. Thakur, H. N. Mahato and L. Raut for technical help.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# PERFORMANCE AND ADAPTATION OF RICE GENOTYPES IN RELATION TO PLANT GROWTH AND DEVELOPMENT UNDER DROUGHT AND NITROGEN LIMITATION

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## ABSTRACT

Experiments were conducted at the research farm and greenhouse of International Rice Research Institute (IRRI), Philippines during the dry and wet seasons of 1994 (Mar.-Nov.). The field experiment was conducted in two water regimes (well-watered and water deficit), laid out in a split-plot design with four replications subjected to two N levels (0 and 100 kg N/ha) as main plots and two rice cultivars (IR72 and PSBRc14) as subplot treatments. The greenhouse experiment was laid out in a factorial RCBD with three replications using same water levels but different N (50 and 120 kg/ha) levels and rice cultivars (IR72, PSBRc14, IR42 and KDML105). The objective of the experiments was to investigate the influence of drought and N limitations on the performance and adaptation of rice cultivars and the plastic responses over the stress environments.

Drought coupled with high N was found more detrimental to plant growth and development than drought or low N alone. Minimizing the transpiration load of water and extent of leaf tip drying by PSBRc14 could be a survival and drought avoidance mechanism. Increase in cumulative transpiration (CT) increased plant growth. Maintenance of leaf area (LA) and shoot dry matter (SDM) under drought, and their increased recovery capability after stress have been identified as desirable drought resistance traits. Developmental plasticity such as delayed heading in PSBRc14 compared to IR72 under drought could be useful in situations where drought occurrence is quite unpredictable. However, rice genotypes might have demonstrated a mechanism to store starch assimilates during drought and its translocation into grain upon stress relief as a strong recovery capability. Thus PSBRc14 was better adapted to drought compared to others, because it depleted soil water less rapidly as the drought progressed. IR72 was better adapted to well-watered conditions and showed faster recovery from drought upon rewatering. These two genotypes can be used as probe lines in further selection works and drought experiments.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food grain in the diet of more than half of the world's population in Asia, Africa and Latin America and accounts for the major portion of the calorie intake (Palacpac, 1980; Yoshida, 1981). One-third of south and Southeast Asian ricelands are rainfed lowlands with anaerobic flooded and aerobic drought condition (De Datta and Seshu, 1982). About 67% of rainfed lowlands of south and Southeast Asia are affected by varying degrees of submergence and drought (IRRI, 1995). These rainfed areas are exposed to erratic distribution of rainfall and characterized by diverse and unpredictable conditions, unstable low yields and financial risks. The rice crop in these areas suffers from some degree of moisture stress regularly.

In Nepal, in terms of area (1.43 million ha), production and consumption, rice is the number one crop. Most rice in Nepal is grown under rainfed lowland conditions (64%). The rice crop in these rainfed areas experiences drought in one or more critical growth stages, due to the erratic and unpredictable nature of rainfall with severe long dry spells occurring at the reproductive stage (Pathic, 1991). The direct seeding of short duration rice in rainfed lowlands is accepted as a technology for increasing cropping intensity and productivity.

The fluctuating water regime resulting from erratic and unpredictable rainfall distribution contributes to the unreliable responses to applied nutrients. Water deficit coupled with nutrient deficiency particularly of N may occur at any growth stages of the rice plant, which can affect the morpho-physiological processes leading to reduced plant growth, development and consequently low yields. Since performance of direct seeded rice is dependent on agrohydrology of the environment and its interaction with N fertilizer, existing knowledge is not adequate to explain the interaction of water and nutrient-stress induced yield loss under rainfed conditions (Tuong *et al.*, 1993). Crop water deficit or drought exists when the rate of actual evapotranspiration falls below that of potential evapotranspiration (Gupta and O' Toole, 1986). Drought resistance is the ability of plants to stay alive, grow, withstand periods of dry weather, and ultimately produce grain yields with part of its life cycle under water stress (Sullivan *et al.*, 1971). According to Ahmed (1992), rice plants stressed at the vegetative stage were able to recover completely after relief of stress while plants stressed at the reproductive stage failed to do so.

Breeders have successfully manipulated drought escape by selecting lines differing in phenological development, generally with short duration. Mechanisms of drought resistance during vegetative growth vary with that of reproductive stage and the factors for the latter are still not well-understood. Potential cultivar differences do exist in their capacity for better water uptake and reduced water loss leading to drought resistance but these have not been exploited as improved genotypes for drought.

Any stress during panicle initiation and flowering time adversely affects the yield, by altering the expression of the relevant yield components. Thus, rice growth and development depends upon combinations of cultivars, environmental conditions and cultural practices. The experiments were conducted to quantify effect of water deficit and N limitation on the performance, adaptation and genotypes variation in the plant growth, development and plastic responses of some rice cultivars.

## MATERIALS AND METHODS

### Experimental design and treatments

The greenhouse (GH) experiment was conducted in factorial randomized complete block design with three replications, two water regimes (well-watered and water deficit or stress imposition), two levels of nitrogen (50 kg/ha - low N and 120 kg/ha - high N) and four cultivars (IR72, IR42, PSBRc 14 and KDML105). The pot experiment was conducted in the IRRI greenhouse in the 1994 wet season (WS).

The field experiment was conducted in two environments in split plot design with four replications having two nitrogen levels (0 kg/ha - control and 100 kg/ha - optimum level) as main plots and two cultivars ( PSBRc14 and IR72) as subplots. The field experiment was conducted on a silty clay loam at the upland farm (Block UM-1) of the IRRI, Los Banos (14° 11'N, 121 °15 'E, 23 m elevation) during the 1994 dry season (DS).

### Planting and crop establishment

Seeds of rice genotypes to be direct wet-seeded were soaked for 24 hours and incubated for another 36 hours before planting. In the greenhouse, planting was staggered, so that panicle initiation would coincide and 3 healthy seedlings were maintained until harvest. In the field, seeds were sown directly 20 cm apart in solid rows at the rate of 100 kg seeds/ha in the plots uniformly well-puddled and fertilized as per treatment to simulate rainfed lowland wet seeded condition. Pots/plots were kept

saturated until emergence and then a water level of 2-3 cm was maintained throughout the experiment, except during the period of water stress in the drought treatments.

**Imposition of water stress and nitrogen treatments**

Water stress was imposed by removal of water in both greenhouse and field experiments from the stressed pots/plots at the time of panicle initiation. This occurred at 13 days after imposition of drought in the greenhouse. Nitrogen fertilization was done in two equal splits - at land preparation and maximum tillering. At night and during rain, the whole stressed main plot in the field was covered with a plastic rain-shelter cover that was removable.

**Cultural practices**

Recommended management practices of rice production and regular crop protection measures were adopted. The greenhouse experiment was terminated at flowering while field experiment was continued until maturity.

**Observations and measurement**

***Meteorological parameters.*** In the greenhouse, diurnal fluctuation in relative humidity and air temperature was monitored by a hygrothermograph while solar radiation and evaporation were measured with a solarimeter and open pan evaporimeter, respectively. All the necessary meteorological weather data such as rainfall, temperature, relative humidity, evaporation and sunshine hours were collected from the IRRI meteorology station.

***Soil matric potential.*** Soil matric potential (SMP) was measured with tensiometers installed in each stressed pot at two depths of 10 and 25 cm in the greenhouse. In the field, it was measured with tensiometers installed in each stressed subplot at depths of 5, 10, 20, 40 and 60 cm installed before stress imposition. Tensiometers were read after every 3 days (0700-1000 AM). Data collected in cm of mercury were converted to kPa using the formula:

$$SMP = (12.6\ h - a)/10.246$$

Where, a = distance between top of mercury in vial and middle of the porous cup in the soil, and h = height of the mercury in the tube

***Cumulative transpiration.*** Cumulative transpiration as expressed in $cm^2$ was measured in the greenhouse as the total water lost from the leaves through transpiration during drought stress period.

***Leaf area.*** In both the greenhouse and the field, LA (leaf area) and leaf area induce (LAI) were measured destructively by an automatic leaf area meter (Model AAM-7, Hayashi Denko Co., Japan) from the fresh leaves separated from the plant samples used for dry matter. LAI was calculated as the ratio of total leaf area to total ground area occupied by the sampled hills in the field.

***Shoot dry matter.*** In the greenhouse, all the plants from each pot were cut destructively from the base while similar samples were taken from 0.5 m row length in the field and were expressed in g/pot and $g/m^2$, respectively. Leaves, stems, sheaths and panicles of the sampled plants were separated and measured. Samples were oven-dried at 70-80°C for 48 or 72 hours.

## RESULTS AND DISCUSSION

**Crop weather environment**

The crop growth stages and drought stress period in relation to weather parameters in the greenhouse during 1994 WS and in the field during 1994 DS of IRRI are depicted in Fig. 1 and 2 as follows.

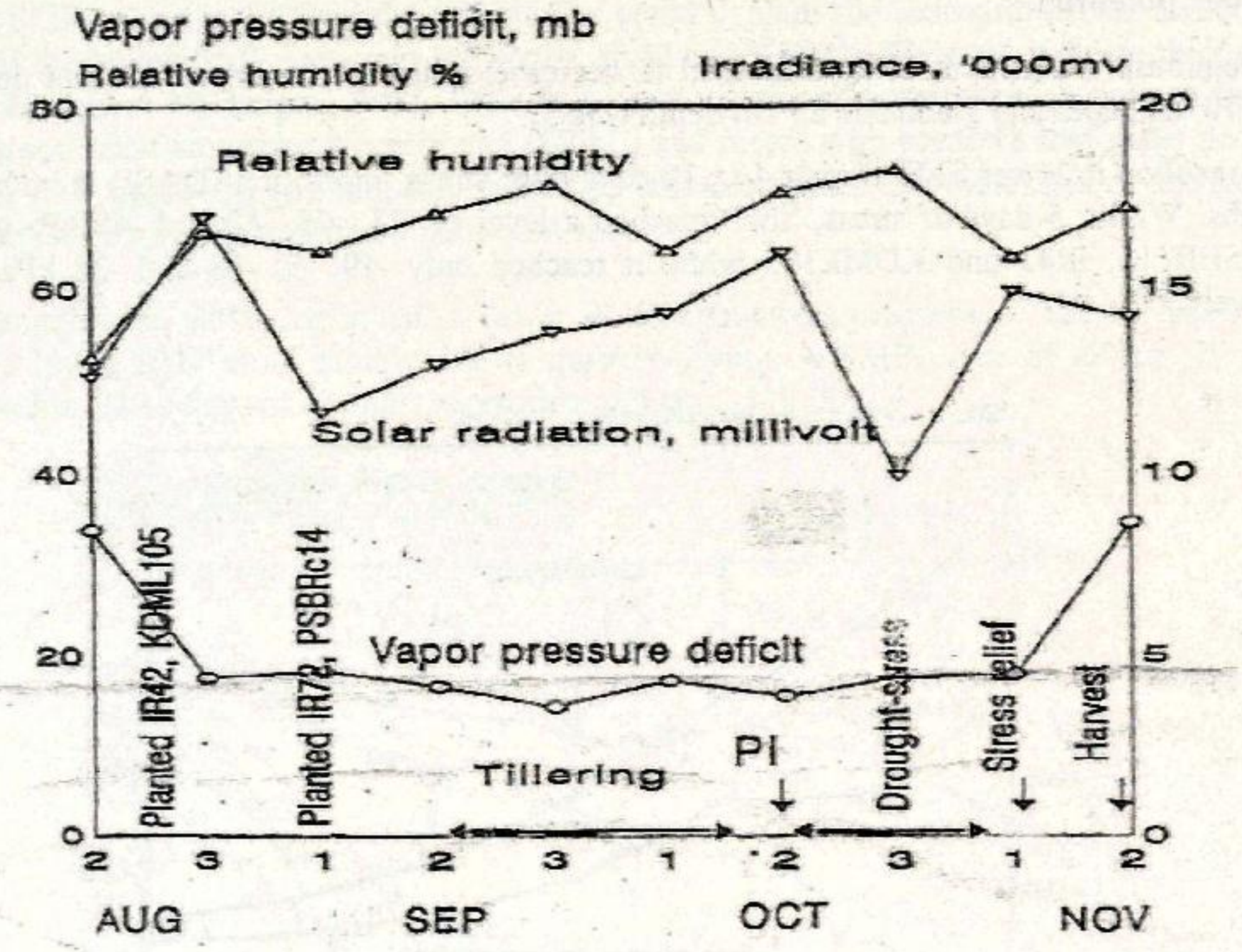


Fig. 1. Crop growth stages and draught stress period coinciding with environmental weather parameters in the greenhouse, IRRI, 1994 wet season; PI = panicle initiation

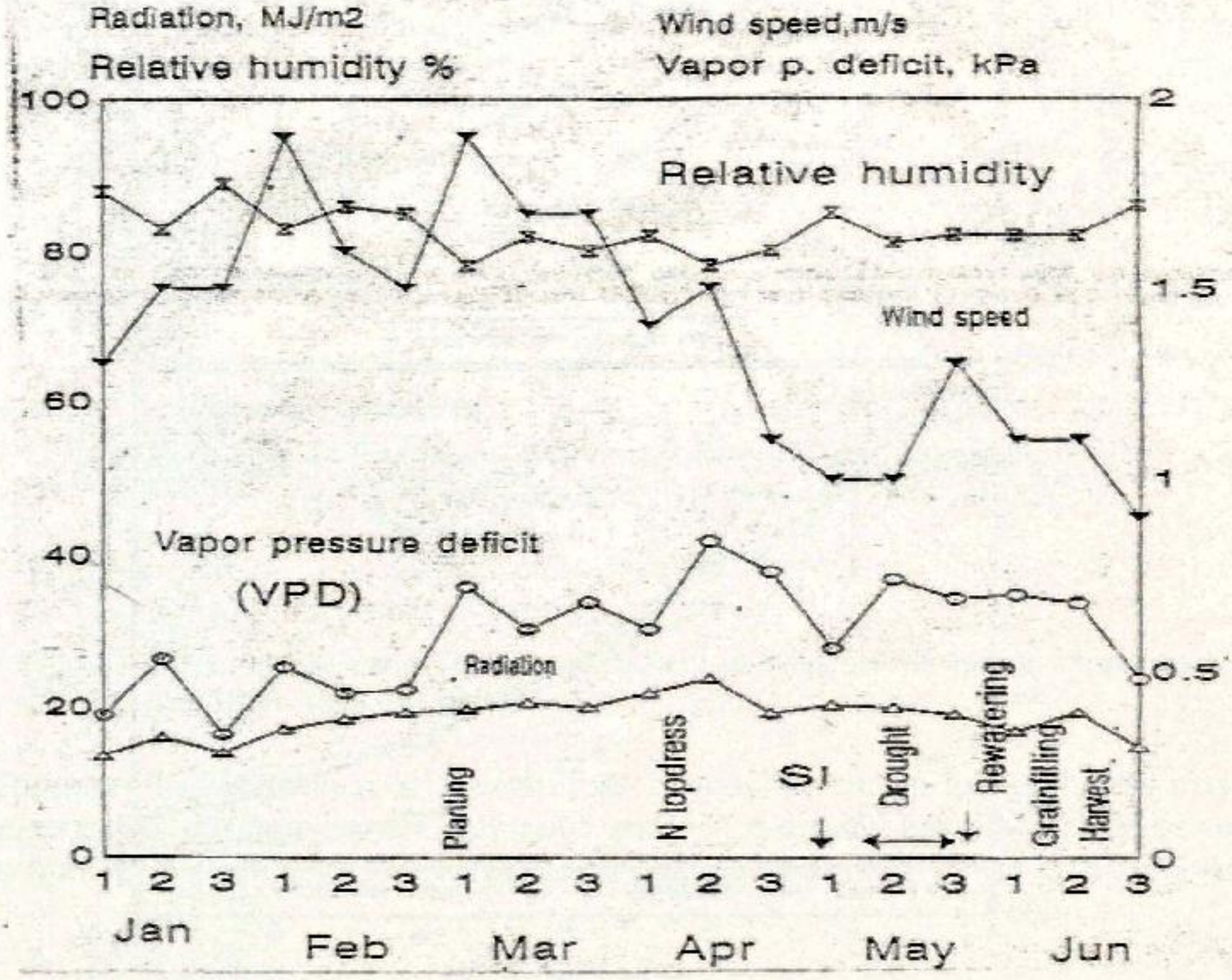


Fig. 2. Crop growth stages in relation to weather parameters at upland site (UM1) during study period, 1994 dry season; SI = Stress imposition at panicle initiation

**Soil matric potential**

In a greenhouse experiment SMP continued to decrease as the stress progressed and decrease was rapid at 10 cm depth and gradual at 25 cm depth (Fig 3).

High N resulted in lower SMP during 4 to 10 days after stress imposition (DASI) at both 10 and 25 cm depths. Within 5 days of stress, SMP reached a level of -73, -66, -62 and -48 kPa at 10 cm in IR72, PSBRc14, IR42 and KDML105 while it reached only -19, -9, -18 and -38 kPa at 25 cm respectively.

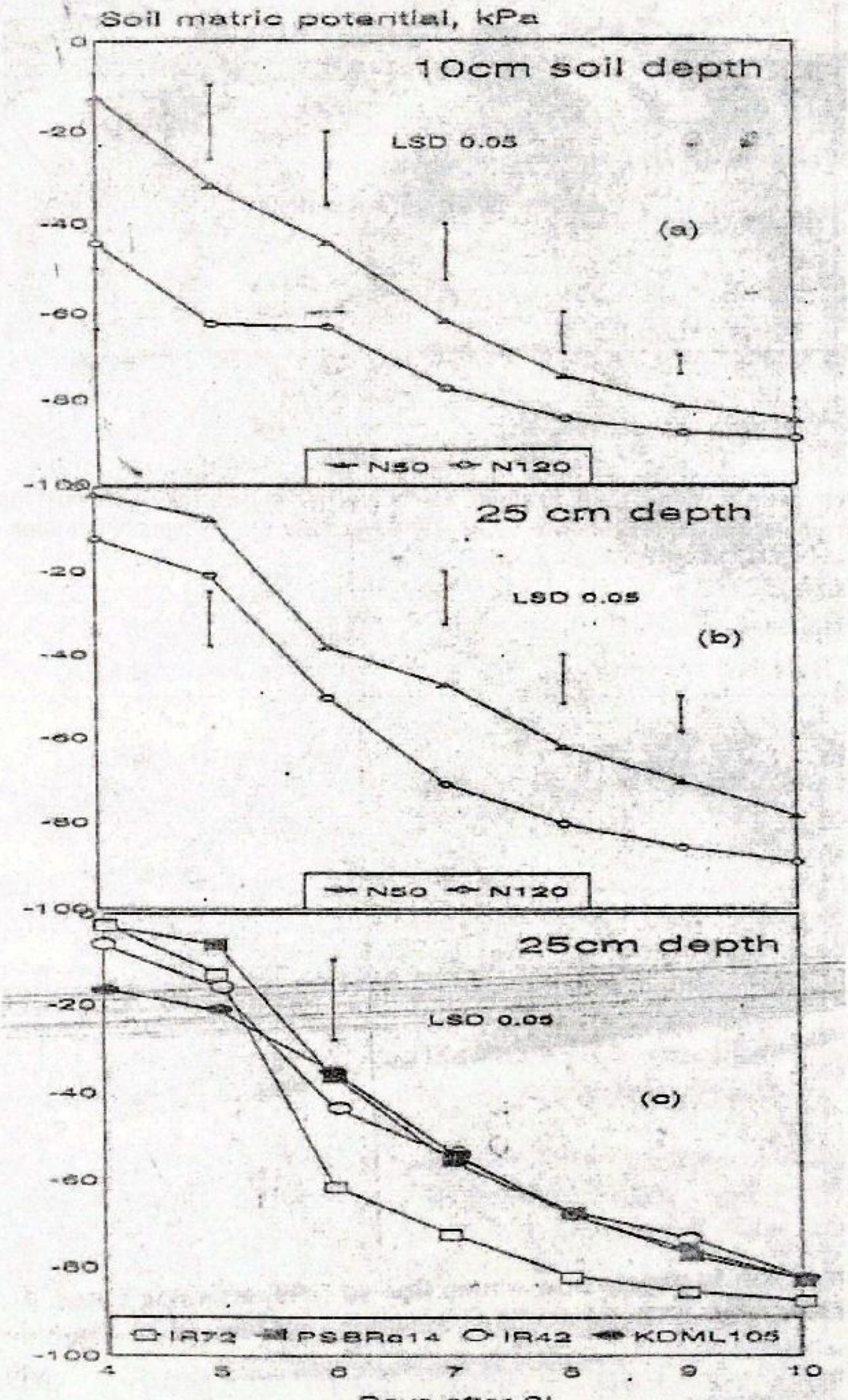


**Fig. 3. Soil matric potential (kPa) by soil depths and stages of rice in response to N at 10 and 25 cm depth (a, b), and four cultivars at 25 cm (c), IRRI, 1994 wet season;** SI = stress imposition

The lower SMP values in IR72 in the greenhouse could explain the susceptibility of this cultivar to drought and the higher SMP values in PSBRc14, IR42 and KDML105 could indicate their ability to withstand drought a bit longer. Thus, SMP can send water communication signals to the leaves through the soil plant atmosphere continuum (SPAC) and match with predawn leaf water potential. It can indicate how tightly the soil moisture is held by soil micropores and the extent of tension needed to extract moisture by plant roots during drought situation.

In a field experiment, SMP continued to lower as drought-stress progressed. The surface layer soil registered a lower SMP more rapidly due to quicker drying. A SMP value of -60 to -70 kPa was observed within 12-15 days of drought imposition at 5 cm depth (Fig. 4).

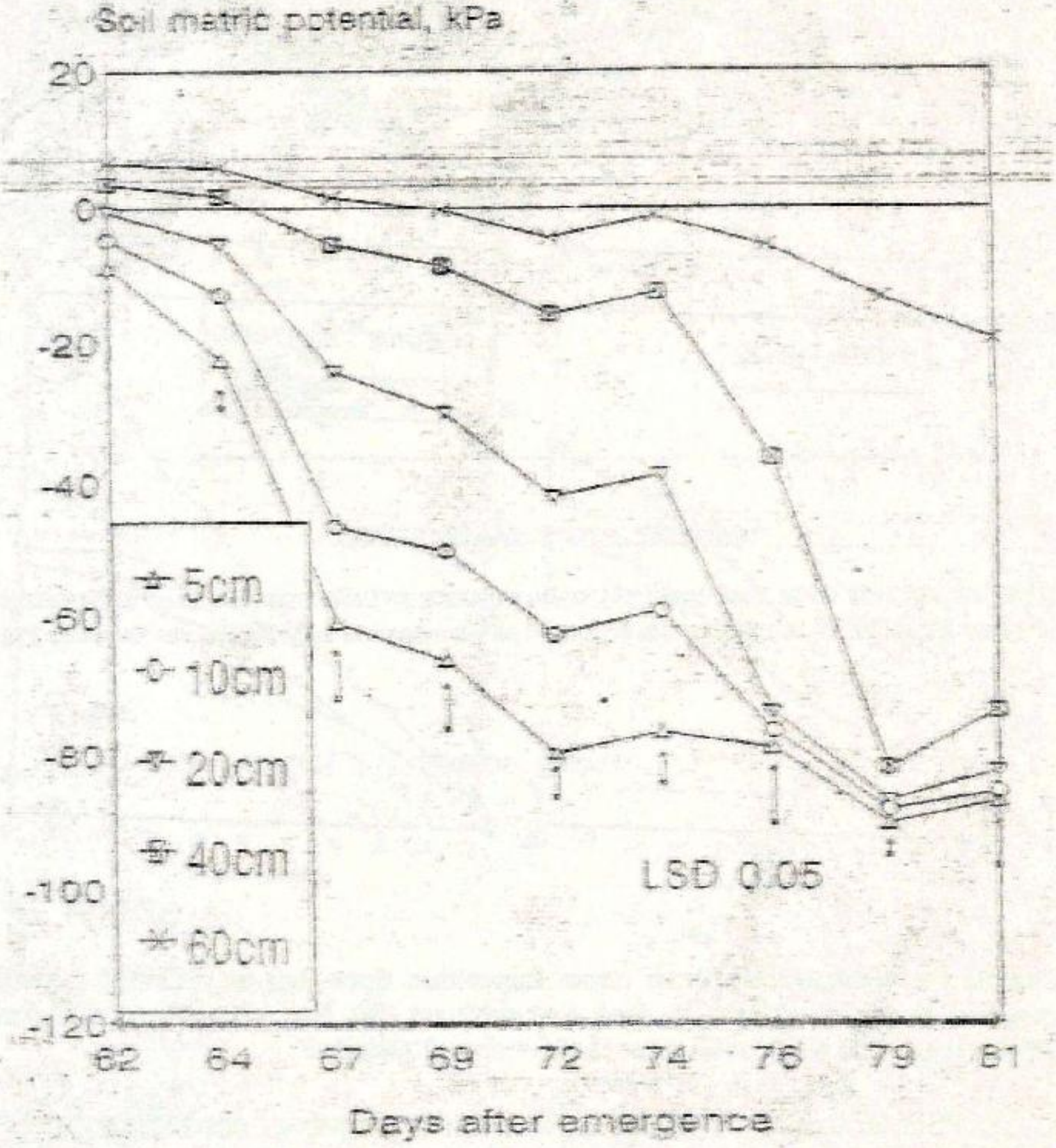


**Fig. 4. Soil matric potential (kPa) in rice field in response to various stages and depths of rice, IRRI, 1994 dry season**

The little difference in SMP values at the start and towards the end of drought stress may indicate little difference in soil moisture content between 5 and 20 cm depth. Thus, SMP could be very useful and reliable for rice as it could show severe drought stress even at SMP of -40 to -50 kPa (Ingram *et. al.*, 1992).

### Cumulative transpiration

In a greenhouse experiment, drought treatments significantly lowered the CT than did well-watered treatments from 7 DASI onwards (Fig. 5). High N significantly increased CT than did low N during initial drought period up to 8 DASI with the magnitude of increase as of 7% every day (double).

Drought coupled with high N decreased CT by 22.6 to 48% as against 9.6 to 29% with low N of what obtained in well-watered condition during 9-13 DASI (Fig. 5).

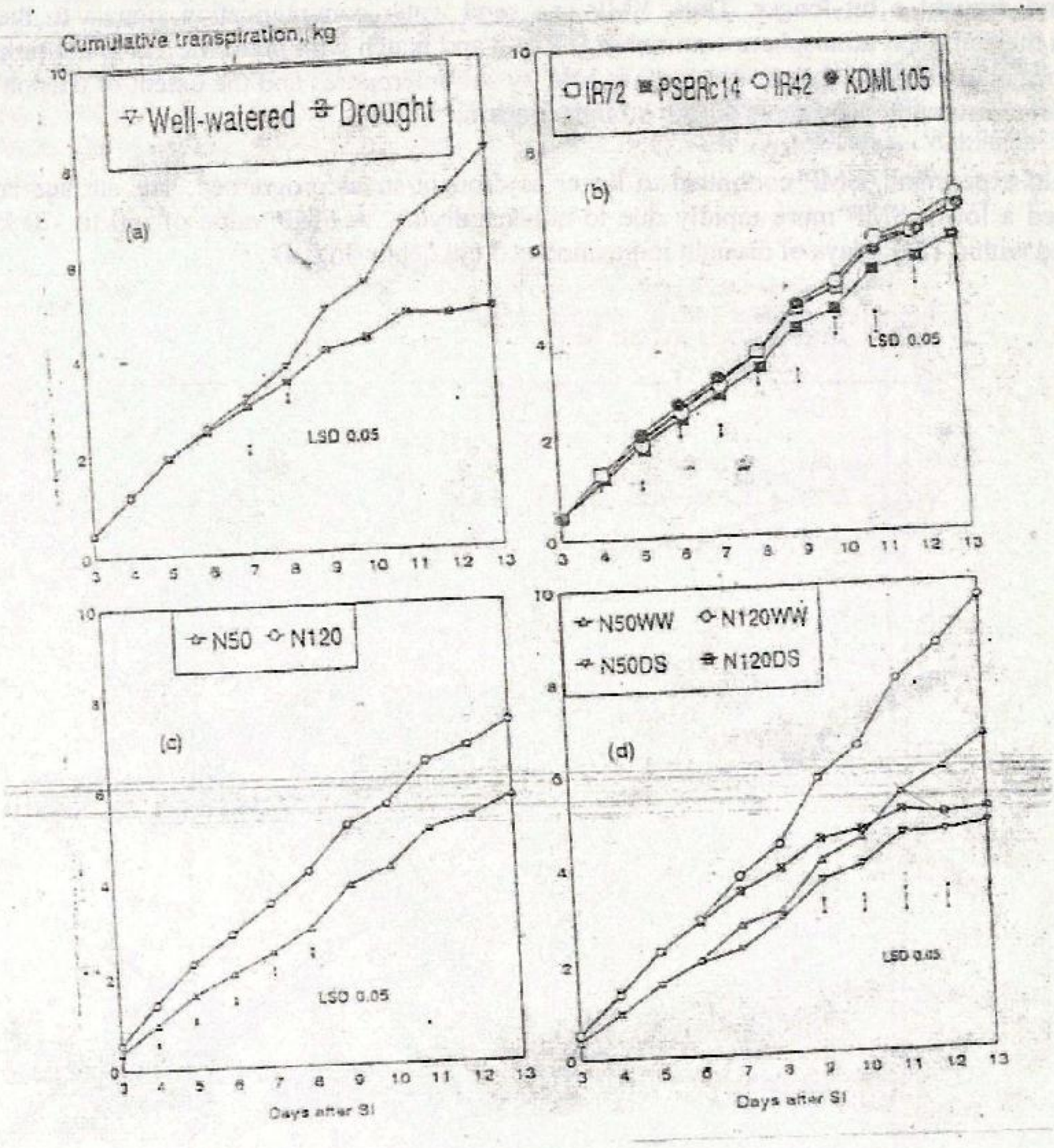


**Fig. 5. Cumulative transpiration from stress imposition time (kg) at different periods of rice in response to water regimes (a), four rice cultivars ((b), N (c), N and water regimes (d), IRRI 1994 wet season;** WW = well watered, DS = drought-stressed

The lowest CT in PSBRc14 might have led to decrease in growth of aboveground parts that might have helped this cultivar to adopt drought adaptive mechanism by sending its roots to deeper soil layers as a plastic response. High CT in KDML105 that might have allowed to continue growth could have depleted moisture faster with less adoption of drought adaptive mechanism. Though most water is lost through stomata at low water potential, cuticular transpiration may operate when stomates are closed (Blum, 1975).

Minimizing the transpiration load of water as noticed in PSBRc14 could be a survival and drought avoidance mechanism under stressful situation as plants might have closed their stomates and reduced their leaf area (LA) exposure through leaf rolling. A high positive correlation between CT and LA formation (r=0.79) and total SDM (r=0.82) indicated that both LA and total SDM increased with corresponding increase in CT (Fig. 6 and 7). Thus, most of the plant growth parameters like dry matter and LA were profoundly influenced by CT at 13 and 27 DASI. The higher the CT, the higher was the growth achieved. Increase in CT and leaf water potential may explain corresponding increase

in dry matter production by various plant parts. A high R2 value of regression between these variables indicated CT as a predictor of high dry matter production and thus a major driving force.

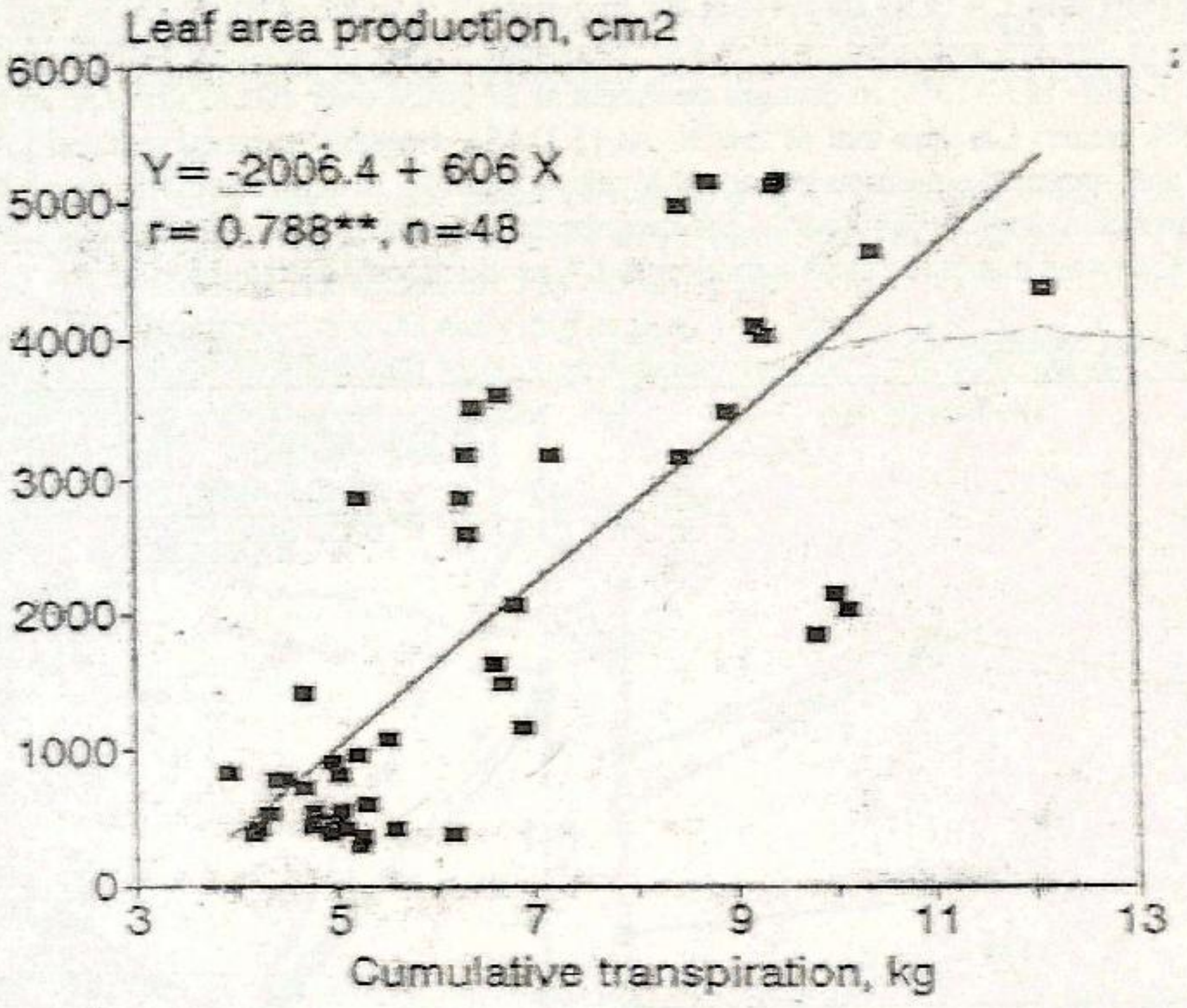


Fig. 6. Relationship between cumulative transpiration (kg) and leaf area formation ($cm^2$) of rice at 13 days after stress imposition in response to N and water regimes, IRRI, 1994 wet season

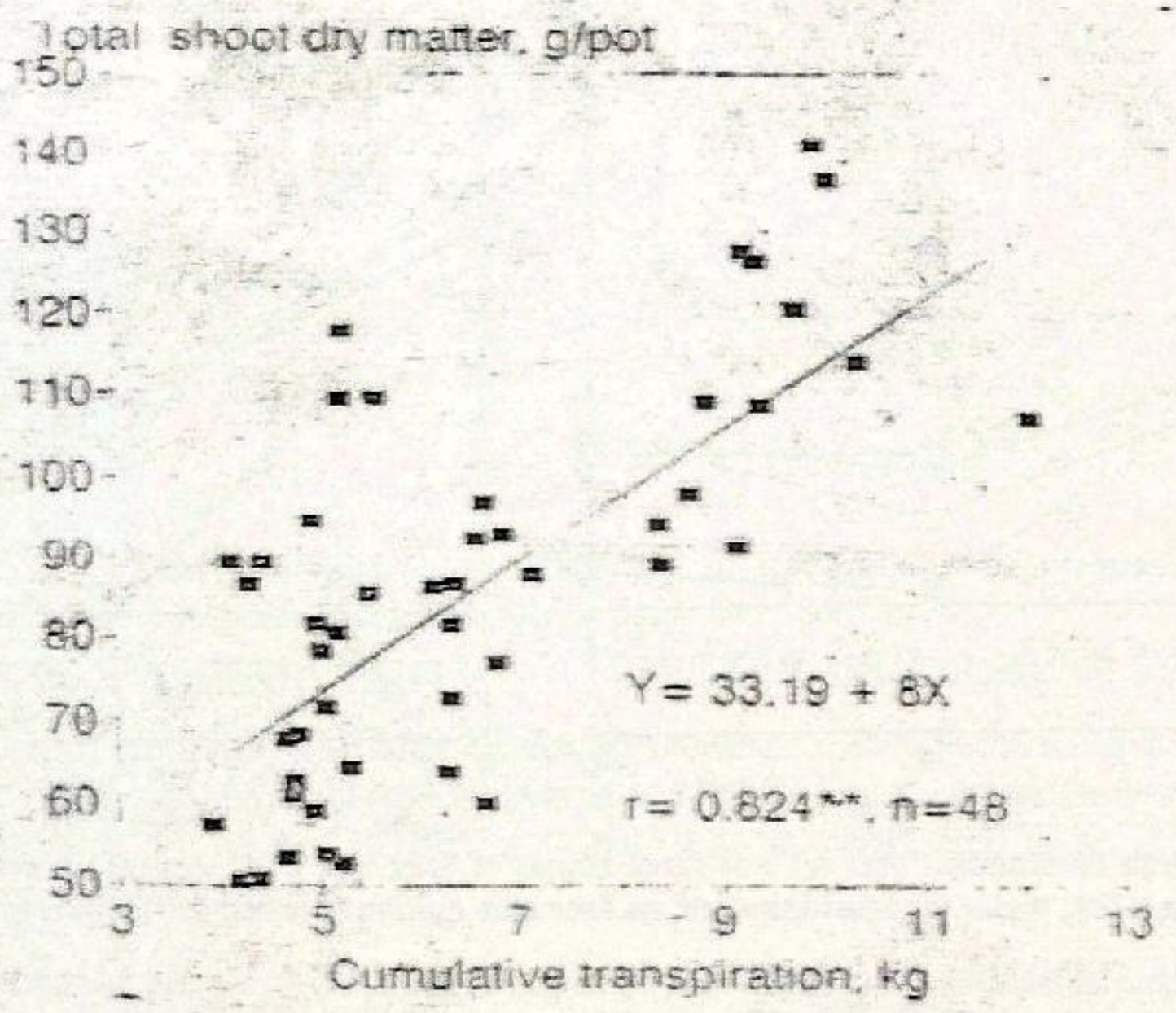


Fig. 7. Relationship between cumulative transpiration (kg) and total shoot dry matter (g/pot) at 27 days after stress imposition of rice in response to N and water regimes, IRRI, 1994 wet season

**Leaf area /LAI**

In a greenhouse experiment, drought significantly reduced LA at 13 and 27 DASI. High N significantly increased LA in all stages (Fig. 8). In general, LA reduced by 9-21% in well-watered and by 75-89.6% in drought treatment at 13 DASI. Leaf area further reduced by 24-25% in well-watered and by 2- to 3-fold (153-313%) in drought treatment at 27 DASI over that of stress relief time. High N produced 31% greater LA than that of low N. At 13 DASI, drought treatment reduced LA by 69-89% over that of well-watered condition at both N levels. It resulted in significantly higher LA of 810 $cm^2$ at low N than that at high N (449 $cm^2$). The magnitude of LA reduction was higher with high N than with low N. Cultivars displayed great variation in LA production in all the three stages.

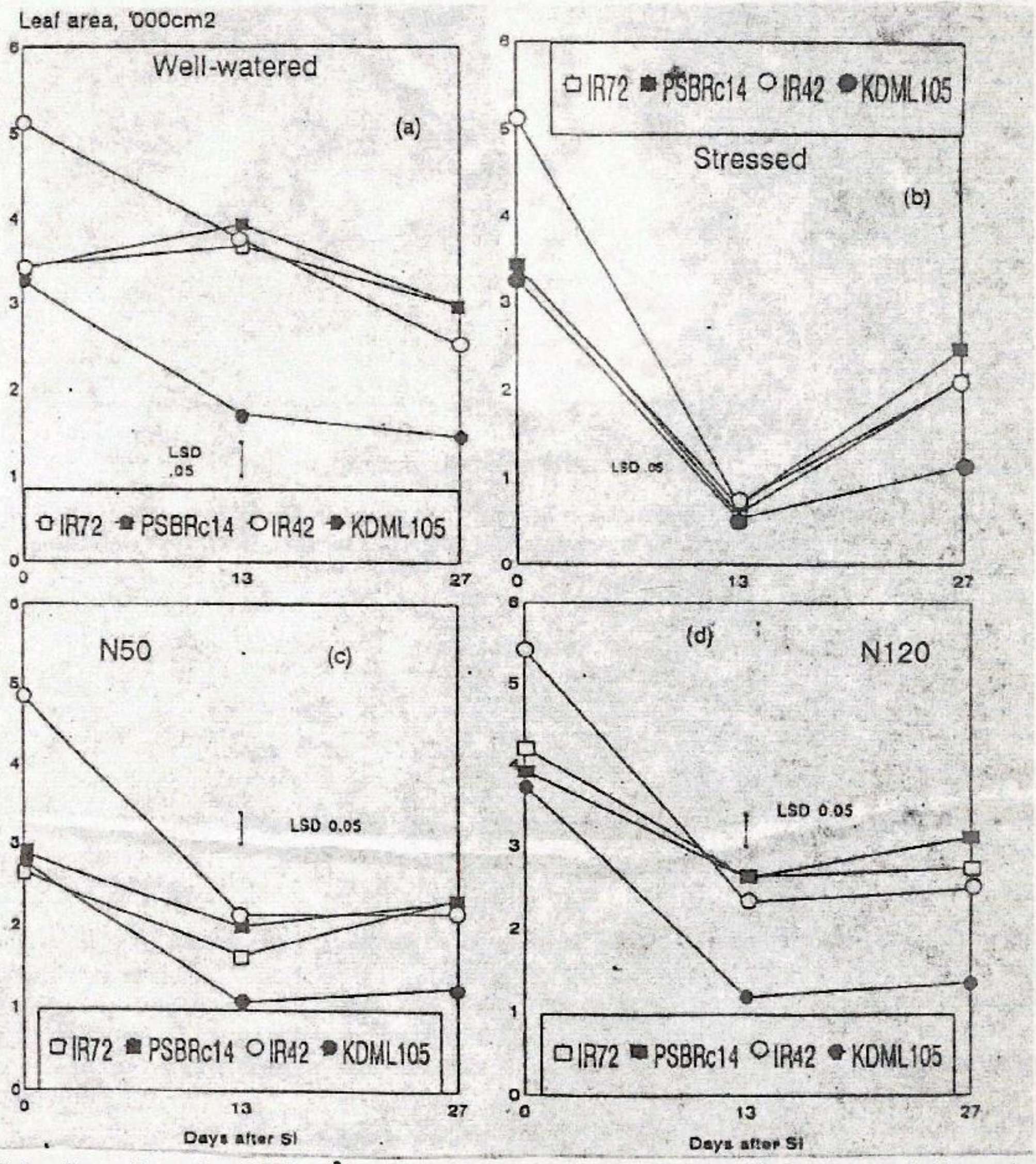


**Fig. 8. Leaf area formation ('000 $cm^2$) at three stages of four rice cultivars (a), in response to N x water regimes (b), water regimes imposed on four rice cultivars (c, d);** PI=Panicle initiation

Under drought condition, all the cultivars showed steep decline in LA by about 80-86%. However, PSBRc14 and IR72 had greater recovery percentage by about 44-52% than the other two (18-27%). Low N resulted in less reduction in LA than did high N under stressed condition.

Leaf area increased with age reaching its maximum near flowering and gradually declining thereafter due to senescence in well-watered condition. However, reduction in LA under drought could be due to leaf rolling, leaf drying and senescence. Similar reductions in rice LA by water deficit have also been reported by Cruz *et al.* (1986) and Ludlow and Muchow (1990). Greater recovery capability displayed by PSBRc14 and IR72 indicates their better adaptation under drought condition compared to the other two.

In field experiment, leaf area index of rice plants increased up to 73 days after emergence (DAE) and then sharply declined towards maturity (Fig.9). Leaf area index also remained higher with high N than that with no N. leaf area index reached as high as 6.3 at 59 and 73 DAE each with high N as against 3.67 with no N. IR72 produced significantly higher LAI than that of PSBRc14 at 93 DAE under drought condition. Drought coupled with N100 significantly reduced LAI in PSBRc14 (5.79) by about 18% compared to that in well-watered condition.

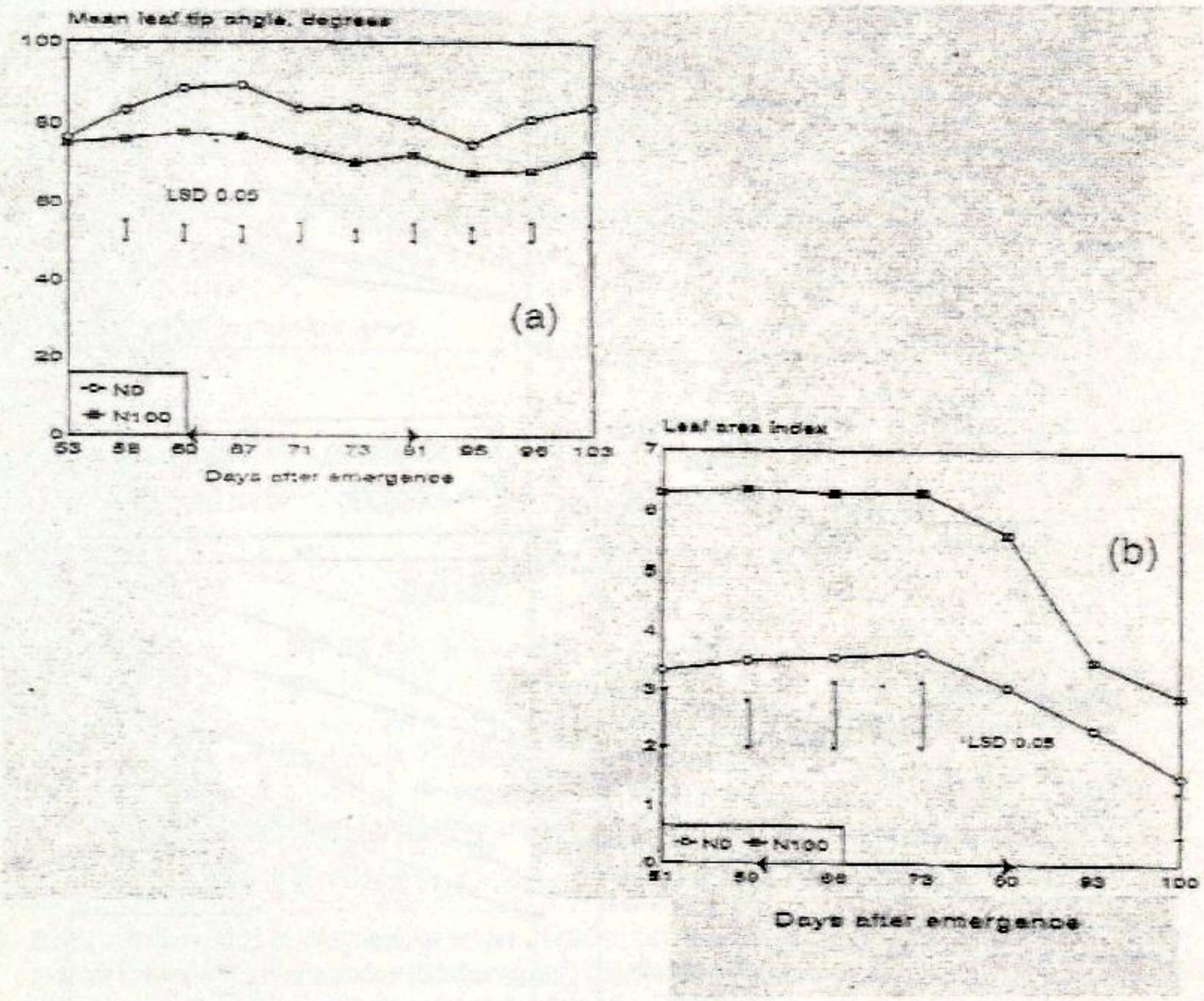


Fig. 9: Mean leaf angle (a), Leaf area index (b) at different growth stages of rice in response to nitrogen (N), IRRI, 1994 dry season; Arrow indicates drought-stress period.

The genotypic variation in LA/LAI maintenance during drought could be utilized as a desirable trait for drought resistance. Thus, in the words of Gardner *et al.* (1985), LAI is one of the best measure of a crop's capacity to produce dry matter. Higher LAI could also be considered as an index for higher interception of incoming solar radiation.

Earlier researchers (Cruz *et al.*, 1986; Ahmed, 1992) have also reported reduction in LAI as a result of water deficit as in the present experiment. Ludlow and Muchow (1990) reported that reduction in LA was the result of stunted leaf growth and rapid leaf senescence. Plants subjected to water deficit during PI were unable to recover from reduced LAI where leaf senescence was to the irreversible extent.

**Total shoot dry matter**

In a greenhouse experiment, drought significantly reduced total shoot dry matter (TDM) on 13 and 27 DASI by about 13 and 22%, respectively. High N produced higher TDM than did low N. Cultivars differed significantly in TDM production in all dates and exhibited interaction effect with N (Fig.10). There was dramatic increase in TDM in IR72 and PSBRc14 compared to the other two cultivars at both N levels.

Though KDML105 and IR42 had comparatively higher TDM production, they had lower recovery percentage than PSBRC14 and IR 72 which demonstrated their ability to increase TDM at the end of drought by 70 and 58% of what obtained at PI and thus showed a further recovery of 31-32% at harvest. These results are indicative of high degree of adaptation to drought by PSBRC14 compared to IR72.

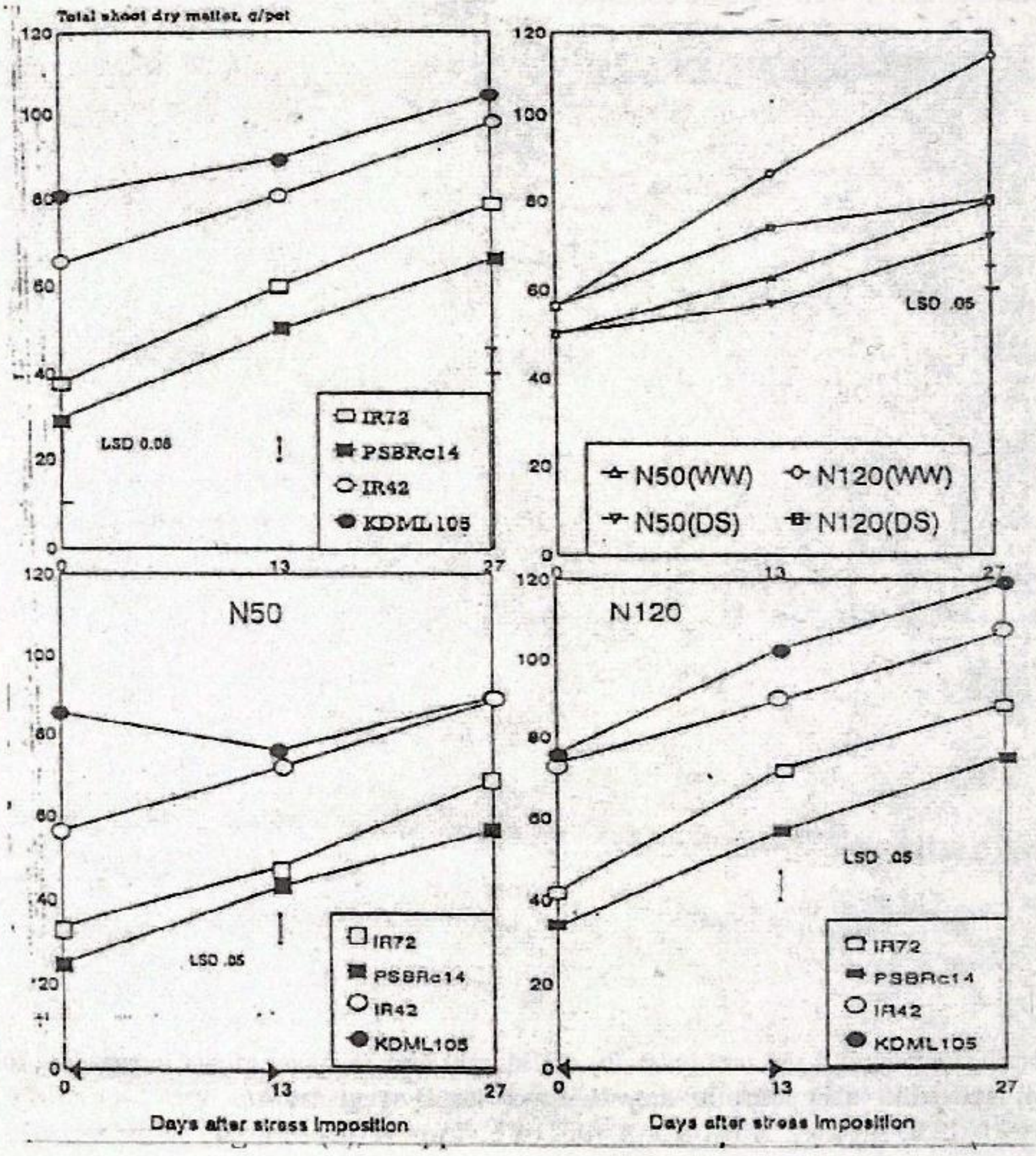


**Fig.10. Total shoot dry matter (g/pot) at three stages of four rice cultivars (a), in response to N and water regimes (b), N applied to four rice cultivar (c, d), IRRI, 1994 wet season;** WW = well-watered, DS = drought-stressed, Arrow indicates drought-stress period.

In general, well-watered plants produced greater shoot dry matter while plants at reproductive stage had the least. Differences in shoot dry matter among cultivars could mainly be attributed to differences in LA, daily and cumulative transpiration. The genotypes greatly displayed their abilities to alter dry matter production in response to drought and nitrogen thereby indicating presence of ample phenotypic plasticity. Crop growth is favored by water and nutrients (Gardner *et al.*, 1985).

In the field experiment, drought treatment reduced panicle dry matter (PDM) from 73 to 100 DAE. (Fig.11). High N produced higher leaf blade weight and total shoot dry matter. PSBRc14 produced significantly higher PDM than did IR72 from 58 to 80 DAE.

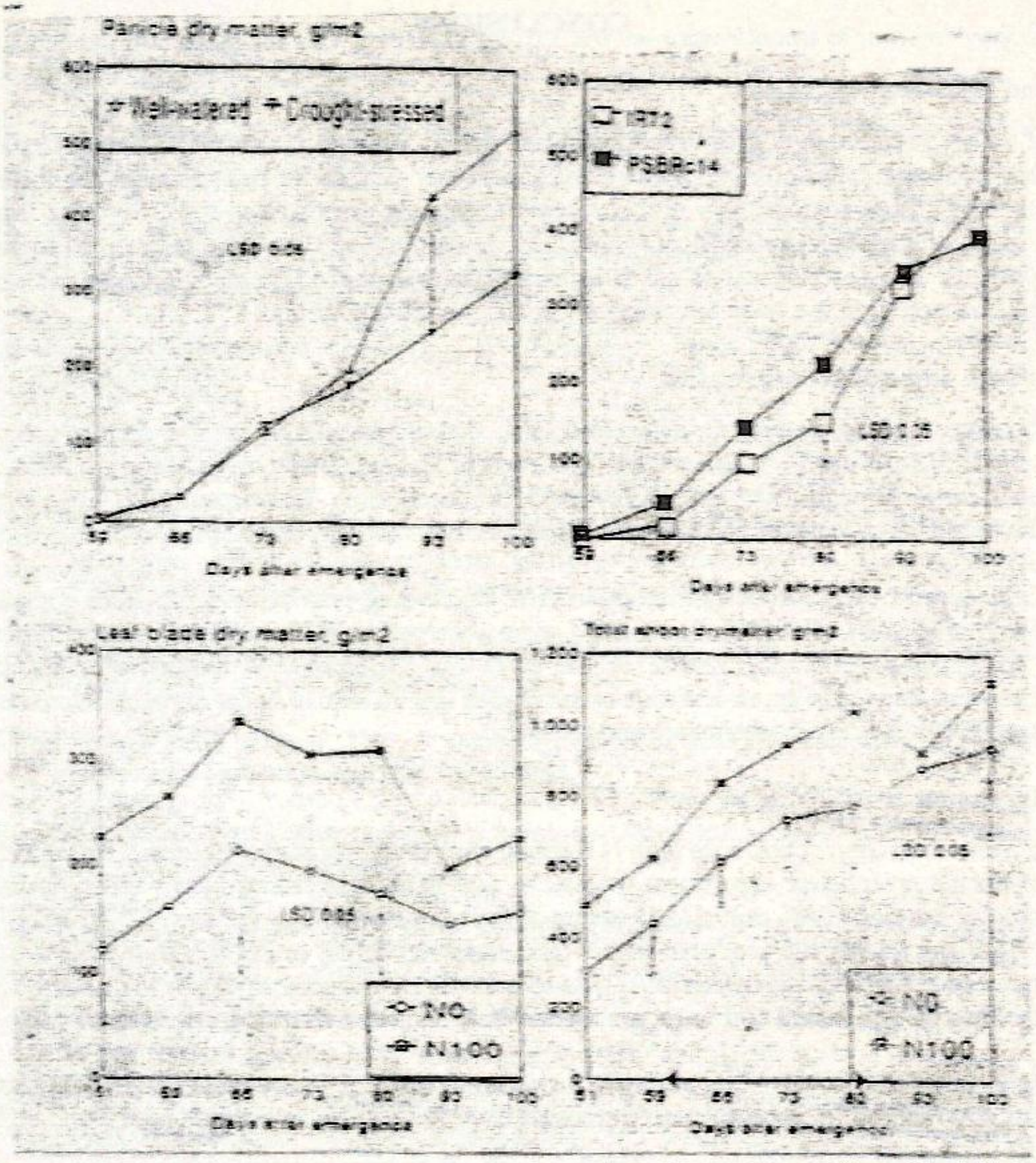


Fig. 11. Panicle dry matter in response to water regimes (a), and two cultivars (b), and leaf blade dry matter (c), and total shoot dry matter (g/m$^2$) (d), in rice in response to nitrogen (N), IRRI, 1994 dry season; Arrow indicates drought-stress period.

Reduced panicle dry matter production under drought compared to well-watered condition was probably due to less recovery of the drought-induced plants. Higher PDM in PSBRc14 indicates greater partitioning of stem dry matter to panicles and drought adaptation and escape mechanism in this cultivar due to higher panicle exsertion rate. Recovery in PDM by IR72 suggests better adaptability of this cultivar under rewatered condition.

Severe drought might have killed panicle primodria giving rise to some secondary shoots. The increased crop growth noticed after rewatering in drought and high N treatments could be possibly due to re-growth of new shoots. The reduced crop growth during drought could be due to rapid senescence, cessation of growth, reduction in shoot dry matter and shoot death.

Dry matter production is the rough estimate of total net photosynthesis that depends on light

interception. Production of higher panicle dry matter by PSBRc14 could be due to its advanced panicle initiation and exsertion rate than that of IR72 that might have contributed to good panicles.

## CONCLUSIONS

### Plant and soil water variables

Drought coupled with high N greatly reduced plant water variables like cumulative transpiration and soil matric potential. Low soil matric potential and a higher cumulative transpiration rate observed in IR72 indicated greater susceptibility of this cultivar to drought compared to PSBRc14. The less rapid decline in these variables by PSBRc14 indicated drought adaptation. Maintenance of higher soil matric potential assisted survival of green leaf area under drought. The above results indicate that cumulative transpiration is a good indicator of soil and plant water status.

### Plant growth and leaf area formation

Drought reduced plant growth variables like LAI, but increased leaf rolling. In the greenhouse experiment, PSBRc14 and IR72 showed less reduction in leaf area under drought and greater recovery upon rewatering. Though IR42 and KDML105 produced high leaf area at PI, they exhibited maximum reduction in leaf area at 13 DASI as well as a low recovery at 27 DASI.

In the field experiment, delayed phenology in term of heading was observed in IR72 compared to PSBRc14. Lower LAI and a higher leaf rolling score observed in IR72 indicated susceptibility of this cultivar to drought while maintenance of the same by PSBRc14 was indicative of its drought adaptation. Maintenance of green leaf area by genotypes like PSBRc14 under drought is considered to be a desirable trait for drought resistance and recovery.

### Shoot dry matter partitioning

Drought alone or in conjunction with high N reduced total shoot dry matter (leaves, stem, sheaths and panicles). In the greenhouse experiment, PSBRc14 and IR72 demonstrated their ability to increase total shoot dry matter by 70% at 13 DASI of that obtained at PI, and by a further 31-32% at 27 DASI. Though IR42 and KDML105 produced higher total shoot dry matter at PI, they showed less increase in shoot dry matter during stress (11-24%) as well less dry matter recovery (17-21%). PSBRc14 and IR42 were thus better adapted to drought among the early and late maturity groups, respectively.

In the field, PSBRc14 displayed its ability to produce higher panicle dry matter than IR72 though it was drastically reduced, in general, during drought. High N was able to increase both leaf weight and total shoot dry matter.

## RECOMMENDATIONS

Under drought, the soil surface dries and the rice plant is forced to seek moisture from deeper layers. It would be desirable to place fertilizer more deeply in rainfed conditions to increase its availability to the crop and thus nutrient use efficiency. Soil matric potential, and cumulative transpiration may provide more reliable estimates of soil and plant moisture status than leaf rolling score.

Breeders should select lines with these traits for drought-prone environments. Since IR72 and PSBRc14 were similar in phenology and dry weight in well-watered conditions but differed in responses to drought, they may be suitable probe lines for drought in a selection nursery. These results support the recommendation of PSBRc14 for drought-prone rainfed lowland environment and of IR72 for favorable environments. Further research is needed to examine more closely why these cultivars differed in water use during drought, and how they respond to drought at different growth stages.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# THE AGRONOMICAL RESEARCH ON FOOD CROPS IN THE CONTEXT OF FOOD SECURITY AND POVERTY ALLEVIATION IN NEPAL

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## INTRODUCTION

Agronomical research in Nepal was initiated in 1954 in Singha Durbar after the Agronomy Section was created in 1953 (Annual Report, DOACR 1968). In 1965, this section was transferred to Khumaltar. Other eight experimental farms were also established in different agro-ecological regions of the country under this section. Recommendation of improved varieties of food grain crops and their cultivation practices were initiated in a modest way. In the beginning, most of the agronomical research was focused on varietal improvement and few on crop management. After the establishment of the crop commodity programs in 1972, agronomical research was further strengthened. As the Agronomy Division focused on crop management at national level, the mandate of the Agronomy Division on crop improvement was taken over by the commodity programs. At present, agronomical research on cropping systems, green manuring, crop modeling, fertility management etc. are being conducted in different stations. Research on crop physiology and agrometerology is being initiated.

Though we have achieved increasing yield in all food grains during the last decades, there is no room for complacency and efforts should be made to enhance production to meet the growing needs. There is limit for further increase in cultivated area. Therefore, the additional requirement of food grains in future has to be met by increasing productivity.

There is a considerable gap between the national average and achievable yield in all crops. The gap is due to numerous biological (varieties, diseases, insects, nutrients etc.) environmental (temperature, moisture, climate, sunlight etc.) and management (time of planting, spacing, seed rate, fertilizer rate etc.) constraints. By removing these constraints and managing them properly, it is possible to achieve potential yields of all the crops and their varieties. For this, it is essential to analyze the limiting factors at micro level. Agronomical research, therefore, consider all these management factors (both biological and environmental) to achieve maximum yield potential of all the crops.

## CROP IMPROVEMENT AND AGRONOMICAL RESEARCH ON FIELD CROPS (1954-1972)

### Rice

The release of the Taiwanese rice varieties in 1960's revolutionized the rice farming in Kathmandu valley and similar other warm temperate zones. The yields of 8 to 10 ton $ha^{-1}$ are not uncommon. The varieties are still popular despite their susceptibility to foliar and neck blast. They were wet season rice and now they are able to grown as spring rice in lower river valley.

The CH45 rice variety triggered the cultivation of two rice crops a year since its release in 1970's. It really helped double rice yields in irrigated areas. The addition of one kilogram of fertilizer increased grain yield by 18-20 kg depending upon the season and variety.

The first fertilizer management study on rice was reported in 1958 (Mallik, 1976). Several agronomical researches were conducted in the past and attempts were made to achieve higher yield of these crops.

***Impact of rice research.*** The success in increasing rice yield after 1970 was based on a research approach of developing high yielding genotypes with their production practices, which can express full yield potential. Farmers were able to grow double crop of rice in Terai and lower valley with the release of CH45. It helped a lot to small and marginal farmers in food security and poverty alleviation. Beside this, intensive cropping demanded more labor per hectare and created jobs for poor.

These varieties expanded the rice area giving two rice crops in a year. The total rice production of 1.3 million tons in 1960 increased to 3.5 million tons in 1998. The increase in production was mainly because of area expansion. The development of early and medium maturity varieties increased the crop intensity giving enough time for wheat planting.

### Wheat

Wheat is one of the major cereal crops after rice and maize in Nepal. It is relatively new crop and widely adopted since late 1960's with the introduction of new high yielding Mexican wheat cultivars. The wheat yield was raised from 950 kg/ha in 1960's to a level of 1680 kg/ha in 1996/97. But the yield is still very low compared to the wheat yield of other countries in the region.

Early maturing wheat varieties stimulated double cropping and even triple cropping in some areas. For example, RR21 variety can be planted until last week of December, which is 45 days later than the tall wheat varieties and harvested with other varieties in spring. It allows to have rice – wheat rotation on large area instead of rice – fallow. It also allows to have three cropping pattern like rice - wheat – mungbean in irrigated lower valley bottom and Terai.

***Impact of wheat research.*** The social impact of modern wheat varieties and technology in the third world was evaluated by a World Bank Consultant, Dr. Grant Scobie in 1979. He considered more economical impact rather than other. He generalized the following impacts, which are applied to Nepal. The general impacts were:

- Irrespective of farm size and land tenure, all the farmers adopted new varieties and new technologies, resulted higher yield and supported in food security.
- The new varieties and technologies increased the demand of agricultural labor. Thus, it created the direct employment opportunity in agricultural sectors and indirect opportunity from transport, storage, processing etc. Multiple cropping was encouraged by early maturing varieties, increasing employment. The increased income from grain crops was spent in other commodities. Thus, it helped poverty alleviation.
- Increasing food grain production decreased price.

## AGRONOMICAL RESEARCH ON FIELD CROPS (1972- TILL NOW)

### Rice

***Seeding date.*** Rice can be grown successfully from February (early rice) to July (normal wet season rice). Different studies on planting date in the past reported that March 15 to 30 seeding is optimum for early rice (spring rice) and May 15 to 30 for normal wet season rice.

***Seedling age.*** For normal season rice varieties such as Radha 7, Radha 11 and Radha 12, 20 to 60 days old seedlings had statistically similar yield response (Table 1). This elasticity is poor if monsoon is delayed or drought prevails for a longer period.

***Spacing.*** Many experiments on spacing conducted in the past in different rice varieties showed that 20 cm X 15 cm for early/medium maturity varieties and 20 cm X 20 cm for late varieties were optimum.

**Table 1. Effect of age of seedlings on yield of rice varieties, 1993-94**

| Varieties | Grain yield (t ha$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 20 days | | 30 days | | 40 days | | 50 days | | 60 days | |
| | 1993 | 1994 | 1993 | 1994 | 1993 | 1994 | 1993 | 1994 | 1993 | 1994 |
| Radha7 | 3.31 | 4.61 | 4.07 | 4.42 | 3.63 | 4.68 | 3.68 | 4.40 | 4.12 | 3.88 |
| Radha11 | 3.86 | 4.71 | 3.82 | 5.23 | 3.38 | 4.83 | 3.31 | 4.97 | 3.61 | 4.16 |
| Radha12 | 4.19 | 5.37 | 4.43 | 5.37 | 3.47 | 5.28 | 4.33 | 4.85 | 4.06 | 4.54 |
| Bansdhan | 3.90 | 3.81 | 2.90 | 3.46 | 3.38 | 4.68 | 4.10 | 5.16 | 3.47 | 4.75 |
| RP1017-169-14 | 3.61 | 4.19 | 3.71 | 4.66 | 3.13 | 4.99 | 2.91 | 3.83 | 3.21 | 4.11 |

***Fertilizer management.*** Fertilizer trials on rice were conducted in the past to study the response of nitrogen, phosphorus and potassium, when applied alone and in combinations. Studies were also made to learn the effects of organic manure. The recommendation of different nutrients was based on the experiments conducted at different locations (Joshy and Deo, 1976).

Cultivar Chainung 242 yielded the highest with 100:40:30: kg N:P:K ha$^{-1}$ in experiments conducted for 5 years at Khumaltar. It also indicated that FYM alone is not enough to maintain soil fertility for sustainable rice production. The highest yield was recorded with 100:40:30 N:P:K and 50:20:15 N:P:K along with green manure till fourth year of the study (Table 2)

**Table 2. Mean grain yield of rice kg ha$^{-1}$ (variety Chainung 242) with different organic and inorganic fertilizer under rainfed lowland condition at Khumaltar, Nepal**

| Treatment | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|
| FYM 10 t ha$^{-1}$ | 1506 | 2666 | 5548 | 2722 |
| Kisan Mal 10 t ha$^{-1}$ (2:10:1.5 NPK) | 1637 | 2380 | 4431 | 2839 |
| Kisan Mal 5 t ha$^{-1}$ | 1344 | 2249 | 4110 | 2260 |
| 100:40:30 NPK kg ha$^{-1}$ | 1539 | 3234 | 6063 | 3596 |
| 50:20:15 NPK kg ha$^{-1}$ + Green manure | 2276 | 3145 | 3500 | 3286 |
| Control (no FYM and fertilizer) | 1370 | 2390 | 4326 | 2453 |
| Compost 10 t ha$^{-1}$ | 1183 | 2609 | 4382 | 2138 |
| Gobar gas slurry 10 t ha$^{-1}$ (dried) | 1374 | 2227 | 4794 | 2203 |

In the long term fertility trial on rice at National Rice Research Program (NRRP), Parwanipur, indicated that NPK 100:30:30 kg ha$^{-1}$ plus 25 kg ha$^{-1}$ ZnSO4 is the optimum dose for rice. In another long-term fertility experiment conducted at Bhairahawa, early rice grain yield was found to decrease linearly and went down to zero by the fifth year in the plots without phosphorus fertilizer.

Variety cum fertilizer trial conducted at NRRP indicated that the rice crop showed response only up to 90 kg ha$^{-1}$. Increasing N beyond this level showed decreasing yield trend in most of the varieties. The Soil Science Unit of NRRP, Parwanipur recommended fertilizer dose for some rice genotypes based on varieties cum fertilizer trials (Table 3).

*Water Management.* Water management study in early rice at NRRP, Parwanipur showed that constant saturation condition (1 cm depth) throughout the growing period yielded maximum. One week drain at early tillering and continuous flooding (5±2cm depth) was better than flooding (5±2cm depth) throughout the growing period.

**Table 3. Recommended nutrients dose for different rice varieties made by National Rice Research Program, Parwanipur, Nepal**

| Varieties | Irrigated (kg ha$^{-1}$) | | | | Rainfed (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | $ZnSO_4$ | N | $P_2O_5$ | $K_2O$ | $ZnSO_4$ |
| Sabitri | 100 | 30 | 30 | 20 | 70-80 | 30 | 30 | 15 |
| IR46 | 100 | 30 | 30 | 20 | 70-80 | 30 | 30 | 15 |
| B 44 B | 90-100 | 30 | 30 | 20 | 70-80 | 30 | 30 | 15 |
| Radha4 | 80-90 | 30 | 30 | 20 | 70 | 30 | 30 | - |
| Radha7 | 50-60 | 20-30 | 20 | 15 | 50 | 20 | 20 | - |
| Radha9 | 40-50 | 20-30 | 20 | 15 | 50 | 20 | 20 | - |
| Mansuli | 60 | 20-30 | 20 | 15 | 40-50 | 20 | 20 | - |
| Radha17 | 100 | 30 | 30 | - | 100 | 30 | 30 | - |
| Radha11 | 90 | 30 | 30 | - | 90 | 30 | 30 | - |

## Maize

Maize is the second important staple food crop in Nepal. It is grown in about 30% of total cultivated area and share about 27% of the cereal production. Nearly 80% of the maize area is in the hills, mostly under rainfed and marginal (Bari) land. Therefore, productivity of maize is low. The area, production and productivity has marginally improved over the last twenty-five years in Terai, whereas in mid and high hills area under maize has increased by 200% but productivity has declined by 17%. Different agronomical researches have been conducted to generate appropriate technologies for increasing the production and productivity in different agro-ecological zones of the country.

*Planting date.* Planting time plays a key role in growth and development of plants. It ensures adequate temperature for germination and growth, avoide extreme temperature (cold) that causes stress and difficulty in setting and developing seeds. Considering these factors, National Maize Research Program (NMRP) in collaboration with other agricultural research stations conducted a number of seeding date trials at Rampur and elsewhere. Sharma (1978) recommended the following planting dates of maize for different agro-ecological zones:

| | |
|---|---|
| Mid and high hills | March – April (Summer maize) |
| Terai and inner Terai | April – May (Summer maize) |
| Mid-hills | February (Spring maize) |
| Inner Terai | February – March (Spring maize) |
| Terai | September – October (Winter maize) |
| Inner Terai | September (Winter maize) |

Winter maize has higher grain yield than summer even if the same variety is used. Almost double yield has been documented in winter maize than in summer maize. The possible reason for obtaining higher yields with winter maize is that it grows and develops over a longer period of time and has long grain filling period. The insects/pests infestation was also found minimal in winter maize (Schmidt and Karna, 1978).

***Plant population.*** Appropriate plant population is a must for efficient utilization of incoming solar radiation. This can be achieved by manipulating plant density and its uniform distribution over the land surface.

Maize is grown either sole crop or mixed/inter-cropped with soybean and finger millet. In such cases, maize plant density might be different. To determine the proper plant density of maize, several researches were conducted under different agro-ecological zones.

Optimum plant population for maize in monoculture is 53000 plants per hectare, but it can be increased to 63000 plants per hectare without adverse effect (Koirala *et al.*, 1978). Sen *et al.* (1982) reported that short duration variety Arun2 did better even with higher (90000 plant per hectare) population.

Maize plant population vary with different cropping pattern and altitude. Under poor plant stand, gap filling with 30 days old seedling reduce yield loss. Seedling transplanted after cutting leaves was better than transplanted with full leaves (Sthapit *et al.*, 1988).

***Weeding / earthing-up.*** First weeding at 20-30 days after sowing, and earthing up before tasselling are important for higher yield. There was no varietal selection for response to weeding and earthing-up (Chand *et al.*, 1991). Pre-emergence application of Atrazina – 50 WP @ 3 g/ht was found effective to control weeds. Subedi (1994) reported heavy yield losses in maize without weeding thinning and earthing-up. Therefore, weeding, thinning and earthing-up were found to be important factors for maize yield grown in rainfed Bari land condition.

**Wheat**

Wheat is relatively a new crop in Nepal. It is widely adopted since late 1960's with the introduction of new high yielding Mexican wheat cultivars. Several agronomical researches have been carried out to improve wheat yield. Technologies generated so far have helped farmers to improve both production and productivity of wheat.

***Crop management.*** The major limiting factor for high yield of wheat is poor crop management practices. It includes crop establishment, planting date, weed management, water management and fertilizer management. Although general agronomical recommendations, especially on the cultural aspects have been a complicated task because of varied agro-climatic and socio-economic conditions prevailing in the country, varieties released by NWRP are tested over a wide range of agro-ecological zones for adaptability.

Optimum wheat planting date for hill is found to be the middle of October, where as in Terai, the middle of November. Wheat sowing in Terai can be delayed up to the second week of December without significant yield reduction, but wheat planted beyond these dates resulted yield reduction of 30-50 kg/ha/ day.

General recommendation of seed rate is 100 kg/ha. Farmers are using as high as 200 kg/ha. It is because of poor seed quality and not adequate moisture for germination. Recent experiments have shown that additional 25 to 50 kg seed per hectare is required in addition to the recommended dose for both line sowing and broadcasting system.

More than 50% of wheat area in the country is under full or partially irrigated condition. It has been proven that irrigation provides a significant increase in yield. Crown root initiation (CRI) stage (21-30 days) is considered as a most critical stage for irrigation. Depending on the water availability, irrigation at heading and grain filling stages are also recommended.

Weeds are becoming an emerging problem in wheat cultivation. Several weed species are associated with wheat crops. *Chenopodium album, Polygonum hydropiper, Rumex* spp. and *Phaleris minor,*

*Avena fatua*, *Polygonum* spp. are major weeds, which causes economic loss. One hand weeding at 30-40 days after planting improves wheat grain yield. 2, 4-D sodium salt (80% water soluable) @ 1 kg/ha for broad leaf weeds and isoproturon (75% water soluable) 1 kg/ha for narrow leaf weeds are recommended for post emergence (30-40 days of sowing) weed control.

*Surface/relay seeding*. Late planting of wheat is caused either by an excess or lack of soil moisture or long-term round time between wheat and previous rice crop. In addition, large area remains fallow during winter because of excess soil moisture at rice harvest. In such cases, wheat can be grown by two ways: planting wheat in fallow wetland and relay with rice before harvesting.
Surface/relay seeding of wheat is a useful technology for timely planting of wheat in excess moisture and also plant wheat in traditionally non-wheat area (lower wetland). It reduces production cost and improves the quality and productivity of wheat because of timely planting.

## CROPPING SYSTEM PROGRAM

The Cropping System Program (CSP) was initiated in 1977 within the Agronomy Division as a part of the Integrated Cereals Project (ICP). The CSP was launched in different agro-ecological zones of the country, including hills, inner Terai and Terai. The basic concept of cropping system research was to look at farm production as the function of environment and management. Management includes the planting of crops in time and at proper spacing with other associated cultural techniques. The cultural techniques of the cropping pattern cover the choice of crop varieties, time and method of its establishments, fertilization, water management etc. The economic performance of cropping system was also evaluated in farmers' conditions. Hence, the objectives of the cropping system research were:

- to find out the best management practices for different environment.
- to develop methodology for dissemination of technologies in similar conditions / environments.
- to develop feed-back mechanism to on-station and on-farm research and develop appropriate technologies.

To meet these objectives the following research activities were carried out:

### Component technology trial

Component technology trial on crop management, fertilizer management and varietal improvement were conducted in different cropping system research sites. The successful components (management practice, fertilizer and or varieties) were verified in cropping pattern trials on loose plots. These studies were successful for identifying location specific technologies in each cropping system sites.

### Cropping pattern trial

The cropping pattern trials tested both improved version of existing cropping patterns that farmers were currently using and introduced alternative cropping pattern that were usually made more intensive by adding additional crops to existing patterns and / or substituting new crops not currently being grown by farmers.

More than 100 cropping patterns were tested in different cropping system sites under different environmental conditions (irrigated lowland, rainfed lowland, upland etc.). The main focus of the cropping system research was to increase production by increasing land use intensity and/or by increasing the yield of individual crops in the pattern.

### Pre-production verification test

The successful technologies on cropping pattern trials were tested in large plots (0.5 ha) for further verification of the technologies. These verification plots replicated 3 to 5 farmers' field. These plots

were used for demonstration in the sites. In case of varietal verification, these plots were served as seed source for large plots.

**Pilot/large-scale production program**

On the basis of results obtained from the on-farm cropping system research, a pilot production program was initiated in 1980/81 with 23 hectares in Parsa district. The results were found encouraging and thus expanded to 513 hectares in 1983. The major source of technology for this program was cropping system sites. This area expanded to 17000 hectares in 1984 and further expanded to 70,000 hectares in 26 district of Terai and inner Terai in 1985/86. During this period, significant achievements were made, and the impact of cropping system production technology on increasing farm productivity in both the irrigated and rainfed areas of Terai was demonstrated to farmers and administrators. Total grain production of 6.5 to 7 t/ha in irrigated condition and 4.5 to 5 t/ha in rainfed was obtained.

The valuable experience and the success gained from the Cropping System Program (1977-1985) made the way for the establishment of the Farming System Research Program, to help increase whole farm production by developing a farming system research approach for the welfare of small and resource poor farmers.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# VARIETAL STUDY ON RADISH FOR OFF-SEASON PRODUCTION

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## ABSTRACT

Six varieties of radish (*Raphanus sativus* Linn.) were evaluated at Agriculture Research Station (Horticulture), Malepatan, Pokhara (848 masl) in two consecutive years 1997 and 1998 to identify the best variety and appropriate seeding date for off-season radish production. A factorial RCB design was applied with three replications. Minu Early, Japanese White Neck, Tokinashi, Lumle-1, Bangaladeshi Red and 40 Days were seeded in last week of August to last week of March with one-month interval. The result revealed that the variety Minu Early and Japanese White Neck produced the highest fresh marketable radish yield of 30.8 and 29.1 t/ha during the main season August and September seeding, respectively. Bangaladeshi Red did not produce marketable root beyond, December seeding because of premature bolting. The variety Minu Early could be produced in two seasons, main season (August to November seeding) and summer season (February - March seeding). December, January and March seedings resulted in premature bolting Lumle-1, Bangaladeshi Red and 40 Days are early varieties and could be seeded in August to October for marketable root production. The results showed that Tokinashi is the only variety that could be produced in all the seasons without premature bolting. It could be seeded in August to January for marketable root production.

## INTRODUCTION

Radish (*Raphanus sativus* Linn.) is one of the most ancient vegetables. It is one of the most popular vegetable root crops in Nepal grown on both kitchen garden and commercial scales. Radish is grown for its young tender tuberous root, which is eaten raw as salad, pickle or cooked as a vegetable. It has pungent flavor and is considered as an appetizer. Radish is a good source of extraction of proteins on a commercial scale (Bagchi *et al.*, 1977).

In general, radish is best adapted to a cool or moderate climate. The Asian cultivars with higher temperature adaptation can resist heat more than the European varieties. At 20-25$^0$C uptake of nutrients is greater and dry matter content is higher, but at a still higher temperature (25-30$^0$C) the water requirement of the plant increases and root deformation occurs. During hot weather, the roots become tough and pungent before reaching the edible size. Flowering of radish, especially of biannual types is greatly influenced by temperature. Low temperature is a critical factor causing flowering, which is accelerated by long photoperiod (Park *et al.*, 1976). Radish is sensitive to day length. Under medium to shorter day length, roots are normally well shaped, but under long day length (15 hours per day), roots tend to become misshapen (Perera, 1993).

Normal season for radish cultivation in the mid-hills of Nepal is from August/September to November/December. During this season, mainly Minu Early, Japanese White Neck, Puthane Red and 40 Days are planted. During the summer season, radish cultivation is limited in the hills due to premature bolting without developing root. However, Tokinashi variety can be grown in the hills in

summer season without premature bolting (Jaiswal *et al.*, 1996). Off-season radish (summer season) production has a lot of opportunities in the mid hills. There is no choice of varieties and farmers are unaware of proper date of seeding for marketable radish root production. If farmers can get a calendar of radish seeding and harvesting time for edible or marketable root they could fetch good market price. This study was conducted with an objective to evaluate different radish varieties for off-season production and appropriate date of seeding and harvesting of each variety.

## MATERIALS AND METHODS

The experiment was carried out at Agricultural Research Station (Horticulture), Maleptan, Pokhara (848 masl) in two consecutive years 1997 and 1998. A factorial randomized complete block design (RCBD) was used with 3 replications.

Variety (Japanese White Neck, Minu Early, Lumle Red, Bangaladeshi Red, 40 Days and Tokinashi) and seeding dates (August 27 to March 27, at one month interval) were two factors tested in the experiment. All the compost (20 t/ha), phosphorus (60 kg/ha), potash (80 kg/ha) and half nitrogen (50 kg/ha) were applied as basal dose. Remaining half dose of nitrogen (50 kg/ha) was applied as top dressing in two equal split doses at 30 and 45 days after planting. Spacing was maintained at 25 cm x 20 cm giving 60 plants per plots (3 $m^2$). Seeding date as one factor was started from August 27 to March 27, exactly at the interval of one month. Seeds were directly seeded in flat beds. Seeds were sown at 3-4 seeds per hill and thinned out to maintain one plant per hill at complete emergence. Required soil moisture was maintained by applying irrigation and the field was kept free from weeds manually. Observations on plant stands at harvest, days to harvest, marketable and unmarketable root yield, bolting and quality (pith formation and other deficiency symptoms) were made and results were analyzed.

## RESULTS AND DISCUSSION

Fresh marketable and unmarketable root yield and bolting are the main characters used to evaluate the adaptability, growth habit and yield potential for each radish variety. The results of the experiment indicated that there were significant differences among the varieties and dates of seeding.

### Days to first harvest

Irrespective of seeding date radish variety 40 Days was the earliest harvested 46 days after seeding. Lumle Red and Bangaladeshi Red were harvested 7 days later than the variety 40 Days. Japanese White and Minu Early were harvested 28 days later than the variety 40 Days. Tokinashi was harvested 42 days later than the variety 40 Days. As the off-season radish production has great market potential, early production of radish is also very important in order to get a good market price.

### Radish yield

Radish variety significantly affected the yield (Table 1). Tokinashi has wider adaptability, which can be grown later than any other varieties. Average yield of all the seedings of Tokinashi was the highest at 14.7 t/ha and maximum yield was obtained in September seeding (27.4 t/ha). This variety also did not produce marketable roots in February seeding and later. This might be due to high rainfall (Table 2). In the early seedings (August and September) Minu Early followed by Japanese White Neck produced the highest root yield. Total average root yield of Minu Early was 14.5 t/ha, second to Tokihashi and the maximum yield was obtained in August seeding at 30.8 t/ha. Japanese White Neck was the third yielder, which produced the total average root yield at 10.6 t/ha and with the maximum yield in September seeding. Lumle Red was low yielder as compared to the above varieties. It produced average yield of 7.9 t/ha and the maximum yield of 18.6 t/h in September seeding. Bangaladeshi Red and 40 Days were the lowest yielders and the total average root yield was 4.6 and

4.3 t/ha, respectively. However, these varieties produced the maximum yield in August seeding (14.2 and 17.6 t/ha, respectively).

**Table 1. Marketable radish yield (t/ha) under different seeding dates at Agricultural Research Station (Horticulture), Malepatan, Pokhara**

| Treatment | Date of seeding (27th of each month) | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | |
| Japanese White Neck | 27.9 | 29.09 | 22.00 | 5.73 | 0.00 | 0.00 | 0.00 | 0.00 | 10.58 |
| Minu Early | 30.8 | 29.1 | 24.0 | 15.0 | 0.0 | 0.0 | 10.1 | 6.9 | 14.5 |
| Bangaladeshi Red | 14.2 | 11.1 | 9.8 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 40 Days | 17.6 | 11.5 | 5.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.3 |
| Lumle Red | 14.7 | 18.6 | 12.5 | 12.1 | 5.1 | 0.0 | 0.0 | 0.0 | 7.9 |
| Tokinashi | 22.9 | 27.4 | 22.6 | 22.7 | 14.8 | 6.8 | 0.0 | 0.0 | 14.7 |
| Mean | 21.3 | 21.1 | 15.6 | 10.1 | 3.3 | 1.1 | 1.7 | 1.1 | 9.4 |
| | | Probability | | | L.S.D. | | | CV% | |
| for Variety (V) | | 0.001 | | | 0.20 | | | | |
| for Seeding (S) | | 0.001 | | | 0.23 | | | | |
| for V x S | | 0.001 | | | 0.58 | | | 3.8 | |

**Table 2. Proportion of bolted plants (%) for individual radish variety under different seeding dates at Agricultural Research Station (Horticulture), Malepatan, Pokhara**

| Treatment | Date of seeding (27th of each month) | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | |
| Japanese White Neck | 0.0 | 0.0 | 0.0 | 95 | 100.0 | 100.0 | 100.0 | 100.0 | 61.8 |
| Minu Early | 0.0 | 0.0 | 0.0 | 33 | 100.0 | 100.0 | 14.7 | 100.0 | 43.4 |
| Bangaladeshi Red | 0.0 | 0.0 | 0.0 | 100 | 100.0 | 100.0 | 100.0 | 100.0 | 62.5 |
| 40 Days | 0.0 | 0.0 | 0.0 | 100 | 100.0 | 100.0 | 100.0 | 100.0 | 62.5 |
| Lumle Red | 0.0 | 0.0 | 24.3 | 41 | 100.0 | 100.0 | 100.0 | 100.0 | 58.1 |
| Tokinashi | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 |
| Mean | 0.0 | 0.0 | 4.1 | 61 | 83.33 | 83.33 | 69.1 | 83.3 | 48.1 |
| | | Probability | | | L.S.D. | | | CV% | |
| for Variety (V) | | 0.001 | | | 0.28 | | | | |
| for Seeding (S) | | 0.001 | | | 0.33 | | | | |
| for V x S | | 0.001 | | | 0.79 | | | 1.0 | |

The results showed that all the varieties could be grown in August to September seeding. The highest average fresh radish yield (21.3 t/ha) was obtained in August seeding followed by September seeding (21.1 t/ha). In August seeding, Minu Early gave the highest yield (30.8 t/ha) followed by Japanese White Neck (27.9 t/ha). Bangaladeshi Red gave the lowest yield (14.2 t/ha) in August seeding. Both Minu Early and Japanese White Neck produced the highest root yield in September seeding (29.1 t/ha) and the lowest yield (11.2 t/ha) was produced by Bangaladeshi Red. The root yield of all the varieties except Tokinashi was considerably reduced in October seeding. The highest root yield was produced by Tokinashi (22.6 t/ha) and the lowest yield (5.5 t/ha) by the variety 40 Days. In November seeding, the yield of all varieties was reduced considerably except Tokinashi. All plants of the variety 40 Days were bolted before maturity and the yield was nil. However, Tokinashi produced good yield (22.7 t/ha) followed by Minu Early (15 t/ha). All plants of Japanese White Neck, Minu Early, Bangaladeshi Red and 40 Days were bolted before maturity in December seeding. The marketable root yield was nil of all these varieties. However, Tokinashi produced medium yield (14.8 t/ha) followed by Lumle Red (5.1 t/ha). All plants were bolted except Tokinashi in January seeding. Tokinashi produced 6.8 t/ha marketable radish yield. All varieties except Minu Early did not produced marketable radish yield in February and March seedings. The variety Minu Early produced the marketable root yield of 10.1 and 6.9 t/ha in February and March seedings, respectively.

**Unmarketable radish yield and bolting**

Variety and seeding dates did not affect the unmarketable (other than bolting) radish yield. All roots except bolted plants were of marketable. It is obvious that the quality of radish roots is better during early winter i.e. September seeding than early or late season. In principle, bolting is accelerated by low temperature and longer day length.

Premature bolting is the main problem in radish for off-season production, which reduces the quality of radish yield. The result of the experiment indicated that there were significant differences among the varieties and dates of seeding on premature bolting (Table 2). Variety Lumle Red bolted earlier than any other varieties. Bolting started in Lumle Red in October seeding (24.3%), and all varieties except Tokinashi started bolting in November seeding. Bangaladeshi Red and 40 Days bolted 100% and all varieties except Tokinashi bolted 100% in December and January seedings. All varieties except Minu Early were either bolted 100% or did not produce marketable root yield seeded in February or later. However, Minu Early produced marketable root yield in February and March seedings though bolting occurred in February seeding (14.7%) and March seeding (100%).

## CONCLUSION

The study indicated that none of the tested varieties is suitable for all seasons. Also, no one variety is suitable for marketable radish production during late summer, because seeding in April and onwards could not produce any marketable radish. This might be due to high rainfall in Pokhara valley. However, different varieties can be selected for different months for better yields and fetch good market price. It could be concluded from the experiment that for early harvesting (August seeding), 40 Days and Lumle Red are better than any other varieties. For main radish production season (August and September seedings), Minu Early and Japanese White neck are better than any other varieties for the highest yield and quality. For late winter Tokinashi is the best variety for marketable radish and high yield. This variety can be seeded until last week of January. Minu Early is the best variety for off- season radish root production, which can be seeded from the last week of February till the end of March. From this calendar radish roots will be available from October to the second week of June.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# GROWTH OF *Azolla pinnata* AND *Azolla filiculoides* ON DIFFERENT GROWING MEDIA IN POKHARA VALLEY

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## ABSTRACT

Two pot experiments were conducted during winter and rainy season, 1998 in a randomized complete block design to evaluate the effect of growing media on the growth and nutrient content of *Azolla pinnata* and *A. filiculoides*. Phosphorus was applied at the rate of 50 kg $P_2O_5$ per ha in all treatments.

The fresh bio-mass production of *A. pinnata* and *A. filiculoides*, grown in the winter was significantly increased (15.7 and 17.5 t/ha) by the addition of compost in soil and water medium as compared to those with water alone or with soil and water medium. A maximum of 26.4 t/ha of fresh bio-mass was obtained with *A. filiculoides* when grown in glasshouse condition in winter. *A. pinnata* grown in glasshouse or outside did not produce any difference in bio-mass as in *A. filiculoides*. A maximum of 26 t/ha of fresh bio-mass was produced by *A. filiculoides* when grown in soil+water+compost media during rainy season, which significantly differed with *A. pinnata* (15.6 t/ha) at the same level of treatment used. No differences in the bio-mass of both the *Azolla* species were observed during rainy season. However, in rainy season *A. filiculoides* produced significantly higher fresh weight (16 t/ha) as compared to that with *A. pinnata* (10.03 t/ha). The trend in their doubling time by the application of compost in the media were found quite similar to that with the bio-mass production in both seasons and in both *Azolla* species. Production of nitrogen was found higher when compost was added to the growing media.

## INTRODUCTION

*Azolla*, a free-floating aquatic fern, which reproduces vegetatively through fragmentation, has the potentials of maintaining an exponential growth rate under optimal conditions. Different *Azolla* species have different production potential. A maximum of 0.26 g/g per day of growth rate *of A. filiculoides* can be obtained with mean daily water temperature of 23.2 °C, while *A. pinnata* produces its bio-mass slightly lesser (0.25 g/g per day) than *A. filiculoides* at the same level of water temperature (Lumpkin and Plucknett, 1982). Air temperature is probably the most important environmental factor limiting the spread of *Azolla* cultivation, and is the factor most difficult for man to influence. It may be possible to overcome the temperature limitations by selecting the *Azolla* strain and by ameliorating the environment. The most favorable mean air temperature range for *Azolla* growth for most of the *Azolla* species range from 20°C to 30°C. Not only the most *Azolla* species be protected from death or injury caused by extremes of cold or heat during part of the year but it is also needed to multiply in sufficient quantity as inoculum, to be applied at the strategic times of the year. Over-wintering and over-summering of the *Azolla* is needed to maintain them around the year. A number of artificial methods, including special structures have been developed to propagate *Azolla* in stress condition (Lumpkin and Plucknett, 1982). However, farmers need new technologies of overcoming this problem, which can sustain in their conditions.

*Azolla* can help improve soil fertility when it is repeatedly applied into the soil. It is reported that a 37.7 percent of increment in soil N is observed when single crop of *A. microphylla* is inoculated into the soil with two split applications of phosphorus (P) to *Azolla*. It is also reported that split application of P to *Azolla* have a positive effect on its nitrogen (N) content and thus increased grain yield to rice (Adhikary *et al.*, 1996a 1996b). A 550 kg of additional rice grains over control (20% increment) can be produced with the single crop of *Azolla* alone. It is mentioned that a 12.6 kg of rice grains per kg *Azolla*-N can be obtained when it is grown twenty days before transplanting and incorporated, where as the monocropped *Azolla* when applied in combination with urea-N may decrease its grain production per kg N application (10 kg grains per kg N) (Adhikary, 1997). Soil Science Division reported that a 16.9% yield increment by *Azolla* over control at 10 t/ha of biomass was obtained while the yield increase by chemical fertilizer at 100:40:30 kg NPK/ha was only 12% over the control (Anonymous, 1991 and 1994).

*Azolla* can have a significant effect on rice yields when used properly. Rice yields increased from 10% or less to more than 100% has been recorded when it is used as a green manure in the rice fields. Moore (1969) reported rice yield increased of 14, 17, 22 and 40% with the cultivation of *Azolla*. The effect of *Azolla* on rice yield varied according to the species of *Azolla* used, methods of cultivation, and time and method of application. A minimum of 6% rice yield increase can be obtained with dual cropped *A. pinnata* without any incorporation, while the incorporate *Azolla* increases rice yield ranging from 9 to 38%. In California, rice yield increase of 112% over control was achieved by incorporating 60 kg *Azolla*-N / ha (Singh, 1977; Talley *et al.*, 1977). The *Azolla* biomass of 11-15.3 $g/m^2$/day can be produced from April to October, whereas it is dramatically decreased during November and March ranging from 4-9.6 $g/m^2$/day. A maximum N content of 4.3% and a minimum of 3% is observed during the months of July and November (Favilli *et al.*, 1988). The dry weight protein content of *Azolla* ranges from 13 to 30% (Fujiwara *et al.*, 1947).

Little is known about the environmental factors and interactions, which may establish the production parameters of *Azolla* species. Of the various environmental factors, the availability and the quality of water is the most limiting factor for *Azolla* growth. Other important environmental factors include P availability, temperature, light and growth media. Deep bodies of water have a greater capacity of attenuate temperature extremes and thus maintain a higher and more stable temperature during winter than shallow bodies of water. Fertilizing *Azolla* during cold weather differs somewhat from other season. Because of low temperature in winter months, the Chinese farmers prefer animal manures or compost in combination with phosphorus. *Azolla* can be protected from cold by maintaining higher nursery temperature by the use of mulching and adding or draining water, and/or by dropping the water level to allow *Azolla* roots to make contact with the soil. This can be effective because soil temperature is usually higher than those of shallow water in winter season (Lumpkin and Plucknett, 1982). Oversummering techniques are used in locations where field temperatures are to high for *Azolla* cultivation, or where *Azolla* is to be preserved through the hot season for the later use (Lu *et al.*, 1965). The water temperature plays an important role in *Azolla* growth in the summer season.

Since the growth of different *Azolla* species are depended on the temperature and growth medium, it is a need to study the growing conditions needed for different *Azolla* species to overwinter them and to enhance their growth in the rainy season. The objectives of this experiment were (1) to study the growth of *A. pinnata* and *A. filiculoides* by cultivating them in different growth media and in different conditions, and (2) to study the effect of growth media on the nutrient content of *Azolla*.

## MATERIALS AND METHODS

Pot experiments were carried out during the winter (16 January - 10 February) and rainy season (16 June 16-10 July), 1998 at Agricultural Research Station, Pokhara. A randomized complete block design (RCBD) with eight treatments was used and replicated three times. *A. pinnata* and *A. filiculoides* were cultivated in different growth media and growing conditions (Table 1) in both winter and rainy seasons. The soil used in the experimental plots was acidic (pH 5.2). The cold water, soil

with cold water, and soil with cold water plus compost were used as the treatments for both of the *Azolla* species in both seasons. The pot experiment was conducted in an open environment but some of the pots were placed in glasshouse for both *Azolla* species in both seasons as a reference pot. The size of the pots were 16-20 cm in depth with a radius of 25-27 cms. Soil was applied at a rate of 10 kg/pot in the concerning pots. The growth limiting nutrient, phosphorus (P), was applied in all the treatments @ of 50 kg $P_2O_5$ ha as single super phosphate. The compost at a rate of 10 ton/ha (50 g/pot) was applied as basal dose in the concerning pots. The depth of the water in all pots was adjusted daily at least three cms depth. Temperature of each of the pots was recorded every morning. Maximum and minimum air temperature of the experimental site was also recorded daily. *Azolla* was applied at the rate of 10 g/pot. Malathion dust was also applied to prevent insect incidence, when needed. Three-split application of phosphorus (SSP) was done at weekly interval. Nutrient analysis of soil, compost and fertilizer were done at Soil Science Division, Khumaltar, Nepal. On the 24th day of *Azolla* growth, all *Azolla* were taken out by hand, water was drained out and their fresh weight (bio-mass) were recorded. The biomass production, doubling time and N content of both *Azolla* species were studies. *Azolla* production parameters were analyzed by least significant difference test (Gomez, 1984). The doubling time (DT) of *Azolla* was calculated by the following formula (Mitchell, 1994).

$$DT = \frac{2 \ln}{\text{RGR (Relative growth rate)}}$$

$$RGR = \frac{(\text{Final weight} \times \ln) - (\text{Initial weight} \times \ln)}{\text{Number of } \textit{Azolla} \text{ growing days}}$$

**Table 1. Treatments detail**

| SN. | Treatments |
|---|---|
| $T_1$ | *Azolla pinnata* in cold water |
| $T_2$ | *A. pinnata* in soil + cold water |
| $T_3$ | *A. pinnata* in soil + compost + cold water |
| $T_4$ | *A. filiculoides* in colds water |
| $T_5$ | *A. filiculoides* in soil + cold water |
| $T_6$ | *A. filiculoides* in soil + compost + cold water |
| $T_7$ | *A. pinnata* in cold water + soil (glasshouse) |
| $T_8$ | *A. filiculoides* in cold water + soil (glasshouse) |

**Table 2. Nutrient analysis of growing media and fertilizer**

| Media | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| Compost | 2.44% | 3.16% | 2.43% |
| Soil | 0.107% | 71.1 kg/ha | 238 kg/ha |
| Single super phosphate | 0.0 | 1.16% | 0.0 |

## RESULTS AND DISCUSSION

### *Azolla* growth

*A. pinnata* grown in the media containing soil, compost and water ($T_3$) produced higher bio-mass (78.7 g/pot) than grown in water ($T_1$) or in water and soil ($T_2$) (Table 3). Ali and Malik (1987) reported that *A. pinnata* were abundant only in cold months (November - April) and were sensitive to high temperature. They suggested to grow *A. pinnata* in cold water containing farm yard manure

(FYM) during the hot days. The study indicated that a small quantity of FYM gave maximum yield with minimum doubling time. The result of this investigation was consistent with their findings.

Similarly, *A. filiculoides* when grown in a medium of the mixture of soil plus compost plus water ($T_6$) produced higher fresh weight of *Azolla* (87.7 g/pot) in winter as compared to those with water alone ($T_4$) or with water combined with soil ($T_5$) (Table 3). Liu *et al.* (1987) reported that water cultivation of *A. filiculoides* produced 63% more biomass than grown in moist soil condition. The result of this investigation also suggested a slight increment of *A. filiculoides* biomass when grown in water over the soil and water media. However, it was not significant. A significantly increased bio-mass production was observed (132.33 g/pot or 26 t/ha) when *A. filiculoides* grown in soil and water medium ($T_8$) in glasshouse condition (12.8°C ) as compared to all other treatments at temperature ranges of 9.2-12.5 °C (Table 3).

**Table 3. Effect of growth media on *Azolla* growth and temperature (16 January - 10 February 1998)**

| Treatments | Fresh weight (g/plot) | | 24 days mean temp. (°C) of media | |
|---|---|---|---|---|
| | Winter season | Rainy season | Winter | Rainy season |
| $T_1$ | 55cd | 39c | 9c | 31c |
| $T_2$ | 52cd | 35e | 10b | 30d |
| $T_3$ | 79b | 78cd | 10b | 34a |
| $T_4$ | 51cd | 63de | 10bc | 31d |
| $T_5$ | 42d | 54de | 10bc | 29e |
| $T_6$ | 88b | 130a | 10bc | 34ab |
| $T_7$ | 59cd | 90bc | 13a | 32b |
| $T_8$ | 132a | 113ab | 13a | 33b |
| F test | HS | HS | HS | HS |
| LSD (0.05) | 25.5 | 27.4 | 0.7 | 0.59 |
| CV (%) | 20.8 | 20.8 | 3.8 | 2.02 |

Means in a column with a common letters are not significantly different at 5% level of significance by LSD.
$T_1$ - *Azolla pinnata* in cold water, $T_2$ - *A. pinnata* in soil + cold water, $T_3$ - *A. pinnata* in soil + compost + cold water, $T_4$ - *A. filiculoides* in colds water, $T_5$ - *A. filiculoides* in soil + cold water, $T_6$ - *A. filiculoides* in soil + compost + cold water, $T_7$ - *A. pinnata* in cold water + soil (glasshouse), $T_8$ - *A. filiculoides* in cold water + soil (glasshouse)

In rainy season also, both *Azolla* species produced higher biomass with compost added treatments compared to treatments without compost. Higher biomass was obtained when grown in glasshouse compared to open condition and was comparable with compost treatments of respective species at open condition (Table 3).

In the winter season the growth trend of two *Azolla* species (Table 4) clearly indicated that no significant difference on biomass production was observed. Both of the species, *A. pinnata* and *A. filiculoides*, produced similar yields (12.36 and 12.03 t/ha), respectively at the same temperature ranges of 9.8 - 9.9°C irrespective of growing media. On contrary, *A. filiculoides* produced significantly higher fresh weight in the rainy season (16.4 t/ha) compared to that of *A. pinnata* (10.13 t/ha) at the similar temperature ranges (31.1- 31.7 °C) irrespective of growing media used (Table 4). Brotonegoro *et al.* (1982) reported that *A. pinnata* produced increased biomass (17.1 t/ha) in dry season than that produced in wet season (15.0 t/ha). The result of this investigation indicated that *Azolla* growth is affected by season and agreed with the findings of Brotonegoro *et al.* (1982).

**Effect on doubling time**

No significant response of treatments on doubling time (DT) was observed in *A. pinnata* grown in winter months (16 January - 10 February) because of low temperatures (9.2 - 10.3°C) (Table 5). However, a slightly low doubling time (8.14 days) was observed in *A. pinnata* grown in soil plus

water medium added with the compost ($T_3$) due to the slight increase in temperature of the medium (10.4°C). Lumpkin (1987) reported that temperature is probably the most limiting environmental factor in *Azolla* cultivation. He mentioned that the most optimum temperature for most *Azolla* species is within the range of 20-35 °C for its better growth. The trend was found quite different in *A. filiculoides* to that of *A. pinnata* grown in winter months. A decreased doubling time (8 days) was obtained when *A. filiculoides* was grown in soil plus water medium when added with the compost ($T_6$) at a temperature of 9.94°C which also significantly differed compared to that of *A. filiculoides* (12 days) grown in soil plus water media ($T_5$) at a temperature of 10.3°C (Table 5). It is indicated by the experimental results that both species produced decreased doubling time by the media added with the compost as compared to that with water alone or in soil plus water at the similar temperature ranges (9.28-10.39°C) (Table 5). A minimum of 6.48 days of doubling time was observed in *A. filiculoides* grown in glasshouse condition in the winter ($T_8$) with soil and water medium, which was significantly different to that of *A. pinnata* (9.53 days) ($T_7$) grown in similar conditions. It is clearly noted that *A. filiculoides* either grown in glasshouse condition in winter (12.8 °C) with soil plus water media ($T_8$) or grown outside in soil and water added with the compost ($T_6$) produced similar doubling times to that with *A. pinnata* while grown in compost added medium ($T_3$) at a temperature ranging from 9.94 to 12.8°C (Table 5).

Table 4. Means comparison of the growth of the two *Azolla* species for different seasons

| *Azolla* species (season) | Bio-mass (t/ha) | Media temp. °C (24 days mean) |
|---|---|---|
| *A. pinnata* (winter) | 12.4ab | 9.9 |
| *A. filiculoides* (winter) | 12.0ab | 10.0 |
| *A. pinnata* (rainy) | 10.0b | 31.7 |
| *A. filiculoides* (rainy) | 16.4a | 31.2 |
| F Test | S | |
| LSD (0.05) | 4.5 | |
| CV% | 17.7 | |

Means in the column with the common letters are not significantly different at 5% by LSD. S = Significant

Table 5. Effect of growth media, *Azolla* species and environment on doubling time

| SN | Doubling time (days) | |
|---|---|---|
| | Winter season | Rainy season |
| $T_1$ | 10b | 12.7a |
| $T_2$ | 10.1bc | 14.0a |
| $T_3$ | 8.1ab | 8.4bcd |
| $T_4$ | 10.2bc | 9.2bc |
| $T_5$ | 12.4c | 10.3b |
| $T_6$ | 8.1ab | 6.5Bd |
| $T_7$ | 9.5b | 7.6cd |
| $T_8$ | 6.5a | 6.9d |
| F Test | HS | HS |
| LSD (0.05) | 2.9 | 2.15 |
| CV% | 12.9 | 11.47 |

Means in a column with the common letters are not significantly different at 5% by LSD.

$T_1$ = *Azolla pinnata* in cold water, $T_2$ = *A. pinnata* in soil + cold water, $T_3$ = *A. pinnata* in soil + compost + cold water, $T_4$ = *A. filiculoides* in colds water, $T_5$ = *A. filiculoides* in soil + cold water, $T_6$ = *A. filiculoides* in soil + compost + cold water, $T_7$ = *A. pinnata* in cold water + soil (glasshouse), $T_8$ = *A. filiculoides* in cold water + soil (glasshouse)

Treatments used in the experiment in the rainy season (June/July) showed a positive effect on *Azolla* doubling time (Table 5). A minimum of 8.4 days of doubling time was observed in *A. pinnata* grown

in compost added soil and water media ($T_3$) while the same species produced a maximum of 12.7 and 14 days of DT when grown in water alone ($T_1$) or in soil plus water media ($T_2$), respectively (Table 5). The trend in *A. filiculoides* was similar to that of *A. pinnata*. *A. filiculoides* when grown in soil and water media added with compost ($T_6$) decreased its DT (6.58 days) compared to those either grown with water alone ($T_4$) or with the soil and water medium ($T_5$). No significant in DT between *A. pinnata* (7.6 days) and *A. filiculoides* (6.9 days) was observed when both the species were grown in glass house condition in soil plus water media ($T_7$ and $T_8$). Similar to the DT of both *Azolla* species grown in compost added soil and water media (Table 5) in winter months, both species showed a similar trend in their DT in the rainy season. Meaning both species produced significantly similar DT (8.36 and 6.58 days) when grown in compost added media to that of both *Azolla* species grown in glasshouse despite of the difference in temperature ranges (32.4-33.7°C) (Table 3).

**Effect on nutrient production**

A maximum of 3.88% N content was found in *A. pinnata* when grown in soil and water medium ($T_2$) at 10°C, while the *A. filiculoides* produced 3.67% N when grown in the similar medium ($T_5$) in the winter season at the temperature of 10°C (Table 6). *A. pinnata* produced higher percent of N content (3.76%) in winter compared to that of *A. filiculoides* (3.08% N) when both species were grown in glasshouse condition in the similar growing media ($T_7$ and $T_8$). *A. filiculoides* produced decreased N content when it was grown only in water (3.15% N). This finding disagreed with the findings of Liu (1987) who reported that the N content of *A. filiculoides* was found increased (4.8% N) when it was grown in water compared to that with soil plus water media (4.5% N). It was noted that no significant difference in N content of *Azolla* was observed among the treatments used (Table 6) at the temperature ranging from 9.3 to 12.8°C.

**Table 6. Effect of growth media on nitrogen and protein content in different *Azolla* species in winter and summer seasons**

| Treatments | N (%) in winter | N production (kg/ha) | Protein (%) | N (%) in summer |
|---|---|---|---|---|
| $T_1$ | 3.63a | 23.95 | 22.9 | 2.17 |
| $T_2$ | 3.88a | 24.21 | 24.3 | 2.33 |
| $T_3$ | 3.20a | 30.14 | 20.0 | 2.46 |
| $T_4$ | 3.15a | 19.70 | 19.7 | 2.52 |
| $T_5$ | 3.67a | 18.49 | 22.9 | 3.08 |
| $T_6$ | 3.73a | 39.16 | 23.3 | 3.45 |
| $T_7$ | 3.76a | 26.62 | 23.5 | 2.65 |
| $T_8$ | 3.08a | 48.78 | 19.3 | 2.90 |
| F Test | NS | | | |
| LSD (0.05) | 1.49 | | | |
| CV% | 24.29 | | | |

* A conversion factor of 6.25 was used to convert N content of *Azolla* to protein content at a dry weight of 6% . Plant samples were analyzed at Soil Science Division, NARC, Nepal in 1997.

$T_1$ = *Azolla pinnata* in cold water, $T_2$ = *A. pinnata* in soil + cold water, $T_3$ = *A. pinnata* in soil + compost + cold water, $T_4$ = *A. filiculoides* in colds water, $T_5$ = *A. filiculoides* in soil + cold water, $T_6$ = *A. filiculoides* in soil + compost + cold water, $T_7$ = *A. pinnata* in cold water + soil (glasshouse), $T_8$ = *A. filiculoides* in cold water + soil (glasshouse)

Nitrogen production of *Azolla* species was affected by the treatments used in the experiment. Both *Azolla* species produced higher N production (30 and 39.6 kg/ha) when they were grown for 24 days in compost added soil and water media ($T_3$ and $T_6$) in winter season (Table 6) because of the higher biomass production due to the effect of the treatments used. *A. pinnata* when grown in soil and water medium in the glasshouse produced almost half of the nitrogen (26.6 kg N/ha) to that produced by *A. filiculoides* (48.8 kg/ha) while grown in similar conditions in winter. A maximum of 3.45% N was observed in *A. filiculoides* when grown in compost added media in the summer season. A maximum of 59.2 kg/ha of N production in 3 weeks was reported by Adhikary *et al.* (1998) in the field condition

in the rainy season when the *A. microphylla* was cultivated by using P in 4 split applications in flooded acid soils. Production of nitrogen and fresh biomass of *Azolla* was found positively correlated (Y=26.4 +0.00017 X; r= 0.976).

The protein content of *Azolla* species varied with the treatments used in the experiment in the winter season. A maximum of 24.3% of protein was observed in *A. pinnata* when grown in soil plus water media ($T_2$) at 10.01 °C of temperature, while a minimum of 19.3% of protein was observed in *A. filiculoides* when grown in glasshouse condition at a temperature of 12.8 °C (Table 6). The protein content of *A. pinnata* was found higher (23.5%) than that of *A. filiculoides* (19.3%) in glasshouse condition. The compost in the media ($T_3$) did not help in the protein content of *A. pinnata* (20%). On the contrary, compost ($T_6$) helped in increasing the protein content (23.31%) of *A. filiculoides*. However, no significant response of the treatments on protein content of both species was observed.

## SUMMARY AND CONCLUSION

The research highlights of the investigation can be concluded as follows:

1. The bio-mass (15.7 to 15.5 t/ha) and N production of *Azolla* species (30.1 to 39.2 kg N/ha) in winter season (9.94 - 10.39°C) can be increased by the application of compost in the growth media. However, *A. filiculoides* increased its bio-mass (26.4 t/ha) and N production (48.7 kg/ha) when grown in glass house at 12.8°C in soil and water medium ($T_8$). In an average, both species produced similar bio-mass (12.0 to 12.4 t/ha) in winter (9.89 - 9.90°C) irrespective of growth media used, while the *A. filiculoides* was found effective to produce increased bio-mass (16.4 t/ha) in rainy season than the produced by *A. pinnata* (10.1 t/ha) at the temperature ranging from 31.2 to 31.7°C.
2. The trend of DT was similar to *Azolla* biomass in both species when grown in compost added media ($T_3$ and $T_6$) compared to those with the water alone or with soil plus water media. The DT of *A. filiculoides* was greatly reduced (6.48 days) when it was grown in glasshouse ($T_8$). Significant effect if the compost on *Azolla* growth was also observed in both the species grown in rainy season.
3. Nitrogen content in both of the *Azolla* species was not affected by the treatments in winter season. However, an increased N production was observed in both the species because of the higher bio-mass production in compost added media.
4. The protein content in both *Azolla* species was not affected by the treatments used. However, a maximum of 24.3% (dry wt. basis) of protein was produced by *A. pinnata* when grown in soil plus water media ($T_2$). The protein content due to the treatments varied raging from 19.3 to 24.3%. However, no significant difference among the treatments was observed in protein content of *Azolla*.
5. It can be recommended that application of compost in both *Azolla* species is needed for higher bio-mass and N production that can be utilized in rice production and other agricultural uses. Because of the higher protein content in *Azolla*, it could be incorporated into the animal feed and poultries.

## ACKNOWLEDGMENTS

A grateful appreciation is extended to Dr. S. L. Maskey, Chef Soil Scientist, Soil Science Division, NARC for providing the *Azolla* species for conducting the experiment. Thanks are due to Mr. S. Lamdary, D. B. Ranabhat and Ms. U. Thapa for their keen interest, hard work and in conducting and handling the experiment. Authors are grateful to Mr. P. Lama for providing the meteorological records. A special thanks goes to Mr. S. Chaudhary, Technical Officer, Soil Science Division Khumaltar for analyzing the soil and plant samples.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# INTEGRATED NUTRIENT MANAGEMENT AND WEED CONTROL IN A MAIZE (*Zea mays*) - RAPESEED (*Brassica campestris* VAR. *TORIA*) CROPPING SYSTEM IN CHITWAN, NEPAL

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## ABSTRACT

Three nitrogen levels (30, 60 and 90 kg/ha) with and without green manuring (GM) of Dhaincha (*Sesbania aculeata*), sunhemp (*Crotalaria juncea*) and cowpea (*Phaseolus vulgaris*) were intercropped with maize. The objectives were to find out (a) the best combination of different GM crops with N levels, and (b) to compare residual effects of those GM on the grain yield of succeeding crop rapeseed. Percentage of soil organic matter (SOM) and N after harvest of rapeseed was found nonsignificant. Increase in N depletion with increase in N applied was also observed. Nitrogen balance was zero in 60 kg N/ha + Cowpea GM treatment and for all of the rest treatments balance was negative. Residual effect of GM to the succeeding crop of rapessed was explained by increase in grain yield. It was also found that N at 90 and 60 kg/ha with inter cropping of Dhaincha were economically superior.

The treatments for weed control experiment in maize were: (i) one hoeing without removing weeds at first weeding, (ii) mulching immediately after sowing of maize with rapeseed straw and wheat (*Triticum aestivum*) chaff at 10 ton/ha, (iii) hoeing and earthing up as first and second weeding by removing weeds, (iv) farmers' practice of weed control (hoeing once by removing weeds and earthing up without removing weeds), (v) hoeing twice by removing weeds no earthing up, and (vi) hoeing twice no removing of weeds and earthing up. The objectives were (a) to find out the responses of different cultural methods of weed control on yield and its components, (b) yield of succeeding crop, and (c) find out economically feasible cultural practices for weed control. Ear height, plant height, 50% silking days after sowing (DAS), unfilled ears, leaf area index (LAI), ear number and plant population were significant. But the grain yield of maize and rapeseed were nonsignificant. Number of weed per $m^2$, 1 day before first weeding (20 DAS) was not significant while weed per $m^2$ before top dressing (37 DAS) and DM% of weeds were found significant. All the tested cultural practices of weed control were comparable to farmer's practice. Mulching with rapeseed straw and wheat chaff at 10 ton/ha was found economical and the most feasible technology of cultural method of maize weed control practice in Bariland.

## INTRODUCTION

Farm managers have several options for restoring productivity of eroded soils. One of the most common approaches is the application of chemical fertilizer to improve crop growth. However, Lamey *et al.* (1995) showed that chemical fertilizer had poor restorative capabilities due to its high immobilization, which render it unavailable for plant uptake. Many researchers on residue management to improve soil health and increase productivity of eroded soil have come into conclusion that efficient use of livestock manure and crop residue may provide alternative to restore eroded soil and reduce inputs of chemical fertilizers. Green manuring grown as inter crop in maize can work as cover crops, which later could supply plant nutrients if residue is incorporated. Thanh (1996) reported that high amount of wheat residue maintained at the soil surface helped improve the macroporosity of surface soil. Organic matter acts like calcium amendments modifying soil pH (Cecil,

1990). Therefore, physical, biological and chemical properties of soil could be improved by the use of green manuring legumes as inter crops in a sandy loam soil of Chitwan and similar areas under maize-rapeseed system. On the other hand, it seems worthwhile to develop cropping systems that have capacity to maximize crop yield per unit area while keeping the fertilizer N to a minimum (Francis and Stern, 1987).

Maize is the second most important cereal crop after rice both in area and production in Nepal. Much of the efforts have given to varietal improvement in Nepal. A little or no work has been done on cultural practices that control weed. First weeding of maize up to 30 DAS is so critical that if the crop is unweeded, up to 100% yield loss have been reported. In Nepal, weeds are major constraints to maize production after nitrogen application. Chemical control of weeds is expensive and ecologically hazardous. Different types of mechanical weed control practices are adopted by farmers rather than chemical method. Mulching is found effective practices for weed control. Extensive use of chemical for weed control in maize was reported in Poland causing problems such as resistant weeds, contamination of water supplies and the limitation of following crops (Rola and Rola, 1990). Similarly, crop injury to maize and sorghum was also reported (Simarmarta and Penner, 1993). Weed control was also obtained with integrated approach (Balsari *et al.*, 1998). In a study conducted in Nepal reported that two weedings are needed for maize. It is also reported that 40-80 man-days are required for weeding a hectare of maize. This author had personnel communication with different nearby farms and found that the first weeding of maize up to 30 DAS was mandatory and if it is unweeded in that period there might be a complete failure of the corp. As reported by the Chitwan farmers in maize based farming system, 60-120 man days per hectare was required for weeding depending on weed intensity. Therefore, huge amount of cost is involved for weeding in maize.

## MATERIALS AND METHODS

The experiments on maize-rapeseed system were conducted in a randomized complete block design (RCBD) in the experimental farm of National Maize Research Program (NMRP), Rampur, Chitwan in 1996/97 summer season. The soil type was sandy loam with pH from 5.8 to 6.1, organic matter (OM) 1.7% and total nitrogen (N) 0.078%. Percent OM and N were analyzed before planting of maize and after harvesting of rapeseed. Initial soil analysis was carried out by taking two samples up to 30 cm depth from each block. Residual OM and N were determined by subtracting final (after harvest) value from initial value (before planting). Nitrogen was supplied through urea (46% N) and diammonium phosphate (18% N and 46% $P_2O_5$). In maize, a constant dose of potassium and phosphoric fertilizer at 40 and 30 kg/ha to all the treatments was applied from diammonium phosphate and muriate of potash (58% $K_2O$) as a basal dose and remaining half dose of N was used as top dressing from urea at knee high stage.

Rapeseed was grown in the same experimental plot following the harvest of maize. For rapeseed, a constant dose of fertilizers at 60, 40 and 20 kg/ha N, $P_2O_5$ and $K_2O$), respectively were applied to all the plots as a basal dose. Maize variety Rampur Composite and rapessed variety Chitwan Local were grown. Maize was sown with a seed rate of 20 kg/ha (2 seeds/hill) and later on thinned to one plant/hill maintaining 75 X 25 cm and rapeseed was broadcasted at a seed rate of 10 kg/ha and thinned wherever necessary as the farmers do in their fields. Yield and yield components of maize and rapeseed were recorded as per the standard procedure developed by CIMMYT, Mexico and National Oil Seed Research Program, Sarlahi, Nepal. Grain yield of maize was recorded from the net harvest areas of 18 $m^2$ from each plot (4 rows of 6 m long) while for rapeseed it was recorded from a net area of 9 $m^2$. Statistical analysis was done by using ANOVA technique of MSTATR-c software packages. Partial economic analysis and dominance analysis were done by using local market price list of input and output. Simple linear correlation analysis for agronomical traits with grain yield was compared by using linear model of $Y = a+bx$.

In the experiment of integrated nutrient management study, there were three replications and three levels of N at 30, 60 and 90 kg/ha which were compared with and without inter cropping of three types of green manuring (GM) crops of Dhaincha (*Sesbania aculeata*), sunhemp (*Crotalaria juncea*)

and cowpea (*Phaseolus vulgaris*). Seed rate for Dhaincha and sunhemp was 50 kg/ha while for cowpea was 40 kg/ha. Maize was sown on 17 May 1996. Seed for green manuring was broadcasted in between the rows of maize at the time of first hand weeding of maize on 5 June 1996 i.e. 30 days after sowing (DAS) and they were incorporated while earthing up. Green matters were cut before an thesis of maize on 13 July, 1996 (45 DAS) and they were incorporated in the plots on the same day. Maize was harvested on 27 August 1996. Rapeseed was broadcasted on 29 October, August 1996 and harvested on 2 February 1997.

Study on different cultural method of weed control practices was also conducted in a RCBD with four replications. For maize, chemical fertilizers at 90, 40, 30 kg N, $P_2O_5$ and $K_2O$ /ha, respectively were applied to all the plots. There were seven different cultural method of maize weed control practices like one hoeing without removing weeds as first weeding, mulching immediately after sowing of maize with rapeseed (*Brassica campestris* var. *toria*) straw and wheat (*Triticum aestivum*) chaff at 10 ton/ha, hoeing and earthling up as first and second weeding by removing weeds, farmer's practice of weed control (hoeing once by removing weeds and earthling up without removing weeds), hoeing twice removing weeds no earthling up, hoeing twice no removing of weeds and eartheing up. Maize was planted on 17 May 1996 and harvested on 27 August 1996. First hoeing was done on 7 May 1996 (20 DAS) and the second hoeing at 37 DAS. Rapeseed was harvested on 2 February 1997. Weed count was recorded from 1 $m^2$ maize plot. Dry matter percent of weed was determined by oven drying weeds at 80°C for 48 hours and later DM yield was reported on hectare basis.

## RESULTS AND DISCUSSION

### Crop performance and meteorological status

There was not much moisture stress except for a few days after maize emergence. The seasonal rainfall for maize and rapeseed was 1301 mm and 13 mm, respectively. The maximum and minimum temperatures for maize growing season were 34.2 °C and 24. 8 °C and for rapeseed were 24.8 °C and 12.5°C, respectively.

In the weed control experiment, yellowing of maize plant until top dressing was observed in rapeseed straw and wheat chaff mulched treatments. After top-dressing, rapeseed straw mulched treatment recovered from yellowing while for wheat chaff, yellowing continued up to pre-silking stage. Decrease in maize grain yield in wheat chaff treatment may be due to slow mineralization.

### Effect of nutrient management on yield components of maize

All agronomical traits except ear height were non-significant (results not shown). Interaction between N level and GM was also found non- significant. All of these traits were not related strongly with grain yield. Thousand grain weight, number of plants, number of ears, number of unfilled ears and number of barren plants of maize were also observed nonsignificant (results not shown).

### Effect of nutrient management on performance of green manuring crops

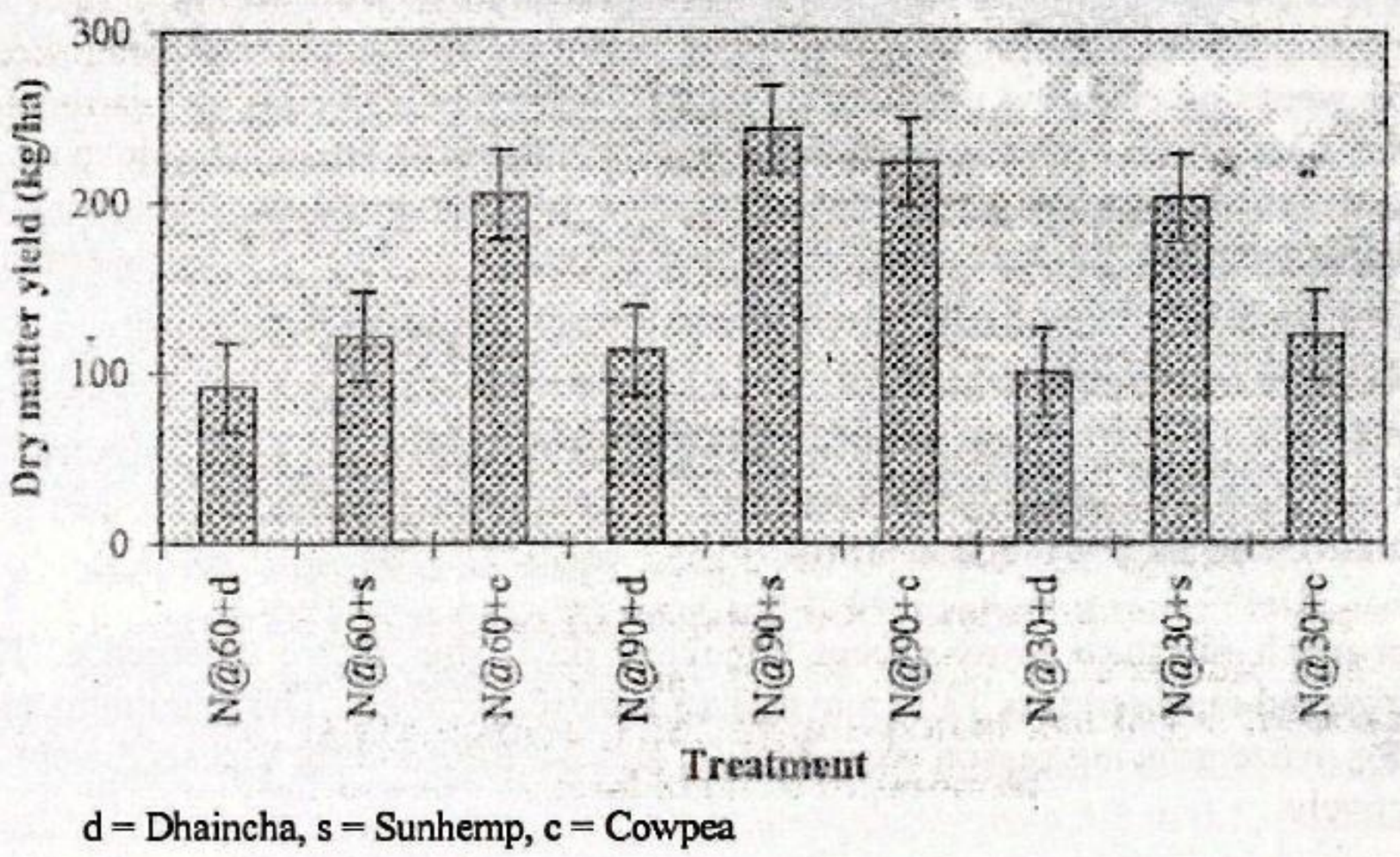
Dry matter yield of different GM were found highly significant but the effect of N on DM yield was not observed (Fig 1 and Table 1). The interaction of N levels and GM crops was not significant (Table 1). Dhaincha produced highest DM yield. Dry matter produced by 30 kg N/ha + sunhemp was compared with 90 kg N/ha (Fig 1).

Grain yield due to N levels and GM species was highly significant while the interaction between N levels and GM was nonsignificant (Table 2). The highest grain yield of maize was obtained with N at 60 kg/ha plus Dhaincha (4598 kg/ha) followed by cowpea (4277 kg/ha) and N at 30 kg/ha plus cowpea (4151 kg/ha) (Table 2).

**Table 1. Dry matter percentage of intercropped green manuring (GM) crops in maize as influenced by different levels of nitrogen (N) at Rampur, 1996/97, summer season**

| GM crops | N level (kg/ha) | | | | F. test | SE± |
|---|---|---|---|---|---|---|
| | 90 | 60 | 30 | Mean | | |
| Dhaincha | 16 | 14 | 14 | 15 | | |
| Sunhemp | 15 | 15 | 13 | 14 | | |
| Cowpea | 12 | 13 | 9 | 12 | | |
| Mean | 13 | 14 | 12 | | NS | 0.06 |
| SE± | | | | 0.69 | | |
| F. test | | | | ** | | |
| F. test for GM X N | | | | NS | | |

** = significant at P<0.01 level, NS = non-significant




d = Dhaincha, s = Sunhemp, c = Cowpea

**Fig. 1. Dry matter yield of green manure influenced by N level and green manure crop**

**Table 2. Grain yield of maize (kg/ha) as influenced by nitrogen (N) levels and green manuring (GM) species at Rampur, 1996/97, summer season**

| GM crops | N level (kg/ha | | | | F. test | SE± |
|---|---|---|---|---|---|---|
| | 90 | 60 | 30 | Mean | | |
| Without GM | 2899 | 3808 | 2746 | 3151 | | |
| Dhaincha | 3487 | 4598 | 3440 | 3842 | | |
| Sunhemp | 3881 | 4043 | 3721 | 3882 | | |
| Cowpea | 4003 | 4277 | 4151 | 4143 | | |
| Mean | 3567 | 4181 | 3515 | | ** | 112.5 |
| SE± | | | | ** | | |
| F. test | | | | 129.9 | | |
| F. test for GM X N | | | | NS | | |

** = significant at P<0.01 level and NS = Non significant.

The GM obtained with 30 kg N/ha was comparable with 90 kg N/ha. This could be because of soil acidity, which might have hindered availability of plant nutrient resulting low grain yield. The highest grain yield of 4143 kg/ha was obtained with the incorporation of cowpea and the lowest (3151 kg/ha) with no incorporation of GM (Table 2). Sarkar *et al.*, (1995) reported that inter cropping of two rows of green gram in paired rows gave higher cotton yield and monetary advantage than sole cropping of upland cotton. Nitrogen substitution by incorporation of different GM crops have been reported by Kumar and Yadav (1995). They reported that in the initial years (3 years), 25-50% substitution of fertilizers through organic sources (farm yard manure, GM and wheat straw) but reducing the rice

yield by 6-23% compared to fertilizer alone. They also reported that in the following years, 25-50% N through farm yard manure or Sesban (*Sesbania aculeata*, *S. cannabina*) GM in combination with 50-75% fertilizer to rice gave comparable yield with of rice NPK fertilizer (120, 26.2 and 33.2 kg/ha) alone. *Sesbania* was superior to wheat straw for grain yield and NPK uptake. Therefore, in the sandy loam soils of Chitwan under Bariland condition of maize rapeseed system, GM seems feasible technology for maintaining soil productivity. The result of the present study clearly demonstrated that lower dose of N in combination with incorporation of green manure favoured fast decomposition and mineralization of nutrients compared to high dose of N in sandy loam soils of Rampur, Chitwan, Nepal.

**Effect of nutrient management on grain yield of rapeseed**

Grain yield of rapeseed was influenced by N level but not by green manuring (Table 3). The highest rapeseed grain yield (1730 kg/ha) was obtained with *Sesbania* green manure + 60 kg N/ha (Table 3). The overall highest mean grain yield of rapeseed was produced from N at 60 kg/ha followed by 30 and 90 kg/ha. Irrespective of N level, mean grain yield of rapeseed was not influenced by GM source.

**Table 3. Grain yield of rapeseed (kg/ha) as affected by nitrogen (N) level and green manuring (GM) crops at Rampur, 1996/97, summer season**

| GM crops | N level (kg/ha | | | | F. test | SE± |
|---|---|---|---|---|---|---|
| | 90 | 60 | 30 | Mean | | |
| Without GM | 790 | 1489 | 761 | 1013 | | |
| Dhaincha | 857 | 1730 | 1028 | 1205 | | |
| Sunhemp | 981 | 1157 | 1185 | 1108 | | |
| Cowpea | 750 | 1158 | 1407 | 1105 | | |
| Mean | 844 | 1383 | 1095 | | ** | 94.0 |
| SE+ | | | | NS | | |
| F. test | | | | 108 | | |
| F. test for GM X N | | | | NS | | |

** = significant at P<0.01 level and NS = Non-significant

**Partial budgeting and dominance analysis for nutrient management**

Partial budgeting for N and labour used for GM incorporation and seed purchase of GM were calculated as the total variable cost that vary in hectare basis. The highest net benefit/ha was Rs. 48626 for N at 60 kg/ha + Dhaincha followed by Rs. 47002 and Rs. 46969 for N at 30 kg/ha + cowpea and N at 60 kg/ha, respectively (Table 4). For the dominance analysis, all treatments except the treatments of N at 30 kg/ha, 60 kg/ha, N at 30 kg/ha + cowpea and N @ 60 kg/ha + Dhaincha were observed dominated (Table 4). Only the undominated treatments were to be recommended for general purpose. Therefore, dominated treatments were rejected from recommendation (Paudel, 1995). Nitrogen at 60 kg/ha has a marginal rate of return (MRR) of 328.4% and N at 60 kg/ha + Dhaincha has a MRR of 131%. Therefore, these two treatments are recommended for dissemination because of higher MRR.

**Soil parameters analysis for nutrient management**

Soil pH, OM and N were depleted in a maize-rapeseed system. It has been found that higher the N level applied more the depletion and faster the decomposition of GM that might have caused more loss of nutrients from the soil. The range of depletion percent of nitrogen was from 0.17 to 0.586 for N 30 kg/ha + sunhemp and N at 90 kg/ha, respectively. Yamoah *et al.* (1998) reported that N removal index was the highest in continuous soybean, lower in continuous maize and the lowest in continuous sorghum. They also reported that rotations and lower N rate both contributed to higher nitrogen removal index and lower soil residual nitrate. In this study, the results showed that there was only a zero balance of residual nitrate. The result also showed that there was only a zero balance of residual N in the plots with N at 90 kg/ha + GM of cowpea. On the other hand, all the other treatments resulted

a negative balance of N% in the soil. For all the treatments, there was a negative balance of residual OM% in the soil (results not shown), too. Researchers have estimated that from return of crop residue to the soil can add N reserve to the soil between 16-80 kg/ha.

There should be a continuous addition of OM to the soil in order to sustain the system. Without addition of soil enriching amendments, there is an danger to go for a maize-rapeseed system, which has been depleting soil nutrients under Bariland condition.

Low content of OM and N in sandy loam soils of Siwalik dun valley needs either inclusion of GM crops or addition of any form of organic residue to the soil. Removal of OM and N was more than addition in the system, which is an alarming signal to sustain the system without disturbing present level of productivity. These results explained why soil fertility status of various agriculture research stations of Nepal has been declining in a faster rate day by day. This calls for maintaining of soil OM either by adding crop residues and farm yard manure or by growing GM in the system under question.

**Table 4. Dominance and marginal analysis influenced by nitrogen (N) level and green manuring (GM) at Rampur, 1996/97, summer season**

| Treatments | Total cost that vary (Rs/ha) | Net benefit (Rs./ha) | Marginal rate return (%) |
|---|---|---|---|
| N @ 30 kg/ha | 638 | 28775 | |
| N @ 60 kg/ha | 1192 | 46969 | 328.4 |
| N @ 30 kg/ha +sunhemp | 1478 | 40993 D | |
| N @ 30 kg/ha+ Dhaincha | 1598 | 36518 D | |
| N @ 90 kg/ha | 1745 | 29096 D | |
| N @ 30 kg/ha+cowpea | 1838 | 47002 | 5.0 |
| N @ 60 kg/ha+cowpea | 2272 | 43295 D | |
| N @ 60 kg/ha+sunhemp | 2332 | 39594 D | |
| N @ 60 kg/ha+ Dhaincha | 2452 | 48626 | 131.0 |
| N @ 90 kg/ha+sunhemp | 2585 | 37378 D | |
| N @ 90 kg/ha + Dhaincha | 2705 | 32786 D | |
| N @ 90 kg/ha+cowpea | 2945 | 33823 D | |

D = dominated treatments having net benefit less than preceding treatments with lower total cost that vary and thus rejected for recommendation.

## Weeds

The prominent maize weeds observed were: *Cyperus rotundus* (Mothe), *Echinochloa colona* (Banso), *Ageratum conyzoides* (Gandhe), *Luca cephalotus* (Gumba), *Cynodon dactylon* (Dubo), *Commelina benghalensis* (Kane), *Euphorbia sp.* (Dudhe), *Celosia argentea* (Chayanphul), *Digitaria adscendens* (Chitre Banso), *Setaria sp.* (Bandar Ghans), *Brachiaria ramosa* (Bans Pate) and *Paspalam commersonii* (Kode Jhar).

Number of weeds per $m^2$ before top-dressing (31 DAS) was found significant (Table 5). The highest number of weeds (457/$m^2$) one day before top dressing was reported for mulching with wheat chaff. Mulching with wheat chaff favoured significantly higher number of weeds per $m^2$ than those of other treatments. Dry matter percentage of weeds before top dressing was highly significant. The highest DM% (18) was produced from the treatment of one hoeing and mulching with wheat chaff which was comparable to one hoeing without removing weeds and hoeing and earthing up by removing weeds. Mulching with rapeseed straw was comparable to farmer's practice of maize weed control.

Different cultural practices of maize weed control were at par with farmer's practice and these practices could be suggested for maize weed control in a maize-rapeseed system of bari land condition in the similar areas of Siwalik dun valley (data not shown).

## Effect of weeds on grain yield of maize and rapeseed

There was no effect of different weed control practices on maize and rapeseed (results not shown). The results showed that wheat chaff mulching had no effect on reducing weed growth as compared to rapeseed straw mulching and other cultural method of maize weed control. Because the number of weeds per $m^2$ was found more in wheat chaff treated plots than mustard straw mulched plots (Table 5). It might be due to high C/N ratio in wheat chaff mulched plots, which took much of the soil moisture and nutrients for decomposition and plant showed N deficiency in the beginning of immobilization process. But in the later stages, mineralization might have started slowly which was already beyond the vegetative stage of maize resulting low production of maize grain yield.

**Table 5. Weed parameters as influenced by different weed control practices at NMRP Rampur, 1996/97, summer season**

| Treatments | Weeds/$m^2$ one day before 1st weeding | Weeds/$m^2$ one day before top dressing | DM% of weeds one day before top dressing |
|---|---|---|---|
| One hoeing without removing weeds | 425 | 241 | 27 |
| Mulching with wheat chaff @ 10 ton/ha | 362 | 457 | 28 |
| Mulching with rapeseed straw @ 10 ton/ha | 237 | 252 | 24 |
| Hoeing and earthing up by removing weeds | 428 | 248 | 27 |
| Farmer's practice | 314 | 178 | 15 |
| Hoeing twice by removing weeds no earthing up | 406 | 146 | 17 |
| Hoeing twice. no removing of weed and earthing up | 406 | 165 | 18 |
| Mean | 369 | 241 | 22 |
| F. test | NS | ** | ** |
| LSD | | 154 | 7 |

** = significant at P<0.01 level, and NS = Non-significant.

## Soil parameters analysis for weeds

Organic matter (OM) was reduced after harvesting of rapeseed compared to before maize. It suggests that OM in the sandy loam soil of Bariland condition should be conserved by adding extra OM to sustain soil fertility of the maize-rapeseed system. Crop residue incorporation from different crops could contribute to a great extent for soil improvement. Cadavid *et al.* (1988) reported that cassava (*Manihot esculenta*) mulch application significantly increased soil organic carbon K, P, Ca and Mg and without much soil pH decreased over the years. They also found that to sustain cassava production in poor sandy soils application of plant mulch and/or chemical fertilizers are highly desirable. This also holds true for a maize-rapeseed production in the poor sandy loam soils of Chitwan and similar domains of Bariland condition. There was a negative balance of N% in the plots except the treatment for mulching with wheat chaff at 10 ton/ha, farmer's practice of weeding maize and two hoeing as the first and the second weeding without removing weeds. It could be explained that wheat chaff decomposed slowly which might have mineralized N accordingly resulting a balance of (+) 0.006% N in the plots. This finding coincides with the result of O'leary and Connor (1997), who reported that there was a tendency for stubble retention to depress soil mineral N in the surface layer possibly through immobilization and denitrification. Similarly, farmer's practice of maize weed control allowed weed incorporation in the field and might have released N slowly making a balance of (+) 0.007% N in the plots. The method of hoeing without removing weeds in the field has also favoured decomposition of plant residues in the plots making a balance of 0.017% N reserve in the soil.

## Partial budgeting and dominance analysis for weeds

A partial budgeting showed that the highest net benefit of Rs. 33052/ha was recorded for mulching with rapeseed straw at 10 ton/ha and the lowest net benefit Rs.22758 from mulching with wheat chaff at 10 ton/ha. All other treatments were found dominated (Table 6). Therefore, all the dominated treatments were to be rejected for general recommendation (Paudel, 1995). Hence, two nondominated

treatments of mulching with rapeseed straw at 10 ton/ha mulching with wheat chaff at 10 ton/ha found economically superior to other treatments of maize under Bariland condition of Siwalik dun valley.

**Table 6. Dominance analysis for a maize-rapeseed system as influenced by weed control practices for maize at Rampur, 1996/97, summer season**

| Treatments | Rupees/ha | |
|---|---|---|
| | Total cost that vary | Net benefit |
| One hoeing without removing weeds | 900 | 30377 D |
| Mulching with wheat chaff @ 10 ton/ha | 500 | 22758 |
| Mulching with rapeseed straw @ 10 ton/ha | 680 | 33052 |
| Hoeing and earthing-up by removing weeds | 3000 | 27390D |
| Farmer's practice | 2700 | 24960 D |
| Hoeing twice by removing weeds, no earthing-up | 2500 | 27637 D |
| Hoeing twice, no removing of weed and earthing-up | 1800 | 29090 D |

Note: D= Dominated treatments that are rejected from recommendation

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# SOIL FERTILITY STATUS IN FARMERS' FIELD OF THE WESTERN HILLS OF NEPAL

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## ABSTRACT

Two hundred and sixty one soil samples from cultivated land representing river basin (<600 m), low (600-1000 m), mid (1000-1600 m) and high (1600-2300 m) hills from Gorkha, Lamjung, Tanahun, Kaski, Parbat, Myagdi, Baglung, Syangja and Palpa districts were collected during 1994. The objectives of this study were to determine soil pH, organic carbon, macro (nitrogen, phosphorus and potassium) and micro-nutrients (zinc, iron, manganese, copper and boron); to find out the effect of land types (Khet and Bari) and soil texture on soil fertility; and the relationships of plant nutrients in the soil. Soil samples were analyzed with standard laboratory procedures.

Variations of soil pH, organic carbon, macro and micro-nutrients were analyzed within and over sites. The soil pH varied from very strongly acidic to slightly alkaline (3.3-7.5). Out of 261 samples, 85 (33%), 15 (6%), 22 (8%) and 92 (35%) samples were low in organic carbon, total N, available P, exchangeable K, respectively. Among micro-nutrients, 29 (11%), 44 (17%), 46 (18%) and 227 (87%) samples were low in available zinc, manganese, copper and boron, respectively. Available iron was high in all samples. In general, Bari land has higher soil pH, organic carbon and both major and micro-nutrients. Mean of all sites data showed that loam and sandy loam texture have higher pH (6.0 to 6.2); sandy loam and silt loam have the highest organic carbon (2.3%), total N (0.22%) and available P (117 to 130 mg/kg) as compared to other textural classes. However, exchangeable K was the highest (0.87 $cmol_c/kg$) in clay soil. Available Zn (0.96 mg/kg) and Fe (2.3 mg/kg) were the highest in clay loam and silty clay loam soils, respectively while available Mn (90.6-91.9 mg/kg) and available Cu, (1.9 to 4.4 mg/kg) was the highest in the silty clay loam to clay loam soils. Boron content was the highest (0.94 mg/kg) in silty clay loam soil. Positive correlation (r=0.01) existed between Fe and Cu, Mn and Cu, K and Fe, Mn and Fe, Mn and K, organic carbon and K, organic carbon and N, organic carbon and P; and P and N. Negative correlation was also noted between B and Zn, pH and N, pH and OC, pH and P and pH and Zn. It is recommended that site specific soil fertility management is needed in the western hills of Nepal.

## INTRODUCTION

The research command area (RCA) of Agriculture Research Station (ARS), Lumle covers 11 hill districts (Gorkha, Lamjung, Tanahun, Kaski, Parbat, Myagdi, Baglung, Syangja, Palpa, Gulmi and Arghakhanchi) of the Western Development Region. The altitude ranges from 200 m in the river basins to more than 3000 m on the ridges of high mountains. Therefore, the RCA of ARS, Lumle has been categories into five agro-ecological research (AER) zones: river basin (<600 m), low hill (600-1000 m), mid hill (1000 - 1600 m), high hills (1600-2300 m) and mountains (>2300 m) in order to develop suitable agricultural technologies. Farming systems in the hills are complex, diverse and predominantly resource poor. The hill soils are particularly vulnerable to losses of organic matter and nutrients through a combination of natural factors, heavy monsoon rainfall, the erosion prone nature of the soils, steep topography and people related activities involving a reduction in ground cover (Tripathi, 1996).

Tuladhar (1995) analyzed soil samples collected from the cultivated land of wheat, barley, maize and rice of the extension command area (ECA) of ARS, Lumle in the low to high hills and reported that organic carbon (OC), nitrogen (N), phosphorus (P) and potassium (K) were low (3.1%), medium (0.24%), very high (155 mg/kg) and medium to high (0.35 $cmol_c$/kg), respectively. National statistics reports a decline in yields of major stable crops (rice, maize) in the hills over the period of 1975 to 1991 (HMG/N, 1993). The validity of such statistics has been questioned (Gill, 1993) but it seems likely that at least in some areas of the hills, increasing cropping intensities, declining livestock numbers and a decline in the rate of FYM/compost application have contributed to a decline in soil productivity (Tripathi, 1996). Moreover, the use of high yielding improved varieties and the diversion of FYM/compost away from Bari land to meet the increasing fertility requirement of lowland (Khet land) may be important factors contributing to this decline. Information on the status of micro-nutrients in the soil of western hills was also lacking. Therefore, the objectives of this survey were to find out the nutrients (macro and micro) status at the different sites, effect of land types, soil texture and altitudes on nutrients status in the western hills of Nepal.

## MATERIAL AND METHODS

### Field survey

Two hundred and sixty-one composite surface soil samples (0-20 cm depth) representing river basin, low, mid and high hills of both upland (Bari) and lowland (Khet) were collected. The samples were collected from the research command area of Tanahun, (Chambas-8, Talbari-5, Khalde Baidi-4, 8), Gorkha (Barapirke-7, 8, 9), Kaski (Hemja- 1 to 4, 9, Deurali-3), Parbat (Pang- 1, 2, Kaphalchaur-6), Myagdi (Arman-6, Kimchaur-6, 8, 9) and Palpa (Nayatola – 4, 5) districts in 1994. Information on altitude, aspects, land-form, land type, soil color, drainage, soil type, fertility rating and distance from the motorable road were gathered. These parameters were given different ratings in order to analyze their effects on crop production and soil fertility.

### Laboratory analysis

Samples were air dried, crushed and passed through a 2 m sieve. Soil pH, organic carbon, total N, available P, exchangeable K and available B were analyzed in the laboratory of ARS Lumle. Available micro-nutrients (zinc, iron, manganese and copper) were analyzed in Cement Water Lab. Pvt. LTD, Ramshah Path, Kathmandu.

*Soil reaction (pH).* Soil extraction was prepared as soil: water ratio of 1:2.5 and determined with a pH meter.

*Organic carbon.* Organic carbon was determined by Walkey-Black dichromate method.

*Total nitrogen.* The standard micro-digestion method (Kjeldahl method) was followed to determine total N. Digested samples were subjected to calorimetric determination with spectrophotometer.

*Available phosphorus.* Bray and Kurt method (0.03 $NH_4F$/0.1HCL extraction) was followed for available phosphorus determination for the soils whose pH were less than 7.3, while for soils whose pH were more than 7.3 the Olsen method (0.5 M $NaHCO_3$ extraction) was followed.

*Exchangeable potassium.* Exchangeable potassium was estimated by 1 M Ammonium acetate extraction followed by flame photometric determination.

*Available boron.* Hot water extraction method was followed for the determination of available boron.

*Available micro-nutrients (Zn, Fe, Mn and Cu).* Ten gram soil was taken and mixed with 100 ml of acid ammonium acetate EDTA extraction solution (prepared according to the method described by Sillanpaa (1982) and then was shaken in horizontal mechanical shaken for about 2 hours. Then the

sample solution was subjected to centrifuge for about 10 minutes and in clear supernatant liquid Zn, Fe, Mn and Cu were determined using Atomic Absorption Spectrophotometer (AAS) with background correction.

### Statistical analysis

Analysis of variance was carried out using each factor in turn as the treatment to obtain P-values. To obtain standard error difference (SED), REML was used. This is because there was unequal replication, so that SED. differs depending on the number of replicates of the means being compared. REML analysis provides an average value for the SED, which is usually quite sufficient for presentation purposes. So all the SED presented are average values.

## RESULTS AND DISCUSSION

Soil pH, organic carbon, total N, available P, exchangeable K, available Fe, Mn and B significantly differed (P=<0.001) except available Zn (P=0.21) and Cu (P=0.11) in different sites (Table 1).

**Table 1. Plant nutrient status in the sample sites of the western hills of Nepal**

| Sites | pH | OC (%) | Total N (%) | Available P (mg/kg) | Exch. K ($cmol_c$/kg) | Available Zn (mg/kg) | Available Fe (mg/kg) | Available Mn (mg/kg) | Available Cu (mg/kg) | Available B (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Arman | 5.78 | 2.67 | 0.24 | 337.4 | 0.43 | 0.71 | 174 | 65.6 | 2.06 | 0.70 |
| Barapirke | 5.30 | 0.97 | 0.15 | 7.3 | 0.48 | 1.19 | 206 | 62.6 | 1.61 | 0.23 |
| Chambas | 5.92 | 0.90 | 0.13 | 19.7 | 0.50 | 0.75 | 175 | 54.1 | 1.32 | 0.41 |
| Deurali | 6.51 | 2.17 | 0.22 | 50.6 | 0.70 | 0.70 | 262 | 70.3 | 2.23 | 0.88 |
| Hemja | 5.15 | 1.81 | 0.17 | 112.8 | 0.12 | 1.03 | 142 | 28.8 | 0.05 | 0.40 |
| Kaphalchaur | 5.05 | 2.48 | 0.23 | 113.4 | 0.32 | 1.26 | 179 | 36.3 | 1.18 | 0.38 |
| Khalde Baidi | 6.62 | 1.31 | 0.17 | 54.5 | 0.20 | 0.85 | 143 | 32.9 | 1.17 | 0.73 |
| Kimchaur | 5.60 | 3.44 | 0.26 | 135.1 | 0.68 | 1.00 | 187 | 58.0 | 1.64 | 0.73 |
| Lumle | 5.51 | 2.55 | 0.27 | 133.9 | 0.27 | 0.77 | 161 | 66.3 | 1.36 | 0.54 |
| Nayatola | 6.33 | 1.90 | 0.20 | 40.0 | 0.53 | 0.72 | 225 | 111.7 | 2.01 | 0.93 |
| Pang | 5.37 | 1.85 | 0.20 | 56.1 | 0.29 | 1.28 | 193 | 57.0 | 1.72 | 0.53 |
| Talbari | 6.33 | 1.45 | 0.16 | 40.7 | 0.41 | 0.94 | 160 | 51.9 | 0.86 | 0.82 |
| Mean | 5.76 | 2.00 | 0.21 | 94.9 | 0.40 | 0.92 | 183 | 58.9 | 1.51 | 0.60 |
| SED | 0.117 | 0.216 | 0.020 | 27.1 | 0.086 | 0.27 | 16 | 17.3 | 0.49 | 0.10 |
| P value | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.21 | <0.001 | <0.001 | 0.11 | <0.001 |
| Minimum | 3.3 | 0.11 | 0.05 | 2.00 | 0.06 | 0.11 | 55 | 3.00 | 0.20 | 0.03 |
| Maximum | 7.5 | 5.26 | 0.52 | 703 | 1.78 | 8.20 | 497 | 363 | 12.6 | 2.22 |

SED = Standard error deviation

Soil pH value ranged between 3.3 and 7.5 with mean value of 5.8 in different sites. Among sites, the lowest mean pH value of 5.2 (strongly acidic) at Hemja (Kaski) site and the highest value of 6.6 (neutral) were recorded at Khalde Baidi (Tanahun). Out of 261 soil samples, 30 samples were very strongly acidic, 73 strongly to medium acidic, 52 slightly acidic, 32 neutral in rating (Table 2). Only one sample showed slightly alkaline pH. The data showed that 39.5% (103) samples were very strongly to strongly acidic (5.0 – 5.5 pH) in rating. Tuladhar (1995) collected 130 soil samples from wheat fields, 114 samples from barley fields, 169 samples from maize fields and 106 samples from rice fields of western hills and reported that mean pH values from wheat and barley fields were medium acidic and that of maize and rice fields were strongly acidic.

Table 2. Rating of pH in the analyzed soil samples from the western hills of Nepal

| | Very strongly acidic | Strongly acidic | Medium acidic | Slightly acidic | Neutral | Slightly alkaline |
|---|---|---|---|---|---|---|
| pH | ≤ 5.0 | > 5.0-5.5 | > 5.5-6.0 | > 6.0-6.5 | > 6.5-7.3 | > 7.3-7.8 |
| n | 30 | 73 | 73 | 52 | 32 | 1 |

Note: n = number of soil samples.

## Organic carbon

Organic carbon content of soil ranged from 0.11 to 5.26% in different sites with mean value of 2%, (Table 1), which is medium in rating. Mean organic carbon of Khalte Baidi (Tanahun) site was the lowest (1.3%) while Kimchaur (Myagdi) had the highest (3%). These values ranged from low to high in rating. Similar low to high values of organic carbon (0.2-7.0%) from the western hills of Nepal were reported by Tuladhar (1995) and Turton *et al.* (1996). Out of 261 samples, 85 (33%) were low, 124 (48%) medium and 52 (20%) high in organic carbon (Table 3), indicating that organic carbon deficiency is localized in the western hills.

## Total nitrogen (N)

Mean soil total N of different sites varied from 0.05% (very low) to 0.52% (very high) with a mean value of 0.21% (medium) (Table 1). About 50% of samples (131) were medium, 44% (115) high and 6% (15) low in N (Table 3). This indicates that 94% of the sampled sites are within medium to high in total N. Mean values of total N in different sites ranged from 0.13% (medium) at Chambas (Tanahun) to 0.27% (high) at Lumle (Kaski). This showed that N fertility of soil in sampled sites in the western hills was not poor. However, N deficiency has been observed in certain pockets of the western hills where cultivation is intensive with the use of high yielding varieties. Variations of total N from 0.001 to 0.80% with a mean value of 0.25% was reported by Turton *et al.* (1996) in the soils of low, mid and high hills of western Nepal.

## Available phosphorus (P)

Available P concentration of soil of different sites varied from 2 to 703 mg/kg with a mean value of 97.9 mg/kg (Table 1). Among 12 sites, Barapirke had the lowest soil available P value of 7.3 mg/kg, which is deficient in available P, while rest of the sites have medium to very high mean available P. Eighty-five percent (221) of the soil samples had high available P. Only 8% (22) and 7% (18) samples were in low and medium in rating (Table 3).

## Exchangeable potassium (K)

Exchangeable K in different sites ranged from 0.06 to 1.78 $cmol_c$/kg. Among different sites, mean exchangeable K was the lowest (0.12 $cmol_c$/kg) at Hemja (Kaski) followed by Khalde Baidi (Tanahun). These two sites were low in exchangeable K, and rest of the sites had medium to high exchangeable K (Table 1). Thirty-five percent samples were in the low category of exchangeable K (Table 3) and might show deficiency symptoms by K susceptible crops.

## Micro-nutrients

Available micro-nutrients ranged between 0.11 to 9.20 mg/kg for zinc, 55 to 497 mg/kg for iron, 3 to 363 mg/kg for manganese, 0.2 to 12.6 mg/kg copper and 0.03 to 2.22 mg/kg for boron in different soil samples. Mean available Cu at Hemja (Kaski) was 0.05 mg/kg, which is low in rating. Mean available B is low in all 12 sites. Eleven percent (29) samples were in the range of low available Zn, while 89% samples had medium to high available Zn (Table 3). All samples fell in high rating of available Fe indicating that iron is enough for the crops. Seventeen percent (44) and 18% (46) samples of Mn and Cu, respectively are low in category, rest of the samples had medium to high Mn as well as Cu. Eighty-seven percent (227) samples had low B (Table 7), which shows that soils of the western hills are deficient in available B. Tuladhar (1994) surveyed different blocks of ARS, Lumle and reported that all the blocks of ARS, Lumle were deficient (<0.5%) in available B.

## Effect of land types on plant nutrients

Organic carbon, available P, exchangeable K, available Fe, Mn and B differed significantly (P=0.013 to <0.001) (Table 4) between Khet and Bari lands. But pH, total N, available Zn and Cu were not different between Khet and Bari (P = 0.11 to 0.44). Organic carbon, available P, exchangeable K, available Fe, Mn and B in soil was significantly higher in Bari land as compared to Khet land indicating that Bari lands are more fertile than Khet lands. The crop cut survey and associated data suggest that Bari soils are relatively fertile because they receive the majority of applied FYM/compost (typically 20-50 t/ha/yr) (Tuladhar, 1995).

**Table 3. Plant nutrients rating of soil samples from the western hills of Nepal**

| Nutrients | Low | Medium | High |
|---|---|---|---|
| Organic carbon (%) | ≤ 1.49 (85) | ≥ 1.49-2.9 (124) | ≥ 2.9 (52) |
| Total N (%) | ≤ 0.1 (15) | ≥ 0.1-0.2 (131) | ≥ 2.0 (115) |
| Available P (mg/kg) | ≤ 6.5 (22) | ≥ 6.5-12.0 (18) | ≥12 (221) |
| Exchangeable K($cmol_c$/kg) | ≤ 0.2 (92) | 0.2-0.66 (119) | ≥ 0.6 (50) |
| Available Zn (mg/kg) | ≤ 0.5 (29) | 0.5-0.8 (130) | ≥ 0.8 (95) |
| Available Fe (mg/kg) | ≤ 2 (0) | 2-10 (0) | ≥ 10 (254) |
| Available Mn (mg/kg) | ≤ 10 (44) | ≥ 10-20 (25) | ≥ 20 (185) |
| Available Cu (mg/kg) | ≤ 0.5 (46) | - | ≥ 0.5 (208) |
| Available B (mg/kg) | ≤ 1.0 (227) | ≥ 1-2 (33) | ≥ 2-5 (1) |

Figures in the parenthesis are the number of observations.

**Table 4. Effect of land type on plant nutrients in the western hills of Nepal**

| Land type | pH | OC (%) | Total N (%) | Available P (mg/kg) | Exch. K ($cmol_c$/kg) | Available Zn (mg/kg) | Available Fe (mg/kg) | Available Mn (mg/kg) | Available Cu (mg/kg) | Available B (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Khet | 5.72 | 1.82 | 0.20 | 63.3 | 0.22 | 0.98 | 163.4 | 30.4 | 1.41 | 0.51 |
| Bari | 5.80 | 2.13 | 0.21 | 116.1 | 0.52 | 0.88 | 195.5 | 78.3 | 1.58 | 0.65 |
| Mean | 5.76 | 1.98 | 0.21 | 89.7 | 0.37 | 0.93 | 179.5 | 54.4 | 1.50 | 0.58 |
| SED | 0.070 | 0.123 | 0.010 | 14.7 | 0.036 | 0.112 | 7.2 | 6.7 | 0.20 | 0.05 |
| P value | 0.32 | 0.013 | 0.114 | <0.001 | <0.001 | 0.34 | <0.001 | <0.001 | 0.4 | 0.004 |

SED = Standard error deviation

## Effect of soil texture on plant nutrients

Soil pH, organic carbon, macro- and micro-nutrients except available Zn were affected by soil texture (P = 0.04 to <0.001) (Table 5). Sandy clay loam and loam have the highest pH of 6.2 and 6.0, respectively. Silt loam and sandy loam soils were rich in organic carbon (2.33%), total N (0.22%) and available P (117 to 130 mg/kg). However, exchangeable K was rich in clay (0.87 $cmol_c$/kg) and clay loam soils (0.73 $cmol_c$/kg). Among the micro-nutrients, Fe (253 to 225 mg/kg) and Mn (90.2 to 91.9 mg/kg), were sufficient in sandy clay loam to silty clay loam soil, while Cu (4.4 mg/kg) was sufficient only in silty clay loam soil. Available B (0.94 mg/kg) was the highest in sandy clay loam soil.

## Effect of aspect on plant nutrients

Aspect affected to soil pH, organic carbon, total N, available P and exchangeable K (P = <0.001) (Table 7). Highest pH (6.1 to 6.2) were obtained in south/east, west and east/south facing aspects, while the highest organic carbon value of 2.7% was recorded in north/east site. The lowest total N (0.14%) and available P (16.0 mg/kg) were analyzed in south/east and north/south sides, respectively. Maximum exchangeable K (0.42 to 0.43 $cmol_c$/kg) was recorded in south to south/east aspects.

Aspect affected to available Zn, Fe and B (P = 0.01 to 0.003) showing the highest values of Zn (2.6 mg/kg) and Fe (208 mg/kg) in north/south, and B (0.7 mg/kg) in north/east and west aspects. Available Mn and Cu were not affected by aspect.

**Effect of altitudes on plant nutrients**

Soil pH, organic carbon, total N, available P and exchangeable K were affected by altitudes (P = <0.001). The highest pH (6.1) was recorded at <600m altitude. Organic carbon, N, P and K values increased at higher altitudes (Table 6). Altitude did not affect the micro-nutrients (Zn, Fe, Mn and Cu) except B (P = 0.05), which increased at higher altitudes.

**Table 5. Effect of soil texture on availability of plant nutrients in the western hills of Nepal**

| Texture type | pH | OC (%) | Total N (%) | Available P (mg/kg) | Exch. K ($cmol_c$/kg) | Available Zn (mg/kg) | Available Fe (mg/kg) | Available Mn (mg/kg) | Available Cu (mg/kg) | Available B (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Loamy sand | 5.80 | 1.66 | 0.20 | 93 | 0.25 | 0.87 | 154 | 47.8 | 1.07 | 0.54 |
| Sandy loam | 5.72 | 2.28 | 0.22 | 117 | 0.30 | 0.96 | 165 | 51.4 | 1.42 | 0.61 |
| Silt loam | 5.52 | 2.33 | 0.22 | 130 | 0.45 | 1.05 | 184 | 54.7 | 1.59 | 0.57 |
| Loam | 6.00 | 2.01 | 0.21 | 85 | 0.50 | 0.81 | 207 | 80.7 | 1.31 | 0.61 |
| Sandy clay | 5.85 | 1.39 | 0.17 | 33 | 0.61 | 0.71 | 241 | 38.0 | 1.33 | 0.68 |
| Clay | 5.83 | 0.83 | 0.12 | 15 | 0.87 | 0.63 | 170 | 26.3 | 1.28 | 0.33 |
| Sandy clay loam | 6.17 | 1.95 | 0.20 | 39 | 0.57 | 0.70 | 255 | 90.2 | 1.50 | 0.94 |
| Silty clay loam | 5.92 | 1.52 | 0.170 | 22 | 0.62 | 0.84 | 253 | 91.9 | 4.44 | 0.51 |
| Clay loam | 5.73 | 1.46 | 0.16 | 16 | 0.73 | 1.14 | 202 | 91.6 | 1.93 | 0.54 |
| Mean | 5.84 | 1.72 | 0.19 | 61 | 0.54 | 0.86 | 204 | 63.6 | 1.76 | 0.59 |
| SED | 0.25 | 0.38 | 0.03 | 47 | 0.12 | 0.37 | 21 | 23.3 | 0.61 | 0.15 |
| P value | 0.009 | <0.001 | 0.04 | 0.003 | <0.001 | 0.82 | <0.001 | 0.006 | <0.001 | 0.005 |

SED = Standard error deviation

**Table 6. Effect of altitudes on plant nutrients in the western hills of Nepal**

| Altitudes | pH | OC (%) | Total N (%) | Available P (mg/kg) | Exch. K ($cmol_c$/kg) | Available Zn (mg/kg) | Available Fe (mg/kg) | Available Mn (mg/kg) | Available Cu (mg/kg) | Available B (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| <600 m | 6.05 | 1.07 | 0.15 | 30 | 0.40 | 0.91 | 174 | 46.3 | 1.29 | 0.50 |
| 600-1000 m | 5.80 | 1.59 | 0.17 | 44 | 0.32 | 1.05 | 179 | 55.9 | 1.42 | 0.55 |
| 1000-1600 m | 5.64 | 2.24 | 0.22 | 98 | 0.42 | 0.87 | 195 | 61.5 | 1.59 | 0.65 |
| 1600-2200 m | 5.66 | 2.90 | 0.27 | 202 | 0.45 | 0.85 | 174 | 68.4 | 1.68 | 0.66 |
| Mean | 5.79 | 1.95 | 0.20 | 94 | 0.40 | 0.92 | 181 | 58.0 | 1.50 | 0.59 |
| SED | 0.11 | 0.13 | 0.01 | 18 | 0.06 | 0.16 | 11 | 10.5 | 0.29 | 0.07 |
| P value | 0.001 | <0.001 | <0.001 | <0.001 | 0.10 | 0.56 | 0.10 | 0.30 | 0.56 | <0.05 |

## Correlation between different plant nutrients

Significant correlation of organic carbon was existed with N, P and K (Table 8), which shows that organic carbon is essential for supplying major nutrients. Significant correlation also existed between K and Fe, K and Mn, Fe and Mn and Cu and Mn. Brady (1984) reported that a similar relationship exists between K and Fe in the production of good quality potatoes, but excess K may adversely affect Mn uptake. He also reported that copper utilization is favored by adequate Mn, which in some plants is assimilated only if Zn in present is sufficient amount. Excess Fe, Cu or Zn may reduce the absorption of Mn.

Table 7. Effect of aspect on plant nutrients in the western hills of Nepal

| Aspect | pH | OC (%) | Total N (%) | Available P (mg/kg) | Exch. K ($cmol_c$/kg) | Available Zn (mg/kg) | Available Fe (mg/kg) | Available Mn (mg/kg) | Available Cu (mg/kg) | Available B (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| East | 5.95 | 1.36 | 0.14 | 27.2 | 0.31 | 0.67 | 184 | 50.1 | 1.23 | 0.60 |
| East/South | 6.15 | 1.59 | 0.20 | 63.5 | 0.19 | 1.05 | 180 | 33.0 | 0.78 | 0.58 |
| East/North | 5.18 | 1.81 | 0.17 | 120.9 | 0.21 | 0.96 | 141 | 31.0 | 1.12 | 0.39 |
| North | 5.79 | 2.25 | 0.22 | 92.8 | 0.37 | 0.86 | 180 | 63.6 | 1.19 | 0.60 |
| North/East | 5.79 | 2.69 | 0.23 | 188.8 | 0.51 | 0.90 | 185 | 72.4 | 1.97 | 0.74 |
| North/South | 5.10 | 1.89 | 0.18 | 16.0 | 0.15 | 2.58 | 208 | 28.0 | 1.23 | 0.35 |
| North/West | 5.85 | 2.21 | 0.24 | 96.5 | 0.36 | 0.77 | 181 | 54.6 | 1.12 | 0.59 |
| South | 5.42 | 1.70 | 0.19 | 48.1 | 0.43 | 1.11 | 186 | 51.6 | 1.44 | 0.45 |
| South/East | 5.85 | 1.16 | 0.14 | 18.5 | 0.42 | 0.90 | 178 | 82.2 | 1.65 | 0.48 |
| South/East | 6.11 | 1.48 | 0.20 | 34.8 | 0.35 | 0.94 | 177 | 56.6 | 1.60 | 0.66 |
| West | 6.11 | 1.92 | 0.21 | 81.8 | 0.52 | 0.70 | 215 | 66.4 | 2.04 | 0.74 |
| Mean | 5.76 | 1.82 | 0.19 | 71.7 | 0.35 | 1.0 | 183 | 53.6 | 1.40 | 0.56 |
| SED | 0.24 | 0.36 | 0.03 | 42.6 | 0.13 | 0.35 | 23.9 | 23.9 | 0.65 | 0.15 |
| P value | <0.001 | <0.001 | <0.001 | <0.001 | 0.009 | 0.02 | 0.04 | 0.23 | 0.21 | 0.003 |

SED = Standard error deviation

Table 8. Correlation matrix of plant nutrients

| | B (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | K ($cmol_c$/kg) | Mn (mg/kg) | N (%) | OC (%) | pH | P (mg/kg) | Zn (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| B (mg/kg) | 1.0 | | | | | | | | | |
| Cu (mg/kg) | 0.14 | 1.0 | | | | | | | | |
| Fe (mg/kg) | 0.12 | 0.23* | 1.0 | | | | | | | |
| K ($cmol_c$/kg) | 0.37 | 0.09 | 0.36* | 1.0 | | | | | | |
| Mn (mg/kg) | 0.14 | 0.21* | 0.37* | 0.26* | 1.0 | | | | | |
| N (%) | 0.23 | -0.01 | -0.02 | 0.13 | 0.17 | 1.0 | | | | |
| OC (%) | 0.21 | 0.03 | -0.01 | 0.26* | 0.15 | 0.58* | 1.0 | | | |
| pH | 0.37 | 0.04 | -0.07 | 0.16 | 0.07 | -0.10 | -0.19 | 1.0 | | |
| P (mg/kg) | 0.16 | 0.09 | 0.08 | 0.13 | 0.07 | 0.34* | 0.44* | -0.16 | 1.0 | |
| Zn (mg/kg) | -0.11 | -0.01 | -0.01 | -0.08 | 0.03 | 0.02 | 0.01 | -0.13 | -0.04 | 1.0 |

## CONCLUSION AND RECOMMENDATION

Soils of Hemja (Kaski), Barapirke (Gorkha), Kaphalchaur and Pang (Parbat) are strongly acidic and should be amended either with agricultural lime or organic manure. Organic carbon content of Chambas and Khalde Baidi (Tanahun), and Barapirke are low and needs addition of organic manure/compost. Among different sites, total N (0.13%) at Chambas, available P (7.3 pip) at Barapirke and exchangeable K (0.12 $cmol_c$/kg) at Hemja were recorded low and these sites need N, P and K nutrients, which should be supplied either through organic or inorganic sources. Among micro-nutrients available Cu was low only at Hemja, while available B was low at all sites. Land types, soil texture, altitudes and aspects have significant effects on plant nutrients. The results showed that different sites of the western hills of Nepal need different soil fertility management practices for better crop production.

## ACKNOWLEDGEMENTS

The author is grateful to Dr. R. P. Sah, Station Chief and Dr. W. S. Jones, Research Adviser, ARS Lumle for their keen interest and encouragement in preparing this paper. The author appreciates the work of soil laboratory staff in analyzing soil samples. Co-operation of the farmers in the surveyed areas of the western hills are gratefully acknowledged. Thanks are also due to Mr. R. R. Adhikari for word processing. This work was conducted under the funding of Department for International Development, UK.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# BOTRYTIS GRAY MOLD OF CHICKPEA IN NEPAL

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## ABSTRACT

Botrytis gray mold (BGM) is a major disease of chickpea. The disease is prevalent throughout the chickpea growing areas. Incidence and severity of the disease are more in eastern Terai than western Terai. Up to 100% yield loss is reported due to BGM in experimental plots. The annual yield loss in farmers' fields is about 15%. The disease generally appears from second to third week of February. None of the chickpea genotypes so far tested was resistant to this disease. Genotypes ICCL 87305, ICCL 87322, ICCV 92501 and ICCV 88506 were tolerant. An experiment with four sowing dates were and 5 chickpea varieties showed that delay sowing (November 25 and December 3) could reduce disease intensity but without increase in yield. Spraying of fungicide Ronilan was more effective in susceptible cultivar H 208 than in tolerant cultivar ICCL 87322. The wider spacing scored less disease and high yield was recorded.

## INTRODUCTION

Chickpea is the third most important legume crop in Nepal. It is widely grown as a sole or mixed crop in the Terai and inner Terai regions. Botrytis gray mold (BGM) caused by *Botrytis cineria* Pers. Ex. Fr. is one of the important yield limiting factors in successful growing of chickpea in Nepal.

BGM is distributed throughout the country wherever chickpea is grown, but its epidemic depends on environmental factors. The disease is more severe in eastern than western Nepal. In Nepal, BGM epidemics occur almost every year, resulting in an estimated yield loss of 66% in experimental plots (Reddy *et al.*, 1988). The annual yield loss in farmers' fields is about 15%. Up to 100% loss was observed where susceptible variety with thick plant density was grown. The disease appears from second to third week of February. Severity of the disease varies with varieties. This paper deals with brief review and status of research work done in Nepal.

## RESISTANT VARIETY

Cultivation of resistant/tolerant varieties is the only economical and durable means to control BGM of chickpea. Chickpea genotypes obtained from different sources were screened and found susceptible to BGM. Only a few lines were found tolerant. The recommended varieties of chickpea in Nepal are tolerant to susceptible against BGM. Several national and international nurseries were conducted at different stations of the country for many years. Some of the genotypes found tolerant are Dhanush, Gaurav, ICC x 840508-33 and ICC x 840508-41 (Karki *et al.*, 1989), Tara (ICC x 840508-36), ICC x 840 508-21 and ICCL 87305 (Joshi, 1996).

## INTEGRATED DISEASE MANAGEMENT

Since there are no varieties with high level of resistance, integrated management is the most economical and feasible methods for farmers to get good yield. Also, integrated management

experiment was conducted at Regional Agricultural Research Station (RARS), Parwanipur in collaboration with ICRISAT to find out a practical base for the management of BGM in 1994/95 and 1995/96. In the experiment, the effect of host tolerance, growth habit of genotypes, different spacing, fungicide spray and dates of sowing of different varieties were used. The genotypes used in the spacing experiment were H 208, bushy and spreading type, highly susceptible to BGM and ICCL 87322, tall erect, compact and spreading type, tolerant to BGM. The seeding dates were November 12, 19, 26 and December 3 in 1994 and October 26, November 5, 15 and 25 in 1995. The varieties used in seeding dates experiment were PG114, H 208, K850, ICCL 87322 and ICCV 88150.

Significantly less disease was scored in variety ICC 87322 than variety H 208. There was no significant difference in disease incidence and severity between fungicides Ronilan spray in variety ICCL 87322, but significantly less disease was found in Ronilan spray plot in variety H 208 in comparison to no spray (Joshi, 1996). Rathi and Tripathi (1993) found less disease and higher yield in cultivar ICCL 97322 with wider spacing 60 x 5 cm and sprayed with Ronilan in comparison to cultivar H 208, no spray and spacing 30 x 10 cm at Pantangar, India.

Significantly higher disease was scored in cultivar H 208 with spacing 30 x 10 cm and significantly less disease was scored in spacing 60 x 10 cm and 45:15:45 in cultivar ICCK 87322 in 1994/95 also less disease was scored in spacing 60 x 10 cm and 45:15:45 in 1994/95 and 1995/96 (Table 1).

**Table 1. Effect of spacing on BGM disease score and yield 1994/95 and disease score 1995/96**

| Spacing | Mean disease score | | Yield q/ha 1994/95 |
|---|---|---|---|
| | 1994/95 | 1995/96 | |
| 30 x 10 | 6.125a | 6.50a | - |
| 60 x 10 | 4.500b | 5.44 b | - |
| 45:15:45 | 5.063b | 5.25b | 4.653 |
| 60:40:60 | 5.5125b | 5.25b | 3.220 |
| CV | 12% | 14.65% | 46% |

The means followed by common letter are not significantly different at the 5% by DMRT.

Higher yield was found in both cultivars with spacing 45:15:45 in 1994/95 than spacing 60:40:60 (Table 2). This may be due to low plant population in 60:40:60. In wider spacing, significantly less disease and high yield was found in both genotypes (Joshi and Chaudhary, 1996).

**Table 2. Effect of cultivar and spacing on BGM disease score and yield 1994/95 and disease score 1995/96**

| Cultivar | Spacing | Disease score (1-9 scale) | | Yield q/ha 1994/95 |
|---|---|---|---|---|
| | | 1994/95 | 1995/96 | |
| ICCL 87322 | 30 x 10 | 5.25c | 5.25cd | - |
| ICCL 87322 | 60 x 10 | 4.00d | 438d | - |
| ICCL 87322 | 45:15:45 | 4.00d | 4.50d | 4.239ab |
| ICCL 87322 | 60:40:60 | 5.00c | 4.50d | 2.354b |
| H 208 | 30 x 10 | 7.00a | 7.75a | - |
| H 208 | 60 x 10 | 5.00c | 5.0b | - |
| H 208 | 45:15:5 | 6.125b | 6.00bc | 5.066a |
| H 208 | 60:40:60 | 5.250c | 6.00bc | 4.086ab |
| CV | | 12% | 11.33% | 46% |

The means followed by common letter are not significantly different at the 5% by DMRT.

Even in susceptible chickpea varieties, H 208 and PG 114, the mean disease severity was significantly reduced in late sown crops, December 3, 1994 and November 25 in 1995. However, delayed sowing did not significantly improve the grain yield in all varieties (Table 3). This may be due to high disease severity in early sowing and chickpea varieties not adaptive to late sown condition. Karki *et al.* (1989) found that BGM incidence was low in delay sown chickpea crop and high in early sown crop. In erect and tolerant varieties (ICCL 87322 and ICCV 88510) significantly low disease was observed (Table 4).

Table 3. Effect of sowing dates on disease score (BGM) and yield (1994/95 and 1995/96)

| Sowing date | | Disease score | | Yield (q/ha) | |
|---|---|---|---|---|---|
| 1994/95 | 1995/96 | 1994/95 | 1995/96 | 1994/95 | 1995/96 |
| Nov. 12 | Oct. 26 | 5.50a | 6.50a | 4.464a | 2.055a |
| Nov. 19 | Nov. 5 | 5.00ab | 6.25a | 6.044a | 1.048a |
| Nov. 26 | Nov. 15 | 5.26a | 5.95a | 4.902ab | 1.02a |
| Dec. 3 | Nov. 25 | 4.20b | 4.40b | 2.911b | 1.430a |
| CV | | 11% | 11% | 57% | 62.47% |

The means followed by common letter are not significantly different at the 5% by DMRT.

Table 4. Effect of sowing dates on (BGM) disease score and yield in different cultivars (1994/95)

| Cultivars | Disease score | | Yield (q/ha) | |
|---|---|---|---|---|
| | 1994/95 | 1995/96 | 1994/95 | 1995/96 |
| PG 114 | 5.375ab | 6.438ab | 7.008a | 1.304b |
| H 208 | 5.500ab | 7.063a | 4.282b | 1.030b |
| K 850 | 4.667bc | 4.938d | 4.686b | 2.008a |
| ICCL 87322 | 4.500c | 4.688d | 4.518b | 1.338ab |
| ICCV 88150 | 4.917c | 5.750c | 4.826b | 1.492ab |
| CV | 11% | 11% | 57% | 62.47% |

The means followed by common letter are not significantly different at the 5% by DMRT.

Significantly less BGM severity was found at Parwanipur in *Trichoderma viride* (a biological control agent), Ronilan and *T. viride* + Ronilan plots in comparison to non-treated plots. At Rampur, although less BGM was observed in treated plots, there was no significant difference among the treatments in relation to disease severity, flower drops, area under disease progress curve value and grain yield (PPD, 1997).

From the experimental results, it can be concluded that BGM of chickpea can be managed through integration of disease resistance or tolerance, wider row spacing as 45:15:45, spraying of fungicides and adjustment of sowing date.

## SEED-BORNE INFECTION

Seed samples of twenty-five chickpea varieties were tested to find seed-borne infection by BGM fungus. Standard blotter method was used for the study. The infection percent varied from variety to variety (0-5.5%). Out of 25 varieties tested 13 were found free from BGM infection. The highest infection (5.5%) was found in the seed sample of variety Sita.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# EFFECT OF DIFFERENT PADDY SEED STORAGE STRUCTURES ON SURVIVABILITY OF *Drechslera oryzae* UNDER RAMPUR CONDITION

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## ABSTRACT

An experiment to study the effect of different paddy seed storage structures such as metal bin, paddy straw ball, Ghyampo, mud bin (Dehri) and jute bag on survivability of *Drechslera oryzae*, was conducted in randomized complete block design at Rampur, Chitwan. Three were three replications. Five kilograms seed of Masuli variety with nine percent initial infection of *Drechslera oryzae* was stored in each storage structure. Percentage of infected grains was assessed using blotter technique at two months interval. Assessments were done on 24th November, 22nd January, 22nd March, 5th June and 24th July 1997. Percentage of infected seed grains was decreased to three percent from nine percent during whole storage period in metal bin. However, the effect of other storage structures was inconsistent in decreasing percentage of infected seed grains during storage.

## INTRODUCTION

Brown leaf spot disease caused by *Drechslera oryzae* of rice is an important disease in all rice growing areas of the country. Under highly favorable conditions, the disease may cause a yield reduction ranging up to ninety percent (Rangaswami, 1996). The disease is seed-borne. The fungus survives on infected plants parts as well. Infected seed is one of the important sources of inoculum. In Nepal farmers store their paddy seeds in different seed storage structure in different parts of the country. Ghyampo, a burnt earthen pot, is used by hill farmers where as Terai farmers use paddy straw ball and mud bin (Dehri) for storing paddy seeds. Metal bin is a recent introduction and progressive farmers store their paddy seeds in it. Jute bag is also use by some farmers to store their paddy seeds. The survival of the fungus on seed depends upon storage temperature and relative humidity. These environmental parameters differ from type of seed storage structures used for seed storage. Temperature and relative humidity inside paddy straw bass and jute bag change as these parameters of storage room change. However, such quick change in these parameters inside metal bin is not expected. Rao (1992) reported more incidences of fungi and bacteria on rice grains stored in cement bin as compared to steel bin and Puri, a straw structure. Puri had the lowest incidence. This study was undertaken to know the effect of different local paddy seed storage structures on survivability of *Drechslera oryzae* on seed grains of rice under Rampur conditions of Chitwan.

## MATERIALS AND METHODS

Metal bin (made of tin), Ghyampo (burnt earthen pot of thirty kilograms capacity), paddy straw ball, mud bin (Dehri) and jute bag were used for study. Paddy straw ball was made of relatively long paddy straw. One end (base) of the straw was tied with paddy straw rope. Other end of the straw was

spread in circle and on it loose paddy straw uniformly and evenly so that seed grains did not pass through it. Paddy seeds was placed in it and spread tied straws were tied together. Mud bin was made of a mixture of mud and chaffed paddy straws. Seed of Masuli variety was procured from the farmers whose field was infected with brown leaf spot disease and its initial *Drechslera oryzae* infection level was determined at Plant Pathology Division of Khumaltar using blotter technique (Richardson, 1983). Five kilograms seed was placed in each storage structures. There were three replications. These seed storage structures were placed in one of the store rooms of office building of Agriculture Research Station, Rampur, Chitwan on 24$^{th}$ November 1996. At two months interval seed samples were drawn from each structure. All together five assessments were made. It was done on 24th November 1996, 22nd January, 22nd March, 5th June and 24th July 1997. Maximum and minimum temperatures, dry and wet bulb temperatures of the storage period were also recorded. Data were analyzed using MSTAT-C programme of computer statistical package.

## RESULTS AND DISCUSSION

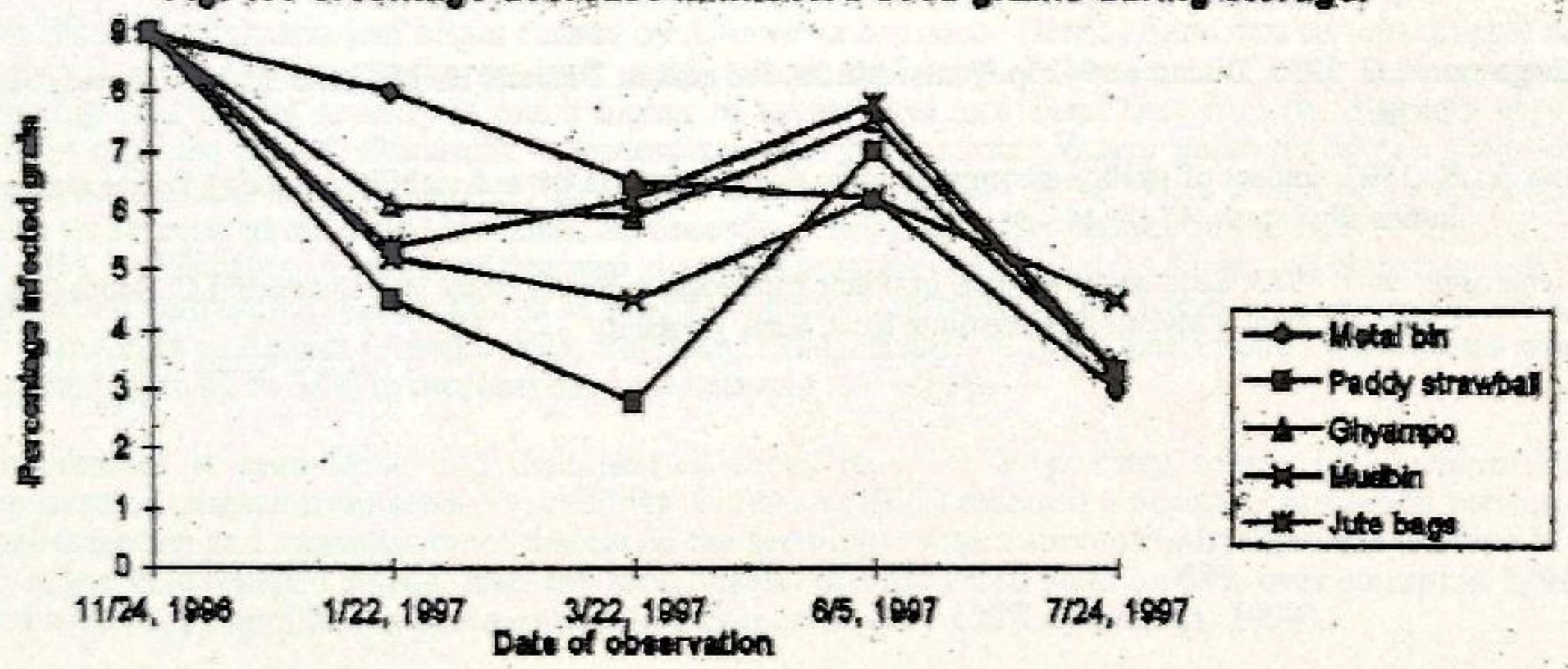
There was significant decrease in percentage of infected seed grains after whole storage period in all the treatments (Table 1). However decrease in percentage of infected seed grains was consistent in metal bin only (Fig. 1).

**Table 1. Performance of different storage structures in reducing percentage of infected seed grains**

| Structure | On observation dates and % infected grain mean | | | | | Mean |
|---|---|---|---|---|---|---|
| | 24 Nov. 1996 | 22 Jan. 1997 | 22 March 1997 | 5 June 1997 | 24 July 1997 | |
| Metal bin | 9.0a | 8.0ab | 6.5abc | 6.2abcd | 3.0ef | 6.5 |
| Paddy straw ball | 9.0a | 4.5cdef | 2.8f | 7.0abc | 3.3def | 5.3 |
| Ghyampo | 9.0a | 6.1abcd | 5.9abcde | 7.5abc | .3.3def | 6.4 |
| Mud bin (Dehri) | 9.0a | 5.2bcdef | 4.5cdef | 6.2abcd | 4.5cdef | 5.9 |
| Jute bag | 9.0a | 5.4bcdef | 6.2abcd | 7.8ab | 3.3def | 6.4 |
| Mean | 9.0 | 5.8 | 5.2 | 7.0 | 3.5 | |

Figures with same letters in row and column are not significantly different by DMRT at 5% level.

**Fig.-1: Percentage decrease in infected seed grains during storage.**




Percentage of infected seed grains was higher in all the treatments except metal bin on 5th June 1997 as compared to preceding date of observations. This may be due to higher average temperature (22-30°C) during preceding period of storage (Table 2). For fungal conidial germination, optimum

temperature is reported to be 25-30°C (Rangaswami, 1996). However, higher relative humidity was also important for conidial germination. The store room where seed storage structures were kept was relatively damp and always had higher relative humidity as compared to outside. Temperature and relative humidity inside paddy straw ball, jute bags, Ghyampo and mud bin change as there is change in these parameters of room where seed storage structures are placed. However, such quick change in temperature and relative humidity is not possible in metal bin. Decrease in percentage of infected seed grains after June was lower between 22nd January and 22nd March 1997 as mean temperature was below 20°C (Table 2). At the end of storage period percentage infected seed grains decreased in all the tested storage structures. Metal bin, Ghyampo and jute bag had same percentage infected grain at the end of storage period. The lowest percentage ofinfected seed grains was recorded in paddy straw ball on 22nd March 1997 followed by mud bin and Ghyampo. Metal bin and jute bags had the highest and the second highest percentage of infected grains, respectively on the above date. At second assessment paddy straw ball had lowest percentage of infected grain (4.5%) followed by mud bin (5.2%), Jute bag (5.4%), Ghyampo (6.1%) and metal bin. The lowest percentage of infected grains were found in metal bin and mud bin (6.2% each), followed by paddy straw ball (7%), Ghyampo (7.5%) and jute bag (7.8%). At the end of storage period (24th July 1997), the lowest percentage of infected grains was found in metal bin (3%), followed by paddy straw ball, Ghyampo and Jute bags (3.3% each) and mud bin (4.5%).

Irrespective of type of structures, the lowest percentage of infected grains was found at the end of storage period 24th July 1997, followed by 22nd March 1997, 22nd January and 5th June. Irrespective of date of assessment paddy straw ball had the lowest percentage of infected grains (5.33%) followed by mud bin (5.86%), Jute bag (6.35%), Ghyampo (6.37) and metal bin (65%). In all types of storage structures percentage of infected grains was reduced at the end of storage period but there was consistent reduction at all dates of assessments in metal bin only. This is in contradiction to the findings of Rao (1992) who reported increased fungal infection in metal (steel) bin.

## ACKNOWLEDGMENTS

The Authors are thankful to the Chief Mr. M. L. Sah ARS, Rampur for providing facilities to carry out the experiment. They express their appreciation to Mr. K. P. Pokhrel for word processing.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# EFFECT OF FUNGICIDES ON ALTERNARIA LEAF BLIGHT OF RAPESEED CROP AND MEASUREMENT OF CORRELATION COEFFICIENT BETWEEN INFECTION OF DISEASE IN THE FIELD AND CORRESPONDING SEED INFECTION IN LABORATORY TEST

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## ABSTRACT

Alternaria leaf blight caused by *Alternaria brassicae* is one of the economically important diseases of rapeseed. The pathogen infects stem, leaf, siliqua and seed causing significant losses in seed yield. An experiment for reducing severity of infection in the crop was conducted during 1996 and 1997. The disease was significantly reduced by the application of iprodione (Rovral) and mancozeb (Dithane M-45) over control. A correlation was measured between field infection and seed infection. The correlation was positive and highly significant which shows that percent of seed infection with *A. brassicae* depends upon the severity of infection in the field.

## INTRODUCTION

Rapeseed (*Brassica campestris* L. var. *toria*, *B. campestris* var. *sarson*) and mustard (*B. juncea*) are important oilseed crops in Nepal. These crops are grown in all ecological regions of the country but their intensive cultivation are found in inner Terai and Terai where the crops occupy about 79% of total oilseed areas (CBS, 1997b). The total estimated areas under oilseed crops are 1,85, 000 ha and the productivity is 627 kg/ha in the country (CBS, 1997a).

The disease, Alternaria leaf blight caused by *Alternaria brassicae* (Berk.) Sacc. is a serious disease of rapeseed mustard that attacks on leaf, stem, siliqua and seed. It occurs in all rapeseed mustard growing area but its severity is much higher in inner Terai and Terai than in hills. Shrestha *et al.* (1998) reported that *A. Brassicae* is widespread and predominant fungal pathogen in the seeds of rapeseed mustard in the country. The disease causes significant yield losses every year depending upon its severity in the field (Shrestha and Shrestha, 1992). In India, various authors have reported 15 to 71% yield losses in rapeseed-mustard due to Alternaria leaf blight (Kadian and Saharan, 1983; Singh and Bhowmik, 1985; Kolte *et al.*, 1987). Similarly in Nepal, yield losses were estimated 20 to 25% in Chitwan district (Anon., 1993; Shrestha, 1994). Based on field experiments, yield losses was reported from 32 to 57% in mustard due to Alternaria leaf blight.

The disease is seed-borne and the diseased seeds may act as primary source of inoculum by transmitting disease from seeds to seedlings. Shrestha (1997) reported a positive correlation between seed infection and transmission of disease in the seedlings. Application of fungicides like Dithane M-45 in the field reduced disease intensity significantly and increased yield by 48% over control in 1991 and in 1992, by application of Rovral, yield was increased by 133% (Shrestha, 1994).

In the present study, it has been tried to evaluate the effectiveness of fungicides applying at different period and determine relationship between seed infection and severity of Alternaria leaf blight in the field.

## MATERIALS AND METHODS

The experiment was carried out in a randomized block design with 10 treatments and replicated 4 times during fiscal year 1996/97 and 1997/98 at Oilseed Research Program, Nawalpur, Sarlahi. Two fungicides Dithane M-45 (mancozeb 75 wp) 3 g a.i. /1iter of water and Rovral (iprodione 50 wp) 1 g a.i. /1iter of water was sprayed at 4 dates viz (i) 30, (ii) 45, (iii) 45 and 60 and (iv) 30, 45 and 60 days after seeding (DAS). Each spray schedule was considered as one treatment. The rest two treatments were seed treatment with Rovral 2 g a.i./ kg of seeds and the control (water spray).

Incidence of Alternaria leaf blight on leaves and pods was scored in 0-5 scale (0= no disease, 1 = 1-5% and 5 = >50% leaf area damaged or pod areas covered with spots) on five randomly selected plants. Disease scoring on leaves was done in 60-70 days old seedlings and the pod at maturity. Seed yield and 1000 seed weight were recorded plot wise.

Seed samples, each about 200 g per plot was collected and stored in refrigerator at Plant Pathology Division, Khumaltar Lalitpur. Four hundred seeds of each sample were tested following deepfreeze blotter method (Limonard, 1966) and modified by Mathur *et al.* (1992). Twenty-five seeds per petri dishes were planted on 3 layers of moistened filter papers. The plates were incubated for 24 h at 20 ± 1°C for 6 days under near ultra violet light (NUV) by adjusting 12 h alternate cycles of light and darkness. At the end of incubation period each seed was examined under different magnifications of a stereomicroscope (x 6 - 50) for the growth of *A. brassicae* and other pathogenic *Alternaria* spp. Each sample was tested for two times and average percentage of seed infection was recorded. Data were analyzed statistically and measured correlation coefficients of leaf and siliqua infection with seed infection. The effect of seed infection on 1000 seed weight was also measured by the same methods as mentioned above.

## RESULTS AND DISCUSSION

Alternaria leaf blight appeared in severe form in the both years, 1996 and 1997, in the field of rapeseed at Nawalpur (Terai). The intensity of disease in the leaves and siliqua was much higher in unsprayed and seed-treated plots than in sprayed plots.

In both years, the analyzed data of disease scoring on leaves siliqua and 1000 seed weight showed that there were significant differences between the treatments and control except in seed treated plots.

Between the treatments, there were no significant differences in a single spray of both mancozeb and iprodione at 45 and 60 DAS. Similarly, differences between two treatments such as two sprays (45 and 60 DAS) and three sprays (30, 45 and 60 DAS) of both fungicides were at par (Table 1).

Comparing the effectively of two fungicides, iprodione was significantly superior to mancozeb in reducing intensity of Alternaria leaf blight in the field. Similarly, 1000 seed weight was also higher in iprodione treated plots than in mancozeb treated ones. These observations are in agreement with the results of Shrestha (1994) who reported that iprodione (Rovral) was much more effective than mancozeb (Dithane M-45) in controlling Alternaria leaf blight of rapeseed mustard.

The relationships of leaf and the siliqua infection with seed infection were measured by correlation coefficient for the both years. The relationships were positive and significant ($P<0.001$). Furthermore, infection in the seed was more closely related with siliqua infection than the leaf infection (Fig. 1 and 2). Similarly, correlation between seed infection and 1000 seed weight was calculated for the both years. The relationship was negative and significant ($r= 0.69$; $P < 0.0010$ in 1996 and ($r= 0.65$; $P< 0.001$) in 1997. The results showed that seed infection has direct effect on 1000 seed weight and ultimately on seed yield.

**Table 1. Effect of treatments on Alternaria leaf blight disease causing different level of infection in leaf, siliqua and seed components of rapeseed and their effect on 1000 seed weight, 1996 and 1997**

| Treatment | Percent mean infection of Alternaria leaf blight | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaf | | Siliqua | | Seed | | 1000 seed weight | |
| | 1996 | 1997 | 1996 | 1997 | 1996 | 1997 | 1996 | 1997 |
| Iprodione seed treatment | 50.0a | 60.0a | 48.8a | 30.0b | 31.1ab | 33.1bc | 2.4de | 2.4e |
| Mancozeb spray at 45 DAS | 35.0bc | 51.3b | 42.5b | 28.8b | 29.4ab | 37.2b | 2.9cd | 2.3e |
| Mancozeb spray at 60 DAS | 36.3b | 45.0bc | 40.0b | 25.0c | 30.0ab | 30.1bc | 3.0cd | 2.8cd |
| Mancozeb-spray at 45 and 60 DAS | 32.5bcd | 40.0c | 42.5b | 25.0c | 26.1b | 33.6bc | 3.0cd | 2.8d |
| Mancozeb spray at 30, 45 & 60 DAS | 27.5d | 30.0d | 35.0b | 25.0c | 23.5bc | 21.4d | 2.9cd | 2.9bcd |
| Iprodione spray at 45 DAS | 28.8cd | 27.5d | 22.5c | 20.0d | 11.5cde | 8.9e | 3.1 | 3.3 a |
| Iprodione spray at 60 DAS | 30.0cd | 30.0d | 18.8c | 20.0d | 15.4cd | 26.3cd | 3.3bc | 3.2abc |
| Iprodione spray at 45 and 60 DAS | 20.0e | 25.0de | 13.8d | 10.0e | 6.3de | 6.1e | 3.7ab | 3.2ab |
| Iprodione spray at 30, 45 and 60 DAS | 20.0e | 20.0e | 13.8d | 10.0e | 4.3e | 4.7e | 3.9a | 3.4a |
| Control spray water | 51.3a | 60.0a | 51.3a | 35.0a | 43.3a | 47.4a | 2.3e | 2.4e |
| *= significant at (P<0.001) | * | * | * | * | * | * | * | * |
| CV% | 6.10 | 7.49 | 9.65 | 4.02 | 21.92 | 12.55 | 11.33 | 8.34 |

Actual value presented. Arc sine transformed value analyzed.
Mean in a column with different letters are significantly different at (P = 0.05).
DAS = Days after seeding.

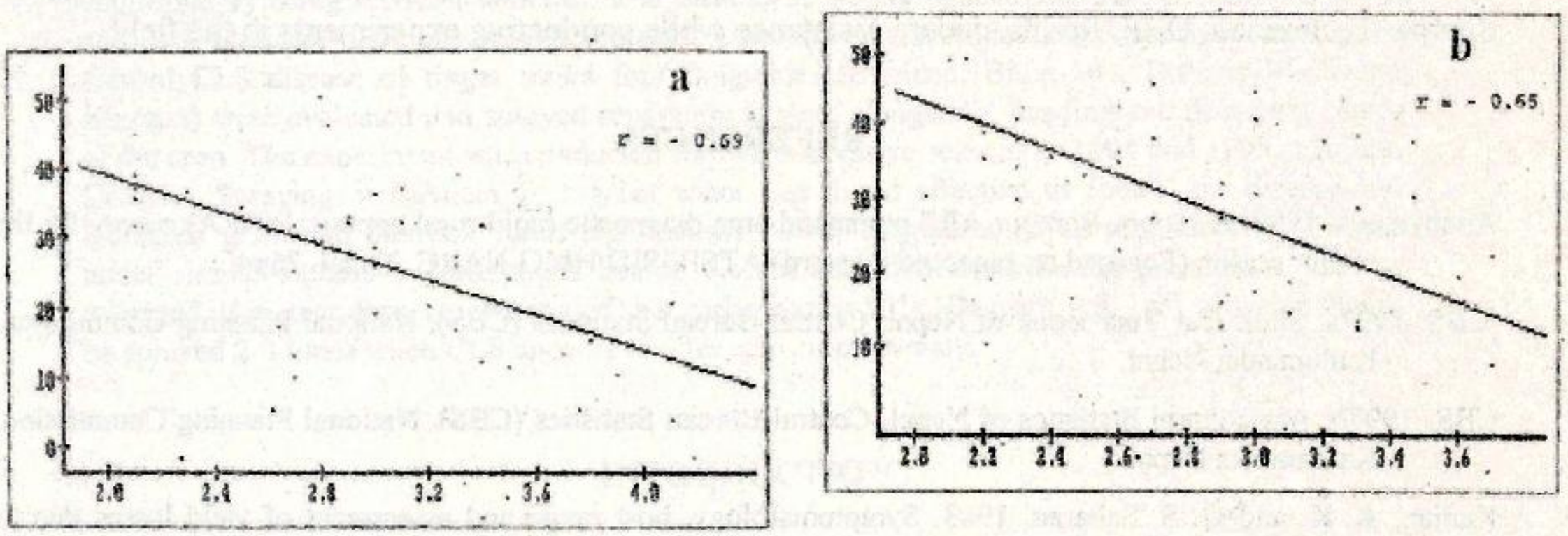


**Fig.1. Correlation between seed and siliqua infection, (a) 1996 (b) 1997**

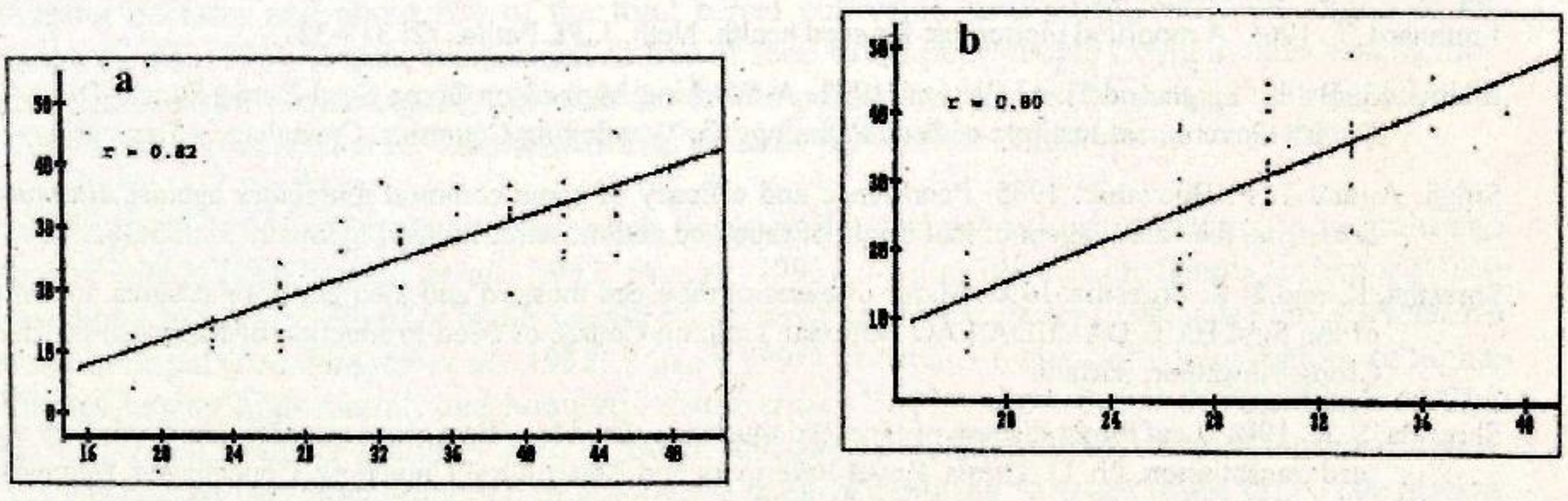


**Fig.2. Correlation between seed infection and 1000 seed-weight, (a) 1996 and (b) 1997**

From these experimental results it indicates that the intensity of Alternaria leaf blight must be reduced at below economic threshold at which seed infection, 1000 seed weight and seed yield would not be affected significantly.

## CONCLUSION

Alternaria leaf blight of rapeseed is effectively managed by the application of iprodione (Rovral ) two times (45 and 60 DAS) in the field. In alternate, mancozeb (Dithane M-45) can be applied at least 3-4 times after 30 days of seeding.

Seed treatment with iprodione or any other chemicals may help to repair the infected seeds for germination and also reducing the primary source of inoculum in the field but the seed treatment alone cannot protect the field crop from air-borne infection of *A. brassicae*. It should be supplemented with 1-2 foliar sprays. To protect the rapeseed crop from seed infection and yield loss a recommended spray schedule should be always followed.

## ACKNOWLEDGMENTS

The authors are grateful to Mr. B. Mishra, Coordinator, Oilseed Research Program (ORP), Nawalpur, Sarlahi for giving all supports to carry out the experiments. They are also thankful to Mr. A. T. Sherpa, Technician, ORP, for his sincere assistance while conducting experiments in the field.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# EFFICACY OF FUNGICIDES AGAINST CERCOSPORA LEAF SPOT OF FINGER MILLET

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## ABSTRACT

Finger millet is the second most important crop after maize in the hills of Nepal. The crop is affected by several diseases and among them, Cercospora leaf spot (CLS) caused by *Cercospora eleusine* is an important disease in the mid high hills of the country. About 15% grain yield loss has been estimated due to the disease at Kabre, Dolakha. Although the disease is effectively controlled by using resistant varieties, it is difficult to obtain multi-disease resistant finger millet cultivars. Besides, there are very few disease resistant recommended varieties. In an attempt to control CLS disease of finger millet four fungicides (Bavistin, Bitox-50 , Dithane M-45 and Hinosan) were evaluated and sprayed separately at stem elongation, heading and flowering stages of the crop. The experiment was conducted for two successive seasons in 1994 and 1995 at Kabre, Dolakha. Spraying of Bavistin @ 1 g/1of water was found effective to control the disease and increased grain and biomass yields significantly. Other fungicides failed to control the disease under similar situation. Correlations among disease and yield contributing parameters were as expected. It is, therefore, recommended that carbendazim 50% (Bavistin ) @ 1g/1 of water should be sprayed 2-3 times when CLS appears to affect the crop severely.

## INTRODUCTION

Finger millet is the fourth cereal crop after rice, maize and wheat in Nepal and it ranks first among mandate hill crops in terms of importance and priority (Upreti, 1993). It is the second most important crop after maize in the hills of the country (Pradhanang *et al.,* 1992). The crop was cultivated in 250 thousand hectares and about 8% of the total cereal cultivated land during 1994-95 season in the country (CBS, 1995). It is an economical source of food to the poor people living in inaccessible hilly areas and its straw is also equally valuable for fodder point of view. Due to its high malt content it is mainly used in preparation for alcoholic drinks in many parts of the country.

Several diseases have been known to attack finger millet and caused heavy reduction in grain and biomass yields (Pradhanang *et al.,* 1992; Prasad, 1993). Among them Cercospora leaf spot (CLS) caused by *Cercospora eleusine* is the second most important disease after blast caused by *Pyricularia grisea* in Nepal (*Pradhanang et al.,* 1992; Prasad, 1995). It occurs in areas of cooler regions of higher altitudes having high rainfall and humidity. Batsa *et al.,* (1993) reported that the incidence of CLS was very high at higher altitudes such as Botch and Jiri of Dolakha district than at lower altitudes. CLS has caused very high reduction in grain yield in early maturing varieties of the crop. The disease reduced grain and biomass yields when it occurred severely in early stages of the crop (Prasad, 1993). Though the disease was serious in Nepal efforts to control the disease was not initiated in the past in the country.

Resistant varieties are cheaper and easier means of controlling the disease. But it is difficult to obtain multiple disease resistance, including CLS resistant finger millet varieties. It is not necessary that a variety will always be resistant to a disease. Therefore, it is necessary to manage the disease by every possible means. With this aim in view, an experiment was designed to evaluate four selected fungicides for the management of CLS.

## MATERIALS AND METHODS

A field experiment was conducted for two successive seasons in 1994 and 1995 at Hill Crops Research Programme, Kabre, Dolakha. A CLS susceptible variety GE-5175 was selected and transplanted in a randomized complete block design. It was replicated four times with five treatments. The treatments included were four fungicides, Bavisting (carbendazim 50%), Dithane M-45 (mancozeb 75%), Hinosan (ediphenphos 50%) and Blitox-50 (copper-oxy-chloride 50%) and a check plot with just water spray. These fungicides were applied along with Triton as a spray sticker. The fungicides, which were found effective against CLS disease in other crops, were considered. A basal dose of 30 kg/ha N and 30 kg/ha $P_2O_5$ was applied at the time of land preparation and 30 kg/ha N was top-dressed during stem elongation and boot stages of the crop in two split doses. Seedlings were transplanted in 10 rows with inter and intra rows spacing of 25 and 10 cm, respectively in a plot size of 4 m X 2.5 m. All the agronomic practices were provided for better disease development and growth of the crop. Each plot was surrounded by 2-3 rows of susceptible border mixture of finger millet to produce sufficient inoculum for reinfection in the plots. Surrounding of susceptible border in each plot also facilitated the accurate spraying. Each fungicide was sprayed in assigned plots at different growth stages of the crop i.e. stem elongation, heading and flowering. The dose of all fungicides remained the same for all sprayings. The disease incidence was noted thrice on 0-9 scale and 10 plants and four leaves of each plant such as lower leaf, middle leaf, one leaf lower than flag leaf and flag leaf from each treatment were evaluated. The final scoring at dough stage was included for analysis. Several yield contributing and other agronomic traits were recorded and among them 1000 grain weight, grain and biomass yields were statistically analysed using ANOVA-2, two factor RCBD and treatment means were separated by using Duncan's multiple range test. Correlation was made among the disease score, 1000 grain weight, grain yield and biomass yield.

## RESULTS AND DISCUSSION

Cercospora leaf spot was not observed at seedling stage of the crop. The disease began to appear at stem elongation stapae and it was maximum at dough stage in both the seasons. In general, all the fungicides reduced the disease and increased grain yield and yield components. It might be due to capability of fungicides on yield contributing factors in spite of not to control the disease. Bavistin was found superior to all other fungicides. However, the fungicides did not control the disease completely (Table 1). Other fungicides were not better than control in the experiment conducted in 1995 season. There was 55.2% grain yield over control in Bavistin sprayed plot. Incomplete control of the disease might be due to low dose for Bavistin, rainfall soon after spraying of the fungicide or less number of sprays. Bavistin and copper fungicides were found effective against tikka disease of groundnut and leaf spot disease of banana (*Cercospora musae*) (Rangaswami, 1975; Kolte, 1976; Vidyasekharan, 1981; Amatya *et al.*, 1992). Bavistin (carbendazim 50% WP ) @ 0.05 a.i. was found highly effective against CLS when sprayed 2-3 times at an interval of 15 days (Subedi *et al.*, 1991).

There was a highly significant difference in disease development in both the years. The significant difference in 1000 grain weight was found only in 1995. In spite of significant difference in some characters, mean values for grain yield of 1994 and biomass yield of 1995 were not significant (Table 1). Biomass yields of all the fungicide treated plots were higher than of water sprayed control plots. The comparison of grain and biomass yields of healthy and affected plants indicated that infection of

leaves upto 27% did not affect the grain yield but affected the biomass yield (Subedi *et al.*, 1991). Pradhanang *et al.*, 1992) reported that CLS did not cause significant grain and straw yield reduction when infection was low to moderate.

Table 1. Effect of fungicides on Cercospora leaf spot (CLS), 1000 grain weight, grain yield and biomass in efficacy of fungicides against CLS of finger millet at Kabre, Dolkha during 1994-1995

| Treatments | CLS score on 0-9 scale | | 1000 grain weight (g) | | Grain yield (kg/ha) | | Biomass (t/ha) | |
|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| Bavistin 1 g/litre water | 5.35c | 1.15b | 2.40a | 3.10a | 1852a | 3012a | 10.11a | 11.52a |
| Dithane M-45 3g/litre water | 8.23ab | 7.15a | 2.45a | 2.58b | 1649ab | 2166a | 9.28a | 8.05ab |
| Hinosan 1ml/litre water | 7.36b | 6.49a | 2.38ab | 2.83ab | 1795a | 2523a | 9.26a | 8.81ab |
| Blitox-50 2g/litre water | 8.72a | 6.25a | 2.20ab | 2.78ab | 1475ab | 2325a | 8.99a | 7.91ab |
| Control (water spray) | 8.89a | 6.69a | 2.13b | 2.50b | 1230b | 1905a | 7.54a | 6.31b |
| CV% | 10.65 | 18.18 | 7.15 | 7.39 | 19.45 | 32.17 | 21.83 | 30.79 |
| F-test | ** | ** | NS | ** | NS | NS | NS | NS |

** Highly significant

There was a significant difference in biomass yield in combination of the season (Table 2). Bavistin spray was better in improving plant height, finger length and straw yield than other fungicides. Force maturity in some plots was observed due to severe infection in the early growth stage of the crop. Maturity period was delayed about 10 days by spraying Bavistin. The straw stayed green even after the maturity of the crop. It was due to control of the diseases, which lengthened the life of growing plants. Correlations between disease and grain yield and other yield components were as expected in both the years (Table 3).

Table 2. Combined analysis of yield and yield contributing parameters with percent yield loss and percent yield increase over control in efficacy of fungicides against Cercospora leaf spot (CLS) of finger millet at Kabre, Dolkha during 1994-1995

| Treatments | Combined mean of 1994 & 95 | | | | | | | | | Percent yield loss | Percent yield increase over control |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CLS score (0-9) scale | 1000 GW (g) | Grain yield kg/ha | Biomass t/ha | Plant ht. (cm) | Tiller/ sq.m. | Head/ sq. m. | Finger length (cm) | Straw yield t/ha | | |
| Bavistin 1g/litre water | 3.2b | 2.75a | 2432a | 10.82a | 101.7a | 80.3a | 76.0a | 9.8a | 8.38a | 35.6 | 55.2 |
| Dithane m-45 3g/litre water | 7.7a | 2.51ab | 1908ab | 8.67ab | 103.3a | 85.9a | 79.9a | 9.6a | 6.76ab | 17.9 | 21.8 |
| Hinosan 1ml/litre water | 6.9a | 2.65a | 2161ab | 9.04ab | 100.3a | 86.3a | 80.0a | 9.8a | 6.87ab | 27.5 | 37.9 |
| Blitox-50 2g/litre water | 7.5a | 2.49ab | 1900ab | 8.45ab | 97.7a | 82.4a | 75.5a | 9.6a | 6.55ab | 17.5 | 21.3 |
| Control (water spray) | 7.9a | 2.31b | 1567b | 6.93b | 99.6a | 81.9a | 76.5a | 9.0a | 5.36b | | |
| CV% | 5.05 | 7.12 | 28.62 | 25.11 | 8.42 | 14.8 | 15.74 | 10.71 | 25.69 | | |
| F-test | ** | ** | NS | * | - | - | - | - | * | | |
| Year | ** | ** | ** | - | - | - | - | - | * | | |
| Inst. X Year | * | * | - | - | NS | NS | NS | - | - | | |

GW = Grain weight, * = Significant, ** = Highly significant

CLS was controlled by spraying Bavistin @ 1 g/litre of water at stem elongation, heading and flowering stage s of the crop and productivity as well as production could be increased significantly. Straw quality was also improved by reducing the leaf spot symptoms in leaves.

**Table 3. Correlations between Cercospora leaf spot (CLS) yield components as well as grain yields at Kabre, Dolkha during 1994-95**

| Correlation between | "r" value | | |
|---|---|---|---|
| | 1994 | 1995 | Combined |
| CLS vs. 1000 GW. | -0.269NS | -0.688** | -0.711** |
| CLS vs. Grain yield | -0.397NS | -0.164NS | -0.394NS |
| CLS vs. Biomass | -0.156NS | -0.184NS | -0.299NS |
| 1000 GW vs. grain yield | 0.577** | 0.455* | 0.450* |
| Biomass vs. Grain yield | 0.824** | 0.930** | 0.898** |

Note : CLS = Cercospora leaf spot, 1000 GW = 1000 grain weight.


## ACKNOWLEDGEMENTS

The author would like to express his sincere gratitude to Mr. D. B. Gharti, Co coordinator, Hill Crops Research Programme, Kabre for his advice and suggestion from time to time. He is also grateful to Mr. S. R. Thapa, LT-2, HCRP, Kabre for helping the author in note taking and managing the experiment. He is grateful to Dr. C. B. Karki, Senior Plant Pathologist, Plant Pathology Division, Khumaltar for his manuscript guidance. Last but not least, he would like to thank Mr. L. B. Jirel (A-5) HCRP, Kabre for his help in word processing.


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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# INDUCTION OF CHITINASE ACTIVITY OF RICE AFTER THE INFECTION BY RHIZOCTONIA SOLANI AND RESISTANCE TO SHEATH BLIGHT

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## ABSTRACT

Sheath blight caused by *Rhizoctonia solani* Kuhn, is one of the most important diseases of rice throughout the world. In Nepal, sheath blight is becoming one of the major diseases in different rice growing areas in the country. No reliable source of resistance has been identified. Because of this problem, the potential of host plant defense mechanism involving chitinase was studied. One hundred and thirteen varieties of rice were selected. The varieties were grouped into three classes based on their reaction to *R. solani*. These groups of plants were used to assess the role of chitinase as determinants of the degree of resistance to sheath blight. The chitinase activity was induced in all the varieties irrespective of the reaction of the sheath blight. In moderately resistant varieties the chitinase activity was induced at 24 hr after inoculation. But in susceptible variety IR58, the chitinase activity was induced at 36 hr after inoculation. Thus, the rapid induction of chitinase after infection of *R. solani* appeared to be associated with the defense mechanism of the rice plant for less disease development. Based on the western blot analysis, the chitinase of 28 and 35 kDa was induced and increased after infection. The negative correlation of relative lesion height and induction of chitinase activity was demonstrated. The low level of chitinase activity was associated with the varieties having more disease severity.

## INTRODUCTION

Sheath blight of rice (*Oryza sativa* L.), caused by *Rhizoctonia solani* Kuhn AG-1 1A, is a disease associated with intensive rice production system (Ou, 1985; Webster and Gunwell, 1992). The disease is considered a major constraint in achieving high yield in many intensive rice growing countries. In Nepal, sheath blight's increasing intensity was observed primarily in dwarf recommended varieties. It is getting more prominent in the Terai and inner Terai region where high yielding varieties are grown (Shah, 1985). In Kathmandu valley its intensity is remarkable. However, it is distributed throughout the country.

A large number of varieties have been screened for resistance to sheath blight but no reliable source of resistance has been identified (IRRI, 1994). In recent year much attention was focused on understanding the complex defense mechanism in response to pathogenic attack (Bowles, 1990; Lamb *et al*., 1989; and Lamb *et al*., 1992). Such studies are of interest not only because it is important to increase our knowledge of the nature of the plant defense mechanism in rice plant but also because there is a potential of enhancing the disease resistance of rice plant to the non-specialized pathogen (Bell, 1981).

In response to a pathogen attack, plants synthesize a large number of proteins with antimicrobial activity. Among these are the hydrolytic enzymes such as chitinases and β-1,3- glucanases which are capable of hydrolyzing the chitin and β-1,3- glucans found in the cell wall of several genera of fungi

(Bartnicki- Garcia, 1968). Further enhancing the endogenous levels of chitinase in tobacco plants has shown to result in greater resistance to infection by fungal pathogens such as *R. solani* (Broglie *et al.*, 1991; and Vierhaeilig, *et al.*, 1993). These experiments point to the potential role of chitinase and β-1,3- glucanase in the defense of the plants against pathogenic fungi.
The objective of the present study was to determine the induction of chitinase activity in response to the infection by *R. solani* AG1, and to determine the role and activity of chitinase in relation to the resistance of some varieties of rice to *R. solani*.

## MATERIALS AND METHODS

One hundred thirteen rice varieties were chosen for this study. The rice plants were grown in the plastic pots in the greenhouse at IRRI. Thirty-five to forty days old rice plants were inoculated with *R. solani*.

Disease evaluation was done at 7 days after inoculation and presented in percent relative lesion height (% RLH).

The % RLH = (Lesion height / Plant height) X100.

The samples of uninoculated and inoculated leaves and sheaths were collected at 7 days after inoculation to determine chitinase activity of all 113 rice varieties. All the samples were stored in a bio-freezer at -80 °C until used.

Protein concentrations were determined using the Bicinchoninic acid (BCA) protein assay kit (Ignatius *et al.*, 1994; Smith *et al.*, 1985). Chitinase assay was determined by colorimetric method (Wirth and Wolf, 1990). The specific activity of chitinase was expressed as unit $mg^{-1}$ protein. One unit can be defined as amount of protein that produces an absorbance change over control of 1 unit.

### Induction of chitinase activity

Nine different rice varieties were selected from three different groups of rice varieties on the basis of RLH% and induction of chitinase activity 7 days after infection. The rice varieties Betichikon, Dudruchi, Khato Chalani, Padi Pulut Malat, Khakibinni, Khajur Kandi, IR72 and IR58 were grown in the greenhouse. The plants were planted in the plastic pots. Thirty-five to forty days after planting, the plants were inoculated with the inoculum of *R. solani*.

The samples were collected at 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, 66 and 72 hr after inoculation. At each sampling time the uninoculated plants were also sampled as control. All the samples were frozen at - 80 °C. The chitinase activity was assayed of all sampling time as mentioned earlier.

Crude extracts were made from healthy and infected plants by homogenizing them in 0.2 M sodium acetate buffer pH 5. Aliquots of extracts containing equal amounts of proteins (250 μg) were analyzed by 12% sodium dodecylsulfate-polyacrylamide gel electrophoresis (SDS-PAGE). After electrophoresis, the protein were transferred to a nitrocellulose membrane by a Bio-Rad transblot apparatus by western blotting and probed with an antiserum raised against a bean chitinase.

## RESULTS AND DISCUSSION

One hundred and thirteen rice varieties showed different reaction to sheath blight disease. Based on RLH (%) the varieties were classified into 3 groups (Table 1). The group 1 consisted of 35 varieties with RLH (%) ranging from 1.51 to 5.36. Similarly the group 2 consisted the 42 varieties with RLH

(%) ranging from 5.57-11.48, and the group 3 of 36 varieties with RLH (%) ranging from 11.58-31.34 (Table 1). All the three groups were significantly different among each other and 35 varieties with low disease, 42 varieties with medium disease, and 36 varieties with medium to high disease on the basis of relative lesion height.

**Table 1. Mean relative lesion height (RLH) percent of sheath blight disease and chitinase activity of 3 groups of rice**

| Group | RLH (%) | | Chitinase activity (U $mg^{-1}$ protein ) | | | |
|---|---|---|---|---|---|---|
| | Range | Mean | Healthy | | Infected | |
| | | | Range | Mean | Range | Mean |
| 1 | 1.51-5.57 | 3.40a | 0.387- 0.598 | 0.548a | 0.617- 0.798 | 0.716a |
| 2 | 5.70- 11.6 | 8.26b | 0.600- 0.723 | 0.665b | 0.800- 0.910 | 0.856b |
| 3 | 12.1-31.3 | 17.0c | 0.725- 0.992 | 0.823c | 0.915- 1.118 | 1.008c |

In a column mean followed by different letters are significantly different at LSD(0.05) =1.98

In all the 3 groups, the chitinase activity of the uninoculated plants remained at a low level as compared to infected plants (Table 1). The mean chitinase activity of uninoculated plants were 0.713, 0.664 and 0.620 unit mg $^{-1}$ protein in 3 groups of varieties 1, 2, and 3, respectively (Table 1). Similarly, the mean chitinase activity of infected plants were 0.931, 0.883 and 0.756 unit $mg^{-1}$ protein in group 1, 2, and 3, respectively (Table 1). The results showed that chitinase activity was low in uninoculated plants compared to infected plants. The data using the colorimetric assay of chitinase in crude extracts of rice sheaths and leaves infected by *R. solani* support the hypothesis that chitinase is induced upon infection may be implicated in plant defense against *R. solani*.

The induction of chitinase activity after inoculation with *R. solani* was determined at different time intervals. The chitinase was induced at 24 hr after infection in the moderately resistant varieties (Fig. 1A, 1B). But in susceptible variety IR58 the chitinase activity was detected at 36 hr after inoculation lag behind 12 hr as compared to moderately resistant varieties (Fig. 1C). In all the varieties, chitinase activity remained at a low level in healthy plants (Fig. 1). In the present study, chitinase was found to be increased in all the infected plants irrespective of their level of sheath blight reaction as compared to their respective uninoculated controls. However, the time at which the increase in chitinase occurred different in these varieties. In the moderately resistant varieties, the induction of chitinase activity started at 24 hr after infection. The moderately resistant varieties showed a rapid response and large increase in the activity within 24 hr in contrast to the susceptible variety IR58 where the induction started after delay of 12 hr. These results agree with findings from other pathosystem. When resistant and susceptible varieties were inoculated with *Phoma lingam*, there was a significant difference in the increase in chitinase activity during the early stage after inoculation (Rasmussen *et al.*, 1992). They reported that resistant variety showed a rapid increase in chitinase activity in constrast to the susceptible varieties where an increase in activity was delayed. Similarly, chitinase activity assayed in *Ascochyta rabiei* - chickpea caused significant induction of the levels of the enzyme activity in the resistant variety than the susceptible variety (Mridula and Sharma, 1992). It appears that the initial increase in chitinase might be crucial for the plant to combat infection.

It was demonstrated the induction of chitinase in *R. solani* infected rice plants by western blot analysis. Upon infection with *R. solani*, the level of 28 and 35 kDa chitinase increased substantially. The susceptible variety IR58 has very faint band (Fig. 2, lane 3). The other varieties IR72, Khato Chalani, and Dudruchi have two bands of molecular sizes 28 kDa and 35 kDa . In Khato Chalani, the uninoculated samples also showed the bands (Fig. 2 lane 6 and 7). The susceptible variety IR58 has very faint band after infection.

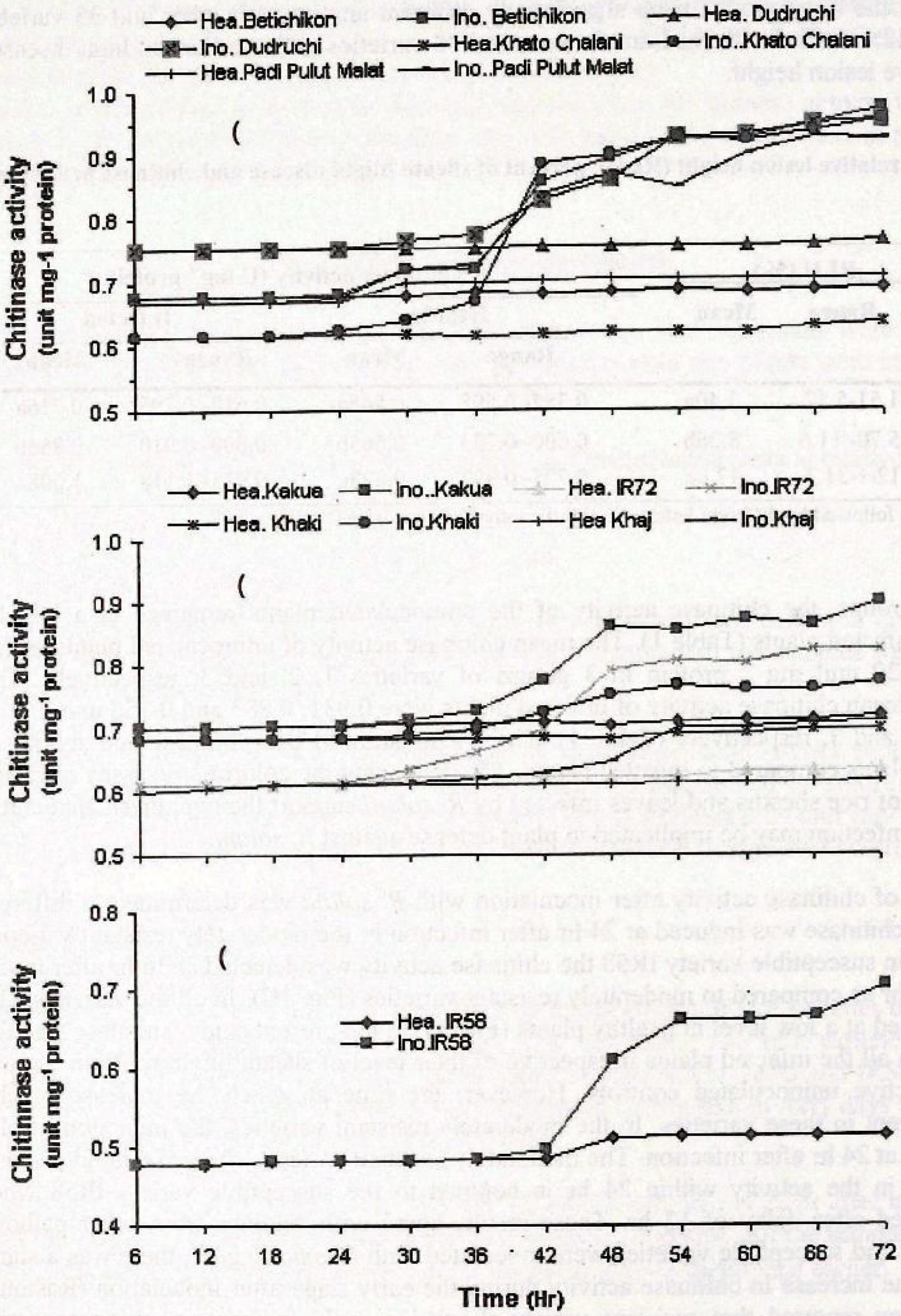


**Fig. 1. Time course of induction of chitinase activity in healthy and inoculated leaf and sheath of rice varieties (A) Betichikon, Dudruchi, Khato Chalani and Padi Pulut Malat (B) Kakua, IR72 and Khakibinni, Khaju Kandi, and (C) IR58.**

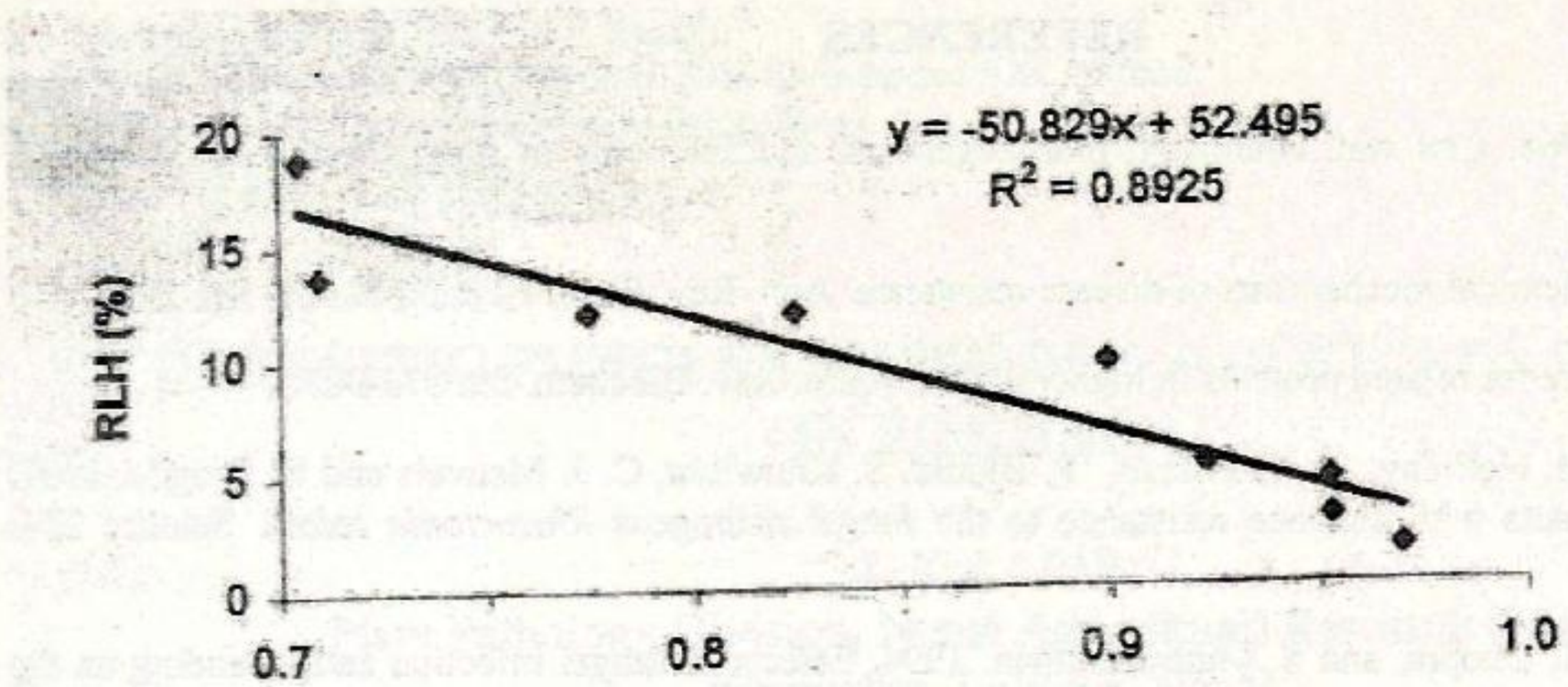


**Fig. 2. Relationship of chitinase activity with relative lesion height**

**Relationship between chitinase activity and RLH. (% )**

The relationship of relative lesion height and chitinase activity at 72 hr after infection was negatively correlated with RLH (%) ($R^2$= 0.892) (Fig. 3).

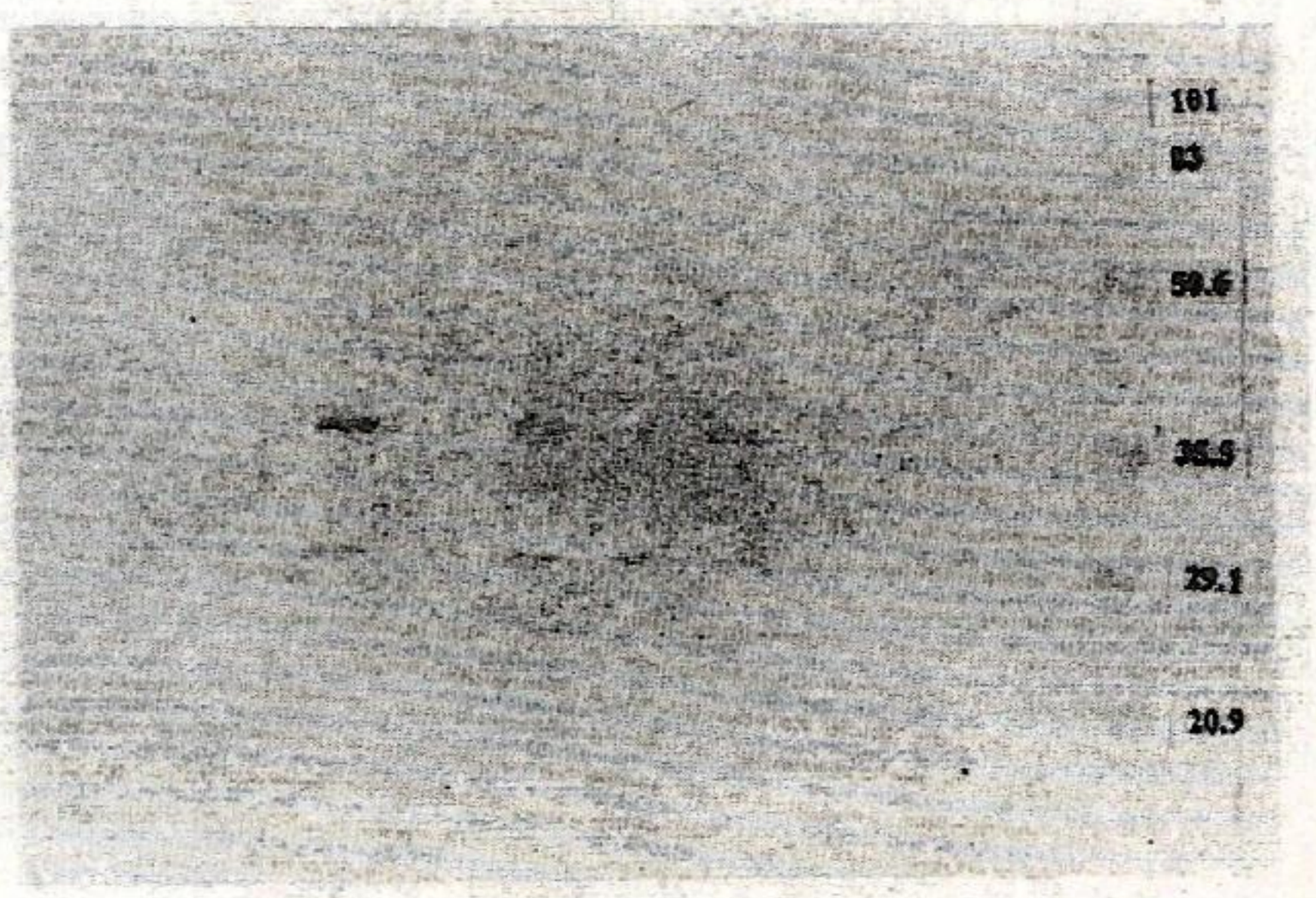


**Fig.3. Induction of chitinase in *Rhizoctonia solani* infected rice varieties lane 1, marker; lane 2-3, IR58 healthy and infected; lane 4 and 5, IR72 healthy and infected; lane 6-7, Khatochalani, healthy and infected; and lane 8-9 Dudruchi, healthy and infected**

The chitinase activity at 72 hr after infection was negatively correlated with RLH (%). These evidences show that chitinase has a defense role in the resistance of some rice varieties. Therefore, it can be concluded that the less the induction of chitinase activity, the higher the disease.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# PARASITIC FUNGI RESPONSIBLE FOR CITRUS DECLINE IN POKHARA

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Pathogenic fungi attacking citrus grown in Pokhara valley were isolated. The mode of infection, symptoms and the extent of damage caused by them were studied. Brief notes on some important fungi causing citrus decline in Pokhara valley are given in this article.

*Phytophthora* sp.

The fungus causes seedling blight, foot rot, gummosis and brown rot of citrus plants. Blighted leaves are dropped-off from seedling trees. It attacks and destroys the bark of basal part of the trunk. Later, the infected trees decline in the orchards. The dead areas of bark may crack vertically with exudation of gum.

*Elsinoe fawcettii*

The fungus causes scab disease. It attacks new foliage, leaves and fruits of citrus causing leaves distorted and lesions on both sides of diseased parts. Under favourable conditions, black postules bearing the fungus fructification can be seen on the lesions. The fungus also attacks on mature fruits causing tear stain.

*Colletotrichum gloeosporioides*

The fungus causes anthracnose on leaves, young shoots and tender fruits showing necrotic patches with distortion and shot lesions. The acervuli are arranged in concentric ring around the necrotic spots. Death parts of the twigs assume silvery grey appearance. Fruit stalks and fruits are also affected followed by decay. On dead twigs acervuli appear as black dots. In severe attacks, branches may die back to the extent of killing the trees in a few years.

*Capnodium citri*

The fungus is associated with sooty mold. The black velvety coating on the affected leaves, twigs and fruits can easily be removed. Under dry conditions, the affected leaves curl and shrivel-up. Sooty mold affected trees give a sickly appearance in the orchards.

*Nectria* sp.

The fungus attacks mostly central branches or even some times main trunk of citrus trees. In the earlier stage a mass of white mycelia are observed on the affected parts of the citrus trees. Later on, the white mycelia are turned into pink coloured fruiting bodies on the diseased parts. Its continuous attack on trees ultimately causes citrus decline.

***Oidium tingitaninum***

The fungus causes powdery mildew on leaves, young shoots and fruits. A white powdery growth develops on the affected leaves, get distorted and followed by defoliation. The twigs show die back symptoms. The powdery mildew affected fruits drop-off prematurely.

***Penicillium italicum* and *P. digitatum***

These fungi cause the blue and green mold, respectively on fruits. Both the organisms cause soft fruit decay disease of citrus fruit in storage. A narrow white margin develops beyond the blue spores soon, which is wider in the case of green mold. Infection occurs in fruits through injuries or wounds. In storage, sound fruits in contact with decayed ones are easily get infected.

***Mycosphaerella horii***

The fungus causes greasy spot on leaves and small twigs. The spots first appear on both upper and under surface of the leaves as a translucent yellowish spot, then change through brown to black later on.

***Pestalotia* sp.**

The fungus causes orange leaf spot disease. This is a newly recorded disease in Nepal. It attacks on upper surface of leaves making a spot. The spots are brownish to grey in the centre and surrounded by brown halos. A mass of conidia are arranged in a ring on the spots.

***Alternaria citri***

The fungus causes fruit rot of citrus. It attacks on young fruits and fruit stalks of citrus. The affected fruits are dropped-off in severe attack. On the surface of affected fruits, a concentric ring of mycelia and conidia are seen.

***Rhizoctonia* spp.**

The fungi cause root rot in field trees planted in flat land. At the early stage of infection the affected trees become yellow followed by defoliation. The root and rootlets and root system as a whole turn into blackish. Also, bark becomes soft with blackish stain on wood under bark. This disease ultimately causes citrus decline.

***Septobasidium* sp.**

The fungus causes felt disease on citrus. It attack twigs and branches of citrus tree. Affected portion get encircled by soft felt like leathery fungal growth, which may extend to the petioles of leaf base and fruit stalks. The surface growth of fungus is smooth, soft spongy and roof-like. The fungus growing over the surface does not penetrate the bark tissues. The growth is light brown to grey in colour.

***Corticium salmonicolor***

The fungus causes pink disease. It appears during or just after monsoon rain in citrus orchards. In the early stages of the infection a white fan-shaped coating of mycelial growth on the branches is seen. The leaves of diseased branches become yellow and followed by defoliation. The postules are of two types, white and pink colour. Hence, the disease is called pink disease.

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# RELATION OF CROPPING PATTERN TO THE INDIGENOUS VAM FUNGAL POPULATION IN ACIDIC SOIL

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## ABSTRACT

The population of indigenous vesicular-arbuscular mycorrhizal (VAM) fungi was determined in three cropping patterns namely, corn-peanut, rice-peanut and corn-fallow at three locations (Plaridel, Compact Farm and Patrocinio) in the Philippines. The most probable number method was used for the estimation of the VAM fungal population. The indigenous VAM fungal population varied with cropping pattern, location and time. The corn-peanut cropping pattern supported more VAM fungi in Plaridel site and Compact Farm than rice-peanut and corn-peanut in Patrocinio site. The least VAM fungi were recorded from rice-peanut in all locations. *Glomus* spp. dominated the VAM spore population in Plaridel. *Gigaspora* spp. were predominant in Patrocinio and in Compact Farm. The corn-peanut cropping pattern supported the highest spore population followed by corn-fallow. The rice-peanut cropping pattern had the least spores. Cropping pattern influenced the relative abundance of the spore types.

## INTRODUCTION

The potential benefit to crop productivity form the symbiotic relationship between plants and vesicular-arbuscular mycorrhizal (VAM) fungi have been amply demonstrated (Abbott and Robson, 1982). In a tropical cropping system, the high temperature favors microbial activity and crops can be grown throughout the year with minimum fallow period provided that rainfall or irrigation is adequate. New crops are often introduced in the tropical cropping pattern to increase productivity as well as soil fertility.

VAM fungi are ubiquitous in nature. They are generally not host specific but preference to plants species have been reported (Abbott, et al., 1984). The population varies with crop, edaphic factors, cultural practices and other factors in the agro-ecosystem (Hetrick, 1994). Change in cropping pattern often brings to changes in the indigenous VAM fungi. It is necessary to understand the biology and effectiveness of the indigenous VAM fungal population for the proper management of VAM technology. An introduced VAM fungus must compete with the indigenous ones in the soil, which are probably better adapted to the edaphic condition (Lambert *et al.*, 1980). For an introduced VAM fungi to succeed, it is necessary that there is low indigenous VAM fungal population and those present are not efficient to improve plant growth or at least do not compete with the introduced one (Abbott and Robson, 1982). A study on the indigenous population in a cropping pattern is also important in determining the stage of a cropping pattern that may require artificial inoculation of VAM fungi. Moreover, cultural practices like heavy fertilization (Kruckemann, 1975), injudicious pesticide

application (Hale and Sanders, 1982), top soil disturbance (O'Halloran *et al.*, 1986), long fallow period (Thompson, 1987), and improper crop rotation (Illag *et al.*, 1988) may reduce indigenous VAM fungal population in the soil. The extent of the change brought about by these practices is important to know for inoculation with VAM fungi to be effective in restoring the biological potential of the VAM fungi in the area.

We reported here the relations of introduced cropping pattern to the indigenous VAM fungal population of three acidic soils in the Philippines. The most probable number method, an indicator of inoculum potential (Porter, 1979), was used to determine the VAM fungal population. The study was carried out from 1987 to 1988.

## MATERIALS AND METHODS

### Site description

Three farmers' fields 5-10 km apart from one another, in Caveria, Misamis Oriental, Philippines (Latitude 8°38' N, Longitude 124°55'E) were selected. All fields were upland, rainfed, well drained with phosphorus deficient soil (Table 1). The Plaridel site was planted to a corn variety prior to the experiment. The Compact Farm site was also planted to corn before the experiment. The Compact Farm was occupied by local cassava (*Manihot esculentus* Cantz.) cultivar for almost 2 years prior to corn. The Patrocinio site was planted to rice var. Speaker (Local) prior to the experiment. The rainy season started in June and the dry season prevailed from November to February in all sites.

**Table 1. Soil analysis of four experimental sites**

| Analysis | Sites | | | |
|---|---|---|---|---|
| | Plaridel | Patrocinio | Compact Farm | IRRI upland |
| pH (1:1 w/v $H_2O$) | 4.6 | 4.65 | 4.2 | 5.3 |
| Total N% | 0.222 | 0.175 | 0.194 | 0.097 |
| P (perchloric acid digestible, ppm) | 1170 | 1085 | 1035 | 947 |
| Available P (Olsen) | 4.8 | 5.0 | 4.3 | 23 |
| Available K (meq/100 g) | 0.272 | 0.531 | 0.188 | 1.05 |
| Particle size %· | | | | |
| Clay | 52.5 | 63.5 | 74.5 | 38.5 |
| Silt | 39.0 | 33.5 | 23.5 | 43.7 |
| Sand | 8.5 | 3.0 | 2.0 | 17.8 |

### Crops and cropping pattern

Three cropping patterns, corn-peanut (CP1), rice-peanut (CP2) and corn-fallow (CP3) were selected. In the fallow plots, weeds remained as such the local farmers' practice. The varieties of corn, rice, and peanut were IPB 1, UPLRI 5 and Pn 4, respectively. The corn in CP1 was fertilized with 25 kg $P_2O_5$/ha as basal application and 50 kg N at hilling up, 35 days after emergence (DAE). Chemical fertilizer was not applied to CP3 plots. The rice was fertilized with 2.5 kg $P_2O_5$/ha basal application, 25 kg N/ha at 14 DAE, 25 kg N/ha at panicle initiation stage. Peanut was fertilized with 25 kg $P_2O_5$/ha as basal application. The source of nitrogen and phosphorus were Urea (46-0-0) and phosphorus (0-18-0), respectively. The three cropping patterns were taken as treatments and were replicated four times in between plots. Row to row spacing for corn, rice and peanut were 60 cm, 30 cm and 30 cm, respectively. Spacing between hills for corn and peanut were 30 cm and 10 cm, respectively. Seed rate for rice was 90 kg/h. Peanut was inoculated with *Bradyrhizobium* spp. obtained from the National Institute of Biotechnology and Applied Microbiology, UPLB Philippines. The recommended cultural practices of the Philippines Council of Agriculture and Resource Research Development (PCARRD) were followed in growing the crops.

### VAM fungal population

Soil sample from the top 15-20 cm of soil from both rhizosphere and nonrhizosphere areas were taken at various stage of crop growth. Each sample (2 kg consisted of 10 pooled sub samples ca. 200 gm, 5 each from rhizosphere and nonrhizosphere areas) from each plot was taken in a diagonal sampling path. Big lumps in the sample were crushed gently, passed through a U.S. standard No. 10 sieve and mixed thoroughly. A series of ten fold dilutions 100, $10^{-1}$, $10^{-2}$, $10^{-3}$, $10^{-4}$, $10^{-5}$ were made of the sample soil with steam-sterilized soil from the same source as diluent. There were five replications per dilution. The test plant was rice var. UPLRI 5. Seeds of test plants were sown in small plastic cups (50 gm soil) containing various dilution. The plants were grown for 6-7 weeks and harvested. The roots were washed, cleared in 5% potassium hydroxide, and stained with trypan blue and examined under a steromicroscope at 50 magnifications for the presence or absence of VAM fungal structures. The number of ineffective VAM fungal propagates was determined using the table of most probable number, Table 100- 1 (Cochran 1950).

Fifty grams of wet soil were used for sieving to recover spores. Spore extraction was done by wet sieving and sucrose centrifugation methods. Root samples of the crops were taken from 10 plants of border rows at 35 DAE, 65 DAE and at harvest. Root samples of the 10 predominant weed plants were taken from fallow plots of CP3. The percent root colonization by VAM fungi was estimated by using the gridline intersect method z (Giovenetti and Mosse, 1980).

### Statistical analysis

The VAM fungal population data obtained by MPN method and spore count data were transformed by log X. The percent root colonization data were transformed by arc sine/X. Mean separation among the cropping patterns was done by Duncan's Multiple Range Test (DMRT).

## RESULTS

### VAM fungal population

Initially, the indigenous VAM fungal population was low in all sites (Fig. 1) and the population increased with crop growth. In Plaridel, there was significant difference in the VAM fungal population among the cropping pattern at 30 DAE of corn. Consistently higher VAM fungal population were observed in the corn-peanut pattern (CP1) followed by corn-fallow(CP3). The rice-peanut (CP2) cropping pattern supported the least VAM fungi population. The highest VAM fungal population was rewarded in November 1987 in all sites.

In Patrocinio, the VAM fungal population was higher in CP3 followed by CP1. The rice-peanut cropping pattern again had the lowest VAM fungal population. Significant differences among the cropping pattern were observed in August when CP1 and CP3 had higher VAM fungal population than CP2.

In compact Farm, the trend of VAM fungal population was similar to that of Plaridel. However, there was no significant difference between CP2 and CP3. Significant higher VAM fungal population was recorded in CP1 in August and September than in CP2 and CP3.

### VAM fungal spores

The VAM fungal spores recovered from the soil by wet sieving using 106 cm and 45 cm sieves were as mixture of different genera and species. Most of the spores in the 106 cm sieve (diameter >106 cm) were *Gigaspora* spp.. The recovered from the 45 cm sieve were *Glomus* and *Acaulospora* species. Some of the identified spores were *Gigaspora gigantea*, *G. margarita*, *G. nigra*. Several species could not be identified. *Glomus* spp. dominated the spore population of Plaridel. While *Gigaspora* was predominant in Patrocinio and Compact Farm (Table 2).

In Patrocinio, *Gigaspora* spores dominated the spore population all through the season except in November when *Glomus* and *Acaulospora* were more. The least number of spores was recovered from CP2. The cropping pattern influenced the relative abundance of spores (Table 2). Initially, there were no significant difference observed except with *Acaulospora* spp. in Patrocinio where CP3 had the least number of *Acaulospora* spp.. In November, when the spore population was the highest, there were significant differences in spore numbers among different cropping patterns. In CP2, *Glomus* spores decreased and *Acaulospora* spores increased. In Patrocinio and Compact Farm, the proportion of *Gigaspora* spores decreased in November. In February, when the spore population was low, the proportion of *Gigaspora* increased in all sites. In Patrocinio and Compact Farm, *Glomus* and *Acaulospora* spore population were low.

**Table 2. Relative abundance of VAM fungal spores (%) at different stages of the three cropping patterns at three sites**

| Cropping pattern | Sampling time | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial (June) | | | At rice harvest (Nov.) | | | At peanut harvest (Feb.) | | |
| | Gig. | Glo. | Aca. | Gig. | Glo. | Aca. | Gig. | Glo. | Aca. |
| **Plaridel** | | | | | | | | | |
| Corn-Peanut | 21a | 68a | 11a | 33a | 46a | 21b | 47a | 41a | 12b |
| Rice-Peanut | 20a | 57a | 23a | 26a | 29c | 45a | 62a | 18c | 20a |
| Corn-Fallow | 21a | 61a | 18a | 37a | 37b | 26b | 56a | 28b | 16b |
| **Patrocinio** | | | | | | | | | |
| Corn-Peanut | 70a | 16a | 14a | 50a | 31b | 29b | 84a | 10a | 6a |
| Rice-Peanut | 75a | 14a | 11a | 45a | 7c | 48a | 90a | 3a | 7a |
| Corn-Fallow | 76a | 22a | 2b | 44a | 47a | 9c | 85a | 11a | 4a |
| **Compact Farm** | | | | | | | | | |
| Corn-Peanut | 60a | 27a | 13a | 59a | 37a | 4c | 88 | 7b | 5c |
| Rice-Peanut | 66a | 19a | 15a | 40a | 32a | 28a | 71 | 9b | 20a |
| Corn-Fallow | 68a | 21a | 11a | 55a | 31a | 14b | 58 | 28a | 14b |

Average of four replications. Actual value presented. Arc sine transformed value analyzed, within site, in column means with common letter are not significantly different by DMRT at 5%.
Gig.= *Gigaspora* spp., Glo. = *Glomus* spp., Aca.= *Acaulospora* spp.

## Root colonization

Corn, rice and peanut roots were mycorrhizal at 35 DAE. In all sites, rice roots were significantly less colonized by VAM fungi than those of corn except in Compact Farm at harvest, when there were no significant differences among cropping pattern (Table 3). In Compact Farm, higher corn root colonization was observed in CP3 than CP1 at 35 DAE and at harvest.

The second crop peanut, was found highly mycorrhizal. Root colonization varied with the cropping pattern. In Plaridel, peanut root colonization was significantly higher in CP1 than in CP2 at all stages. In Patrocinio, peanut root colonization was similar in CP1 and CP2. In Compact Farm, initially there was no difference but at harvest peanut root colonization was higher in CP1 and CP2.

## Dry matter and grain yield

The highest total dry matter (shoot) and grain yield of the first crop, corn or rice, was obtained from CP1 followed by CP2 in all the sites (Table 6). Because of long drought period, peanut performed poorly. Grain yield of peanut was obtained from Plaridel. Significant higher weed dry weight was obtained from Patrocinio and Compact Farm. Peanut grain yield was not different among the cropping patterns.

Table 3. Mean percent root colonization by VAM fungi of first and second crop in three cropping patterns at three experiment sites

| Cropping pattern | First crop (corn or rice) | | | Second crop/peanut or weed | | |
|---|---|---|---|---|---|---|
| | 35DAE | 65 DAE | Harvest | 35DAE | 65 DAE | Harvest |
| | | | **Plaridel** | | | |
| Corn-Peanut | 17.5a | 76.4a | 80.2a | 30a | 61a | 65a |
| Rice-Peanut | 9.5b | 32.2b | 41.7b | 22b | 40b | 49b |
| Corn-Fallow | 25.3a | 71.4a | 75.6a | 20b | 31c | 36c |
| | | | **Patrocinio** | | | |
| Corn-Peanut | 17.7a | 67.0a | 70.0a | 24a | 38a | 43a |
| Rice-Peanut | 8.3b | 32.0b | 35.7b | 22a | 40a | 38a |
| Corn-Fallow | 18.5a | 71.0a | 75.5a | 38b | 50b | 59b |
| | | | **Compact Farm** | | | |
| Corn-Peanut | 14.2b | 63.3a | 67.7a | 32a | 51a | 55a |
| Rice-Peanut | 9.5c | 26.4b | 42.3a | 34a | 47a | 49b |
| Corn-Fallow | 18a | 56.4a | 64.4a | 28b | 36b | 40c |

Average of four replications. Actual value presented. Arc sine transformed value analyzed, within site, in column means with common letter are not significantly different by DMRT at 5%, DAE = Days after emergence.

### Weed root colonization

Weeds in the experimental plots were highly mycorrhizal. Weed species differed in the sites with respect to root colonization by VAM fungi (Table 4).

## DISCUSSION

Difference in the VAM fungal population were observed among the different cropping pattern. The difference could be attributed by several factors, namely crop species in the cropping pattern, cultural practices, fallow period, soil moisture and seasonal changes.

Mycorrhizal system is a complex system involving a three-way interaction among the plants, VAM fungi and soil (Harley and Smith 1983). In that system the plants, being the producer of the system that feeds the microorganism in the rhizosphere, play a vital role. In some cases, plants release compounds that are inhibitory to some microorganisms (Kapustaka and Rice, 1976). Therefore, acts as driving force for rhizosphere development and maintenance the rhizosphere was found to contain microorganisms than bulk soil (Whipps and Lynch, 1986). There were 10 times more VAM fungal propagules in the rhizosphere than in non-rhizosphere area (Illag *et al.*, 1988).

Table 4. Percentage of weed root colonized by VAM fungi growing with crops and in fallow in the experimental sites of Claveria

| Weeds | Percent root colonized | | |
|---|---|---|---|
| | Plaridel | Patrocinio | Compact Farm |
| *Ageratum conyzoides* | x | 60 | x |
| *Bidens pilosa* | 45 | 30 | x |
| *Calopogonium mucunoides* | x | 15 | 10 |
| *Borreria laevis* | x | 50 | 45 |
| *Brachiaria distachya* | 0 | 10 | 12 |
| *Digitaria ciliaris* | 20 | x | x |
| *D. longiflora* | x | 15 | 17 |
| *D. setigera* | 18 | x | x |
| *Cyperus rotundus* | 10 | 8 | 8 |
| *Hyptis suaveolens* | 35 | x | x |
| *Rottboellia cochinchinensis* | x | x | 24 |

x= Weed species not found in the place.

Cropping pattern brings changes in root density in the soil. Warner and Mosse (1982) observed that the effect of plant species was much greater than the effect of root density. Hence, the difference in the crop species in the cropping pattern would play a major role in changing the VAM fungal population. In the present study, higher VAM fungal population was observed in the corn plot than in the rice plot. Corn appears to support more VAM fungal population than rice does. Initially, the VAM fungal population was very low in all the sites and the number increased with crop growth. The population increased faster in Plaridel than in the in the other two sites. The difference could be due to the composition of the VAM fungal population and the initial VAM fungal population. Plaridel had a higher initial VAM fungal population and had more spores of *Glomus* spp. and *Acaulospora* spp. High fertility decreases VAM fungal population (Plechentte *et al.,* 1984). Phosphorus fertilizer application stimulates mycorrhizal infection and external hyhal growth only when it alleviates a severe P deficiency (Abbott and Robson, 1977; Abbott *et al.,* 1984; Pairunan *et al.,* 1980 Same *et al.,* 1983). The addition of P decrease VAM spread at P levels adequate for plant growth. Soil fertility of Patrocinio site appeared to be higher than that of Plaridel and Compact Farm because corn yield was higher at Patrocinio without fertilizer. Also, tissue analysis showed high nitrogen, phosphorus and potassium in plant tissue samples collected from Patrocinio site. Probably, the addition of 25 kg $P_2O_5$ per hectare in Patrocinio reached that level of P that might be inhibitory to infection and external hyphal growth. The same quantity of P addition might be below the inhibitory level in Plaridel and Compact Farm.

The cropping pattern with rice supported the least VAM fungal population (Fig. 1). The close spacing of rice plants apparently suppressed the weed population. Weeds in the experiment sites are highly mycorrhizal (Table 5). The decrease in mycorrhizal weeds could be a contributing factor for the reduction of VAM fungal population. VAM fungi are non-host specific but preference to certain host species are known (Abbott and Robson, 1984). The change in relative abundance of VAM fungal population (Table 5) could be due to this preference. The proportion of *Acaulospora* spp. was higher in rice plots. Probably, *Acaulospora* spp. was favored by rice as host plant. This observation is important because specificity between host plant, VAM fungal species and soil affect the degree of stimulation of plant growth by mycorrhiza (Mosse, 1986). It may be feasible to consider selection of proper crop species that will encourage the prolife station of selected spore types.

The VAM fungal population was not reduced by the fallow period in the various cropping pattern. The VAM fungal population continued to rise after corn harvest. The weeds growing in the plots and the roots left in the soil after harvest nursed the fungi during the fallow period. Moreover, regrowth of harvested corn stalk as ratoon was also observed.

**Table 5. Means of number of VAM fungal propagules in three cropping patterns of the three experimental sites**

| Cropping pattern | Number of VAM fungal propagules per 100 g oven dry soil | | | | | |
|---|---|---|---|---|---|---|
| | June | July | August | September | November | January |
| | | | **Plaridel** | | | |
| Corn-Peanut | 107 | 487a | 1921a | 3027 | 6006 | 277 |
| Rice-Peanut | 113 | 212b | 721c | 1099 | 1918 | 187 |
| Corn-Fallow | 102 | 310c | 922b | 1402 | 1376 | 211 |
| | | | **Patrocinio** | | | |
| Corn-Peanut | 48 | 66 | 181a | 148 | 442 | 104 |
| Rice-Peanut | 43 | 88 | 98b | 432 | 405 | 61 |
| Corn-Fallow | 51 | 79 | 186a | 260 | 557 | 77 |
| | | | **Compact Farm** | | | |
| Corn-Peanut | 76 | 128 | 372a | 423a | 1105 | 304 |
| Rice-Peanut | 67 | 98 | 128b | 169b | 548 | 221 |
| Corn-Fallow | 68 | 99 | 120b | 133b | 683 | 187 |

Average of four replications. Actual value presented. Arc sine transformed value analyzed, within site, in column means with common letter are not significantly different by DMRT at 5%.

**Table 6. Means of yield and yield parameter; tissue analysis of corn/rice and peanut of three cropping patterns at three sites**

| Site/cropping pattern | Corn or Rice | | | | | | Peanut or Weeds | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plant height (cm) | DM t/ha | Yield t/ha | Tissue analysis | | | Plant height (cm) | DM t/ha | Yield t/ha |
| | | | | % N | % P | % K | | | |
| **Plaridel** | | | | | | | | | |
| Corn-Peanut | 147 | 3.72a | 1.76a | 2.44 | 0.19 | 1.55 | 12.3a | 0.35a | X |
| Rice-Peanut | 89 | 10.82b | 2.95b | 2.15 | 0.08 | 1.97 | 14.8a | 0.36a | X |
| Corn-Fallow | 125 | 2.3c | 0.76c | 2.02 | 0.15 | 0.15 | X | 0.71a | X |
| **Patrocinio** | | | | | | | | | |
| Corn-Peanut | 183 | 4.350a | 2.38a | 2.52 | 0.23 | 1.91 | 32.3a | 3.13b | 578a |
| Rice-Peanut | 89 | 7.549b | 3.54b | 2.15 | 1.10 | 2.38 | 31.1a | 2.70b | 612a |
| Corn-Fallow | 167 | 2.616c | 1.38c | 2.23 | 0.19 | 0.19 | X | 4.36a | X |
| **Compact Farm** | | | | | | | | | |
| Corn-Peanut | 120 | 2.183a | 1.10a | 2.43 | 0.17 | 1.59 | 24.1a | 1.71b | 246a |
| Rice-Peanut | 93 | 8.119b | 3.18b | 2.28 | 0.12 | 1.93 | 26.2a | 1.425b | 238a |
| Corn-Fallow | 101 | 1.538c | 0.88c | 2.80 | 0.15 | 1.62 | X | 5.56a | X |

Average of four replications. Actual value presented. Arc sine transformed value analyzed, within site, in column means with common letter are not significantly different by DMRT at 5%.

The VAM fungal population dropped to a very low level in January and February. There was little rainfall after November and soil moisture in the site continued to decline so that the top 6 cm soil was very dry in January and February. The general soil moisture of the sample was estimated on the basis of 10 g oven dry soil. The moisture content of soil sample from July to November was 34-45%.

The moisture content of January and February sample was 10- 12%. Drought was found to reduce the VAM fungal population despite the presence of host because of hyphalysis (Hetrick, 1984). When condition becomes unfavorable, fungi change to resting spores. The VAM fungal spores are resistant to unfavorable condition but poor in infectivity (Menza, 1985). The low VAM population in January and February could be due to low soil moisture.

The number of spores differed with the sites regardless of cropping pattern. Spore population was high in November in all sites. Probably seasonal variation might be a factor for spore production. The highest spore production was 10 per gram soil in CP1 at Plaridel. Reported spore number in natural soil ranged from a low of 0.2 to 8 per gram soil in Rhode Island (Koske and Halvorson, 1982) to a high of 50 to 100 per gram soil in north India (Singh and Verma, 1981) and Pakistan (Khan,1974).

Fluctuation in the number of *Glomus* and *Acaulospora* spores were observed, particularly in Plaridel. Many unhealthy dark spores were observed in Plaridel. In a separate test, those dark spores were found noninfective to rice seedlings. In June, January and February, more than 50% of the spores were dark and unhealthy, which were not included in the count. Many natural enemies of VAM fungi might be present in the soil. The high spore production of *Glomus* and *Acaulospora* may be a survival mechanism of the fungi to compensate for the spore lost because of natural enemies.

Peanut plants in the plots (CP1 and CP2) with a high VAM fungal population had high root colonization. This implies that proper selection of crop species in the cropping pattern could be made to initiate favorable mycorrhizal population for the succeeding crop. In the present study, despite good root colonization, a positive yield response was not observed. No significant increases in the yield were observed among the various cropping patterns.

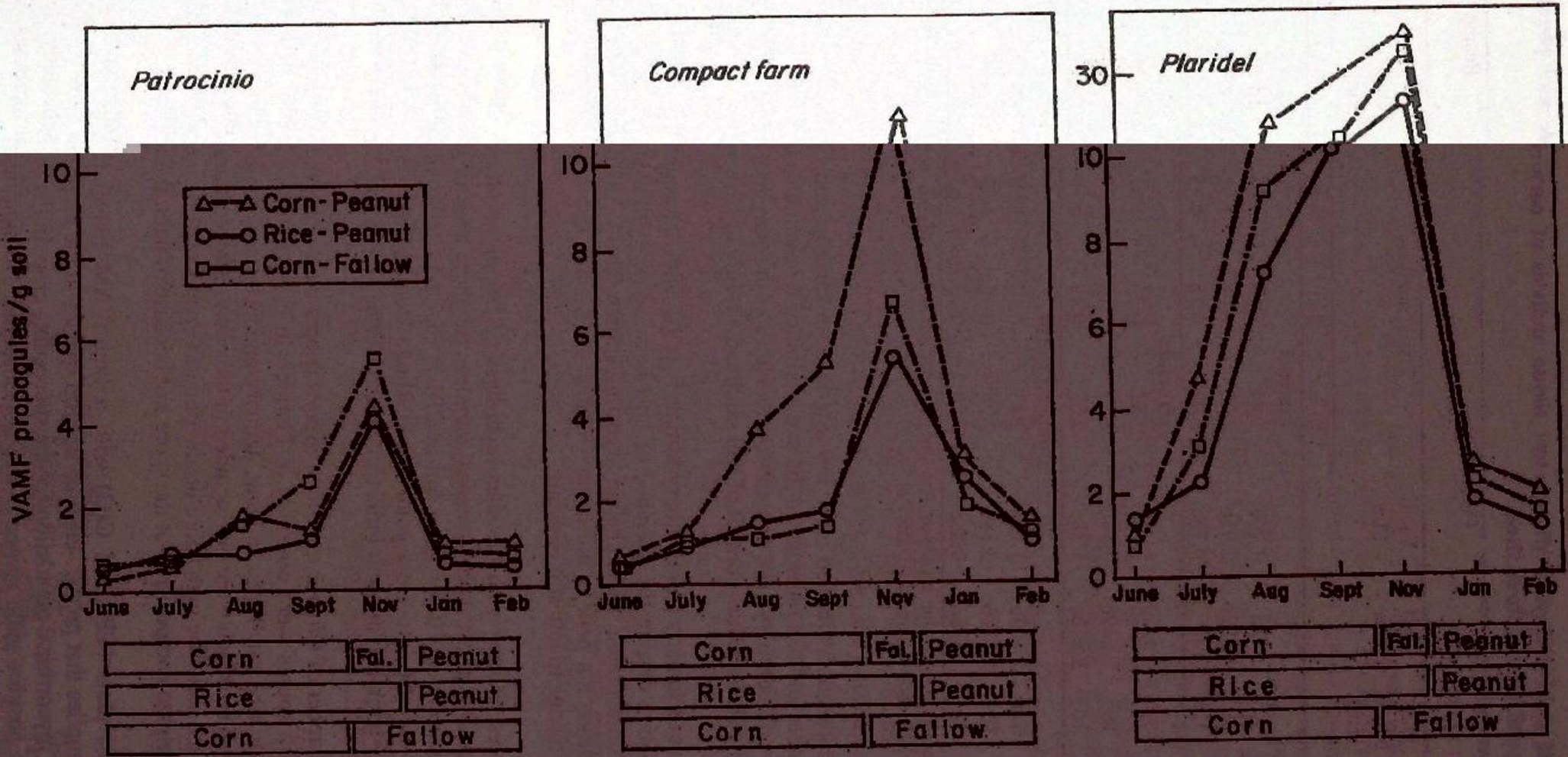


**Fig. 1. Change in VAM fungal population with time in three different cropping pattern**

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# SOURCES OF RESISTANCE TO BACTERIAL WILT IN TOMATO AND ITS MANAGEMENT

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## ABSTRACT

Twenty-nine tomato genotypes were evaluated against bacterial wilt pathogen *Ralstonia solanacearum* under screenhouse conditions at Khumaltar and under field conditions at Panchkhal during 1995-1996. Of them, 15 genotypes showed resistant to moderately resistant reactions under greenhouse conditions whereas only two genotypes BL 342 and BL 333 were found resistant and moderately resistant, respectively under field conditions. Biovar analysis of twenty-five isolates of the pathogen from different crop plants revealed biovar III infecting tomato, eggplant and *Tagetes* sp., biovar II infecting potato and tomato, biovar I infecting tomato, and biovar IV infecting tomato and chili. Greenhouse experiments on the management of bacterial wilt showed that soil amendment with stable bleaching powder at the rate of 15 kg per hectare and seedling treatment with garlic cloves extract (15%) before transplantation controlled the disease by 53 and 43%, respectively as compared to untreated control (wilt incidence 100%) in the year 1997. In the year 1998, soil amendment with bleaching powder and seedling treatment with 20% dried fruit extract of *Zanthoxylum armatum* reduced the disease incidence by 50% as compared to untreated control. The effect of garlic clove treatment was at par with the above treatments.

## INTRODUCTION

Bacterial wilt caused by *Ralstonia solanacearum* Smith (RS) is one of the major limiting factors of solanaceous vegetable production in the tropics and warm temperate regions of the world (Vawdrey and Gounder, 1993). In Nepal, the disease is prevalent in Terai, inner Terai and foot hill areas where tomato (*Lycopersicon esculentum* Mill.) and eggplant (*Solanum melongena* L.) are grown and in the hills where potato is cultivated. Bacterial wilt is encountered as the major problem of Terai and inner Terai (Thapa and Manandhar, 1992) and is the second most important disease after late blight. The disease is not observed as a problem in winter tomato production in Terai because its development is favoured by high temperature and high soil moisture thereby appearing after rain in summer (Timila *et al.*, 1997). The incidence of wilt in tomato and potato was reported to be as high as 70% (Adhikari *et al.*, 1993). In some locations, more than 80% incidence was observed in tomato where as in eggplant as high as 40% was recorded (Timila *et al.*, 1997). However, bacterial wilt is location and strain specific with environmental conditions. Race 1, biovar III in tomato and race 3, biovar II in potato are the prevalent strain of RS in Nepal (Shrestha, 1977; Adhikari *et al.*, 1997).

The disease is very difficult to manage because of its wide host range having more than 44 plant families (Hayward, 1991) and soil-borne nature of the pathogen. The intensive cropping of tomato due to its high value is one of the barriers for the control of the disease through crop rotation. Use of resistant varieties is the most effective and simplest method of controlling the disease. In the absence of such varieties investigations are felt necessary in search of other alternative measures for its integrated management. Some botanicals such as turmeric powder (*Curcuma longa* L.) and asafoetida (*Ferula* sp.) in brinjal (Pun and Das, 1997) and mustard green manure in tomato (Akiew *et al.*, 1996) were reported to be effective in reducing bacterial wilt. Similarly, soil amendment with sodium

nitrate was reported to suppress RS population to non-detectable level (Hanudin and Machmud, 1994).

Taking above mentioned facts into consideration, investigations were carried out in order to identify resistant sources or cultivars to the disease and to find out effect of some botanicals and other agents for the management of the disease through seedling treatment and soil amendment.

## MATERIALS AND METHODS

### Biovar testing

*Ralstonia solanacearum* from wilted plants of tomato, eggplant, chilli, potato and marigold was isolated in Tetrazolium chloride medium. A typical single colony from each isolate was multiplied on 523 medium. A total of 25 isolates were subjected for biovar separation using Hayward's medium (1964) as basal medium supplemented with 10% carbohydrates. A drop of turbid suspension of each isolate was inoculated in duplicate. The medium without carbohydrates served as control. The tubes were incubated at 28°C. Observation was taken for the change in colour of the medium from olive green to yellow and continued for two weeks.

### Host resistance

A total of 29 genotypes were included in the experiment. Among them, 21 were received from Asian Vegetable Research and Development Center and the rest were local and exotic improved varieties grown in Nepal. Seedlings were raised in plastic pots of 3 inches size containing steam sterilized soil. The pots were arranged in randomized complete block design and replicated twice. At 4-5 leaf stage (3-4 weeks old) 40 ml bacterial suspension made from 24 hours old culture (Panchkhal isolate) was drenched in each pot at the rate of 1:10 v/wt. The concentration of the suspension was maintained at $10^8$ colony forming unit (cfu) per ml (OD=0.3 at 600m). Watering was stopped before 24 hours of inoculation. Each genotype received 10 plants per replication. The observation was taken for the typical wilting and continued for a month. The scoring was done according to the scale of Mew and Ho (1976). The same set of genotypes was screened in the infested field at Panchkhal during 1995 and 1996. Based on the wilt incidence and its progression, area under disease progress curve (AUDPC) was calculated.

### Management

For the management of bacterial wilt disease, a preliminary study was made under screenhouse conditions using a susceptible variety L 390, during June-July, 1997-98. Steam sterilized soil was inoculated at the rate of 1:10 v/w with Khumal isolate from tomato which was identified as biovar III of race I. The bacterial population of the inoculum was maintained at $10^8$ cfu/ml. The infested soil was immediately amended with the following treatments in separate lots with the given doses mentioned below.

1. Calcium oxide and urea - 5 and 0.5 ton/ha, respectively
2. Compost (cowdung) - 4 ton/ha
3. Mustard cake - 2 ton/ha
4. Bleaching powder - 15 kg/ha
   The amendments were given 2 days before transplanting in 1997 and a week before in 1998. Seedlings were treated by dipping in the following treatments for 20 minutes before transplanting.
5. *Allium sativum* (Garlic) clove extract - 12-15 % v/v
6. Fluorescing *Pseudomonas* - Turbid suspension
7. Multineem solution - 0.5%
8. *Zanthoxylum armatum* fruit extract - 20%
9. Untreated control

The extract of *Zanthoxylum* was prepared by boiling dried fruit at the ratio of 1:10 w/v water. The extract was then diluted to 20% before use.
The experiment was conducted in randomized complete block design with 3 replications. Each treatment received 10 plants. Four weeks old seedlings were transplanted and observation was taken for wilting of plants each week after transplanting and continued for 6 weeks.

## RESULTS AND DISCUSSION

### Biovars grouping

Based on the ability of oxidizing carbohydrates such as maltose, lactose, cellobiose, mannitol, dulcitol and sorbitol, the isolates were grouped into different biovars. Out of 25 isolates, 13 were identified as biovar III, 2 biovar II, 2 biovar IV and one was biovar I. Some of the isolates were found not oxidizing dulcitol and some oxidizing only mannitol (Table 1). The results indicated the prevalence of biovar I and IV in tomato and biovar IV in chilli in Nepal. However, most of the isolates infecting tomato and eggplant were biovar III and one isolate from tomato was biovar II. This biovar II isolate was from Kavrepalanchowk where tomato and potato are extensively cultivated. Some of the isolates could not be grouped due to not oxidizing dulcitol. According to He *et al.*, (1983) the strain from mulberry not oxidizing dulcitol and sorbitol was grouped into biovar V. Similarly; the isolate from chilli from Jhapa and potato from Kavrepalanchowk oxidized only mannitol. It shows that collection of more isolates and testing them for biovar separation are quite necessary. Present study showed that *Tagetes* sp. is also one of the hosts for *Ralstonia solanacearum* but its population in soil was reported to be suppressed when planted *Tagetes erecta* (Terblanche and Villiers, 1996).

**Table 1. Oxidation of carbohydrates by strain of *Ralstonia solanacearum* of different solanaceous vegetables and their grouping into biovars**

| Isolates | District | Ma | La | Ce | Man | Sor | Dul | Biovar |
|---|---|---|---|---|---|---|---|---|
| T1 | Saptari | + | + | + | + | + | + | III |
| T2 | Jhapa | + | + | + | + | + | - | * |
| T3 | Kathmandu | - | - | - | - | - | - | I |
| T4 | Kavrepalanchowk | + | + | + | + | + | + | III |
| T5 | Lalitpur | + | + | + | + | + | + | III |
| T6 | Chitwan | + | + | + | + | + | - | * |
| T67 | Tanahun | + | + | + | + | + | + | III |
| T8 | Lalitpur | + | + | + | + | + | + | III |
| T9 | Kavrepalanchok | + | + | + | + | + | + | III |
| T10 | Kathmandu | + | + | + | + | + | - | * |
| T11 | Lalitpur | - | - | - | + | + | + | IV |
| T12 | Kavrepalanchok | + | + | + | + | + | + | III |
| T13 | Kavrepalanchok | + | + | + | - | - | - | II |
| E1 | Morang | + | + | + | + | + | + | III |
| E2 | Doti | + | + | + | + | + | + | III |
| E3 | Sunsari | + | + | + | + | + | - | * |
| E4 | Sunsari | + | + | + | + | + | - | * |
| E5 | Kathmandu | + | + | + | + | + | + | III |
| E6 | Lalitpur | + | + | + | + | + | + | III |
| E7 | Bhaktapur | + | + | + | + | + | + | III |
| C1 | Saptari | - | - | - | - | - | + | IV |
| C1 | Jhapa | - | - | - | - | - | - | ** |
| P1 | Kavrepalanchok | - | - | - | - | - | - | ** |
| P1 | Kathmandu | + | + | + | + | + | - | II |
| Ta1 | Lalitpur | + | + | + | + | + | + | III |

T= Tomato, E= Eggplant, C= Chilli, P= Potato, Ta= Tagetes, *.= not oxidizing dulcitol, **= Oxidizing only Mannitol, Ma= Maltose, La= Lactose, Ce= Cellobiose, Man = Mannitol, Dul = Dulcitol,
Sor = Sorbitol, + = Positive, - = Negative

**Host resistance**

Out of 29 genotypes screened under artificially inoculated conditions, 13 showed resistant reaction (0-20% wilt), 3 moderately resistant (21-40% wilt), 2 moderately susceptible (41-60% wilt) and the rest showed susceptible reaction. The AUDPC value for the resistant genotypes ranged from 0 to 394.77 while for moderately resistant group, it ranged from 453.98 to 782.94 (Table 2). It was observed that the disease progress was slower in resistant genotypes than in susceptible ones. After inoculation, wilt progress was quite faster in the first two weeks exceeding more than 60% incidence in susceptible genotypes.

**Table 2. Wilt incidence and AUDPC values on different tomato genotypes under screenhouse conditions at Khumaltar during 1996**

| Genotypes | Wilt % | AUDPC Values | Disease Reaction |
|---|---|---|---|
| L 390 | 100.0 | 2328.58 | S |
| BL 333 | 4.54 | 0111.23 | R |
| BL 323 | 10.0 | 192.0 | R |
| BL 341 | 9.09 | 222.70 | R |
| BL 350 | 0.0 | 0.0 | R |
| BL 342 | 0.0 | 0.0 | R |
| BL 312 | 17.42 | 213.39 | R |
| BL 355 | 5.55 | 19.42 | R |
| BL 410. | 19.08 | 394.77 | R |
| CL 1131-0-0-13-0-6 | 52.22 | 1123.85 | MS |
| CL 143-0-10-3--0-1-10 | 5.0 | 52.5 | R |
| CL 5915-93D4-1-0 | 38.33 | 621.47 | MR |
| CL 6047-1-1-2-3-2-7-0 | 80.71 | 122.44 | S |
| CL 9-0--0-1-3 | 0.0 | 0.0 | R |
| CL 8-0-7-1 | 5.0 | 122.5 | R |
| CL 11D-0-2-1 | 100.0 | 2296.87 | S |
| CLN 65-649D5-2-0 | 10.0 | 247.5 | R |
| CLN 475-BC1 F2-265-4-19 | 17.5 | 140.00 | R |
| CLN 657-BC1F2-285-0-21-0 | 32.54 | 782.94 | MR |
| L 285 | 51.13 | 1173.16 | MS |
| CL 5915-206D4-2-2-0 | 22.61 | 453.98 | MR |
| Money maker | 100.0 | 2275.0 | S |
| Lapsigede | 100.0 | 2531.62 | S |
| Roma | 85.48 | 1042.75 | S |
| Pusa ruby | 100.0 | 1842.67 | S |
| Yachana local | 88.19 | 1515.08 | S |
| Dhading local | 100.0 | 2450.0 | S |
| Jhapa local | 89.89 | 20.92.23 | S |
| Pusa early dwarf | 100.0 | 2400.0 | S |

Most of the genotypes, which showed moderately resistant to resistant reactions under the screenhouse conditions, were found moderately susceptible to susceptible when screened under naturally infested field at Panchkhal (Table 3). Only two genotypes, BL 333 and BL 342 were found resistant and moderately resistant, respectively in both the years. However, almost all the genotypes of BL and CLN groups were moderately resistant to moderately susceptible with lesser AUPDC values.

Table 3. Wilt incidence in different genotypes of tomato and AUDPC values under field conditions at Panchkhal during 1995-1996

| Genotypes | 1995 | | | 1996 | | |
|---|---|---|---|---|---|---|
| | Wilt % | AUDPC Value | DR* | Wilt % | AUDPC Value | DR* |
| L 390 | 100.0 | 2640.8 | S | 100.0 | 2613.31 | S |
| BL 333 | 7.7 | 215.6 | R | 15.27 | 262.43 | R |
| BL 323 | 36.8 | 939.9 | MR | 51.52 | 706.3 | MS |
| BL 341 | 40.0 | 997.5 | MR | 46.36 | 669.97 | MS |
| BL 350 | 45.0 | 1242.5 | MS | 80.36 | 918.68 | MS |
| BL 342 | 31.6 | 884.8 | MR | 20.84 | 433.44 | MR |
| BL 312 | 43.7 | 1060.9 | MS | 53.34 | 462.28 | MS |
| BL 355 | 36.7 | 887.6 | MR | 57.73 | 556.78 | MS |
| BL 410 | 57.2 | 1180.8 | MS | 60.39 | 577.08 | S |
| CL 1131-0-0-13-0-6 | 100.0 | 2341.3 | S | 95.0 | 1613.01 | S |
| CL 143-0-10-3--0-1-10 | 72.7 | 1559.5 | S | 75.57 | 1187.28 | S |
| CL 5915-93D4-1-0 | 50.7 | 733.2 | MS | 54.23 | 666.89 | MS |
| CL 6047-1-1-2-3-2-7-0 | 100.0 | 2152.5 | S | 100.0 | 1609.72 | S |
| CL 9-0--0-1-3 | 72.4 | 1532.8 | S | 90.91 | 1723.05 | S |
| CL 8-0-7-1 | 78.3 | 1964.2 | S | 87.5 | 1544.41 | S |
| CL 11D-0-2-1 | 94.5 | 2295.2 | S | 100.0 | 1955.45 | S |
| CLN 65-649D5-2-0 | 56.7 | 1353.8 | MS | 64.25 | 982.45 | S |
| CLN 475-BC1 F2-265-4-19 | 45.0 | 770.0 | MS | 50.25 | 828.87 | MS |
| CLN 657-BC1F2-285-0-21-0 | 58.1 | 1524.9 | MS | 50.77 | 1416.45 | MS |
| L 285 | 52.6 | 1197.8 | MS | 36.76 | 581.42 | MR |
| CL 5915-206D4-2-2-0 | 66.7 | 1663.2 | S | 96.87 | 1644.79 | S |
| Money maker | 91.7 | 2047.1 | S | 96.87 | 2748.27 | S |
| Lapsigede | 85.7 | 2300.3 | S | 100.0 | 2201.92 | S |
| Roma | 100.0 | 2543.7 | S | 100.0 | 2545.13 | S |
| Pusa ruby | 100.0 | 2386.5 | S | 100.0 | 3018.4 | S |
| Yachana local | 100.0 | 2695.0 | S | 100.0 | 2673.86 | S |
| Dhading local | - | - | - | 100.0 | 2534.91 | S |
| Jhapa local | - | - | - | 100.0 | 2482.41 | S |
| Pusa early dwarf | - | - | - | 100.0 | 2187.5 | S |

* Disease reaction, S = Susceptible, MS = Moderately susceptible, MR = Moderately resistant, R = Resistant

Screening at seedling stage was considered to be useful to select highly resistant genotype against single strain of pathogen (Wang *et al.*, 1997). In the present study, most of the genotypes were found resistant in seedling evaluation but most of them were found moderately susceptible under field conditions at Panchkhal. It could be due to differences in environmental conditions and soil type. The mean maximum temperature, mean minimum temperature and total rainfall of experimental period at Khumaltar were 28.11°C, 16.94°C and 383.7 mm, respectively, while at Panchkhal they were 30°C, 18°C and 750 mm, respectively (average of 1995 and 1996). The night temperature also considered to affect the level of resistance of genotypes (Messiaen, 1989). Similarly, natural infection becomes higher at the flowering stage and henceforth (Mew and Ho, 1976). Furthermore, bacterial wilt resistance in tomato can be unstable depending on locations (Hanson *et al.*, 1996) and that stability levels among the genotypes of tomato vary (Wang *et al.*, 1996).

## Management

The effect of soil amendment with compost, mustard cake and lime plus urea were at par with untreated control in both the years. This could be due to short gap between soil amendment and tomato transplanting. Soil amendment with bleaching powder showed effective reduction of wilt incidence from more than 80% to 47% in 1997 and 40% in 1998. As reported by Ho (1988) bleaching powder amendment was found superior among the treatments used. The result of 1998, showed that the effect of *Z. armatum* fruit extract was statistically similar with bleaching powder amendment in soil (Table 4). The antibacterial effect of *Zanthoxylum* sp. was reported by Grainge and Ahmed (1988).

**Table 4. Effect of different treatments on bacterial wilt incidence of tomato under screenhouse conditions at Khumaltar**

| Treatments | Dose | Methods of treatments | Wilt incidence % | |
|---|---|---|---|---|
| | | | 1997 | 1998 |
| Compost | 4 t/ha | Soil amendment | 100.0a | 75.00ab |
| Mustard cake | 1-2 t/ha | Soil amendment | 100.0a | 61.66bc |
| Control | - | - | 96.66ab | 80.00a |
| Lime + Urea | 5.0+0.5 t/ha | Soil amendment | 92.85ab | 66.66abc |
| Garlic clove extract | 12-15 % | Seedling dip | 56.66d | 58.33bcd |
| Fluorescing *Pseudomonas* | Turbid suspension | Seedling dip | 84.89bc | 73.33ab |
| Multineem Solution | 0.5% | Seedling dip | 71.69cd | 50.00cd |
| Bleaching | 15 kg/ha | Soil amendment | 47.21d | 40.00d |
| *Zanthoxylum* fruit extract | 20% | Seedling dip | - | 41.66d |
| CV% | | | 11.95 | 11.87 |

Means followed by common letters are not significant at P = 0.05.

Soil amendment with lime and urea suppressed the bacterial population (Anonymous, 1994; Chang and Hsu, 1988), but the present study showed at par result of this treatment with untreated control. Though Akiew *et al.* (1996) reported the reduction of bacterial wilt by mustard green manure and mustard seed meal, no such effect was observed in the present study. The lesser wilt incidence in garlic extract in the present study is supported by the results of Sadashiva (1997). Also, Grainge and Ahmed (1988) reported the antibacterial effect of *Allium sativum.* In the present study, the use of fluorescing *Pseudomonas* isolated from tomato rhizosphere was not found effective. But collection and screening of fluorescing *Pseudomonas* from different plant rhizosphere is necessary for selection of biocontrol agents of such disastrous disease. Because, biocontrol of RS with fluorescing *Pseudomonas* has been reported (Anuratha and Gnanamanickam, 1990) and is eco- friendly, too.

The botanical products such as the extracts for *Zanthoxylum* and garlic were found to have good effect against bacterial wilt. It could be a good locally available material in controlling bacterial wilt disease and eco-friendly agent. However, field-testing is necessary for the verification of their effect on bacterial wilt.

## ACKNOWLEDGEMENTS

The authors are grateful to Dr. S. K. Shrestha, Chief Plant Pathologist, Plant Pathology Division, NARC, Khumaltar for providing necessary facilities. Thanks go to all the personnel of Plant Pathology Division who helped during the course of investigations. Cooperation from AVRDC are highly acknowledged for providing fund and supplying seed.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# VIRUS AND VIRUS-LIKE DISEASES OF CITRUS IN NEPAL

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The existence of citrus virus and virus-like diseases was not known in Nepal until late fifties when a mass of grafted citrus planting materials were introduced to the country from Saharanpur (U.P.), India. The planting materials brought from India were planted at Horticulture Research Station, Pokhara. The plants began to express symptoms of decline since 1964. Then experts were invited from FAO, USAID/Nepal and India. All the experts agreed in a point that the causes of citrus decline in Pokhara were citrus greening disease, tristeza virus, and exocortis. xyloporosis, wooly gall and bud union crease.

## Citrus greening disease

Citrus greening disease (CGD) is one of the most destructive diseases of citrus plants in many countries of Aftrica and Asia. The causal organism of CGD is *Candidatus liberobacter asiaticum.* The organism is psyllid-borne and associated with the phloem-seivetube elements. The disease is spread in new areas with contaminated plants and by its vector, *Diaporthe citri.*

Both the pathogen and its vector thrive well in hot climate with temperatures above 30°C as well as in the highland cooler climates. *D. citri* flies over short distance (2-3 km). Besides *citrus, Murryaa paniculata* is a common host for *D. citri.*

***The control measures are:*** (1) establish citrus nurseries and citrus orchards above 700 m elevation and if possible, surrounded the nursery by thick forest trees, (2) raise nurseries under insect proof conditions and protect the orchards with chemical spray of dimathoate, especially during spring flush when vector is active, and (3) biological control by rearing and releasing natural enemies of *D. citri.* This technique has already given excellent results in Nepal.

## Citrus tristeza virus

The citrus tristeza virus (CTV) was reported from Pokhara valley for the first time in 1971. The virus is naturally transmitted by the vector *Toxoptera citricida.* The CTV is the primary cause of lime trees decline in the orchards. The lime reaction test was carried out at Pokhara Station in 1985 and the results revealed that severe strains of CTV were existed in Pokhara valley, Dhankuta, Gorkha and Dhading.

***The control measures are:*** (1) establish disease free citrus nursery for distribution, and (2) control vector with chemical spray and with natural enemies (biological control).

## Exocortis

Recent surveys have revealed the presence of exocortis-like disease symptoms on trifoliate stock and its hybrid as well as Rangpur lime and some other stocks grown in Pokhara. Detail investigation is needed to confirm the disease.

*The control measures are:* (1) use clean disease free bud wood for propagation, and (2) avoid trifoliate stock showing exocortis-like symptoms.

### Cachexia-xyloporosis

The symptoms of cachexia-xyloporosis was, for the first time, observed on lemon and Amil bed trees with strong stem pitting on branches and main trunk. This is a viriod disease known to be spread through infected bud wood.

### Woody gall vein enation

Several cultivars of citrus trees have shown galling symptoms, the indicative of woody gall virus, with true vein-enation symptoms. The typical woody-gall symptoms are seen on the branches of Kamala orange, volkamer lemon, Rangpur lime and rough lemon trees. The virus is aphid vector-borne.

Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# YELLOW RUST DISEASE OF WHEAT IN WESTERN HILLS OF NEPAL

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## ABSTRACT

Wheat disease monitoring in different agro-ecological zones in the western hills of Nepal revealed that yellow rust outbreak was found increasing during 1997 and 1998 year. The genotypes Annapurna 1, Seri 82, and Pak 81 with Yr9 gene were found moderately susceptible and the score were 60MS, 60MS, and 40MS, respectively. Field screening, disease progression study and seedling test revealed that NL 810, WK 810, WK 823, NL 731 and NL 769 were resistant to moderately susceptible to yellow rust with slow disease development. The genotypes NL 776, BL 1473, BL 1530, WK 810 and Pasang Lahmu were resistant (with low yellow rust severity) at mid hill region of Lumle Agricultural Research Centre. The yellow rust pathotypes in the past were less virulent. They were 2E0, 3E0, 6E0. A new virulent pathotype attacking Annapurna 1, Annapurna 3 and Annapurna 4 was detected in 1997 at Lumle Agricultural Research Centre was identified at Regional Rust Laboratory, Shimla. The pathotype was 46S119 according to Indian nomenclature system. The spread of this disease was severe in 1998 at the river basin area of Kaligandaki river. Epidemiological study revealed that yellow rust appeared usually during mid February at both low and mid hill. The disease development in low hills is rapid up to the end of March. Similarly, the maximum development of yellow rust in mid hills proceeds up to the end of April.

## INTRODUCTION

In Nepal, wheat is the third important cereal crop in acreage after rice and maize. It is grown in 647210 ha and produces 1000770 mt with average productivity of 1.5 mt/ha. The popularity of wheat cultivation in the hills is increasing, 416600 mt ton of wheat was produced from 280290 ha of land (CBS, 1998). However, the productivity is far below satisfaction and is caused by several constraints. One of the main constraints for low productivity in hills of Nepal is disease. In mid and low hill regions of Nepal, yellow rust (*Puccinia striiformis* Westend) is a major threat to wheat cultivation. Frequent epidemics of yellow rust have been experienced in the hills of Nepal. In 1985, RR 21 lost its resistance to yellow rust due to attack by a new virulent race 7E150. Yield loss up to 25-30 percent was recorded. This race was speculated to be introduced from Pakistan. There are evidences that there is a movement of rust pathotypes from West Africa to this subcontinent, resulting several epidemics. The varieties Annapurna 1, Annapurna 3 and Annapurna 4 were forecasted to be threatened when there was explosive yellow rust outbreak in Pakistan causing loss of more than 250,000 tons in the northern part (Saari, 1995). The race was identified as 134E150 and 70% of cultivated wheat area with the genotype with *Yr9* gene was heavily infected. As most of our hill varieties possessed this genotype this was a special concern to wheat cultivation in the hills of Nepal. Nepal has adopted several strategies with a view to manage yellow rust of wheat. Frequent monitoring, epidemiological study, gene postulation, pathotype identification, screening in field as well as in glasshouse conditions were done for effective minimization of yellow rust of wheat in Nepal.

## MATERIALS AND METHODS

### Wheat disease monitoring

Periodic visits and field inspections were made in wheat growing areas of Yampaphant and Rishing Patan of Tanahun, Bhotewodar and Chambas of Lamjung, Kewere and Mirdi of Syangja, Sigana and Kudule of Baglung, Arghali and Chharaha of Palpa, Bhakkimle of Myagdi, Pakuwa of Parbat, and Taranagar of Gorkha. Rust diseases in promising wheat varieties including those in the farmers' fields were scored on the basis of Modified Cobbs Scale.

### Field and glasshouse screening of yellow rust

Wheat genotypes, including local and exotic from breeding nursery, yield trial and other sources, were planted at Lumle Agricultural Research Centre during November 1997 and 1998 in rod rows of one meter length with two rows per entry. Two rows of susceptible varieties (Agra Local, Morocco and Paudur Local ) were planted as border around the experimental plots. During 1998 wheat season, 20 days old wheat seedling of 455 different wheat genotypes were tested at seedling stage against new virulent isolates collected from Myagdi and Tanahun districts. Spore suspension of rust was sprayed to the seedling raised in pots during mid February and disease scoring was done as described by Nayar *et al.* (1994) during mid March.

### Yellow rust virulence study

International set of yellow rust differential was planted at Lumle Agricultural Research Centre from mid to last of November 1995 and 1996 wheat season. Planting was done in a rod row design of one-meter length with two rows per entry. Disease scoring was done using Modified Cobbs Scale in field condition and seedling observation was done according to infection type produced by them. Race nomenclature was done as described by Stubbs (1988), using the world and European sets of differential (Johnson *et al.*,1972). During 1997 several rust infected samples were collected from lower river basin area and mid hills of Syangja and Kaski districts. These samples were tested for virulence at Directorate of Wheat Research, Regional Station, Flowerdale, Shimla.

### Rust disease progression study

Fourteen different wheat varieties were planted at Lumle Centre (1675m asl) and Chambas on 9 and 5 December 1997, respectively. Rust disease scoring was done using Modified Cobbs Scale at an interval of seven days. The disease severity for each date was plotted in the graph to determine the disease progress.

## RESULTS AND DISCUSSION

### Wheat disease monitoring

Yellow rust was observed at Mirdi (Syanja) infecting Annapurna 4 (5 MS) and at Kewere infecting Annapurna-1 (60 MS). The disease severities on the varieties Pak 81, Annapurna-1, Seri 82 were 40MS, 60MS and 60MS, respectively during mid May at Lumle Agricultural Research Centre (Sharma 1997). Glasshouse study at Rust Laboratory Shimla revealed that presence of Yr 9 virulent pathotype in Nepal. Severe outbreak of yellow rust was observed on river basin area of Baglung, Parbat and Myagdi districts during 1998 wheat season (Sharma and Bhandari, 1998). In the variety BL 1066, the disease severity was recorded up to 100S while RR21 was relatively less affected in many areas. However, in the affected areas the disease severity up to 80S was recorded. The disease was prevalent more in humid area ranging from an altitude of 700-1000 m. At Kudule of Baglung and Pakuwa of Parbat district, yellow rust severity ranging from 40MS-S to 60MS-S was noted in the variety Annapurna 4. The disease in BL 1022 was very high and scored 80S at Pakuwa. At Chambas, yellow rust was severe in the variety Morocco with 100 S score. The variety Rohini had no infection of yellow rust at low hill river basin and the varieties WK 685 and BL 1473 were found to be rust free at mid hill domain.

## Field and glasshouse screening of yellow rust

Yellow rust disease appeared in mid February and reached maximum in the third week of April. In screening nursery, Annapurna 1, Annapurna 4 and Kanti recorded 50MS-S, 60 MS and 30MS yellow rust, respectively (Table 1). The genotypes NL 776, NL731, NL847, WK 846, WK 823 and NL 810 were either free or with low yellow rust disease. The varieties NL852, NL753, NL783, Annapurna 1, Pak 81 and BL 1694 were found moderately susceptible. The variety Pasang Lahmu was found resistant and this variety showed resistance in field as well as in glasshouse conditions for several years, including glasshouse test at Research Institute for Plant Protection (IPO) Wageningen, the Netherlands.

**Table 1. Disease score in recommended, promising and susceptible varieties of wheat genotypes in wheat disease screening nursery at Lumle Agriculture Research Centre (1997/1998)**

| Varieties | Yellow rust seedling reaction* | Yellow rust adult plant reaction** |
|---|---|---|
| NL 850 | 2 | 10 MR |
| NL 859 | ; | 0 |
| NL 860 | 2 | 0 |
| NL 846 | - | 0 |
| NL 847 | 1 | 0 |
| BL 1699 | 33+. | 80S |
| NL 852 | 33+ | 20MS |
| NL 853 | 33+ | 30MS |
| BL 1813 | 3 | 0 |
| NL 769 | - | 20MS |
| NL 753 | 3 | 20MS- S |
| WK 846 | 3 | 10MS |
| NS 783 | 3 | 20MS |
| NL 814 | ; | 0 |
| NL 776 | ;,2 | TMR |
| NL 810 | ; | TMR |
| WK 823 | 2 | 0 |
| NL 731 | 2 | 0 |
| Achyut | 2 | 0 |
| PAK 81 | 33+ | 40- 60MS |
| NL 750 | 3 | 0 |
| BL 1854 | 33+ | 60MS |
| BL 1897 | 33+ | 80S |
| NL 844 | ; | 0 |
| NL 853 | 33+ | 30MS |
| BL 1694 | 2 | 20MS |
| Annapurna 4 | 3 | 60MS |
| UP 262 | 3 | 40MS- S |
| Kanti | 33+ | 30MS |
| NL 297 | ; | 0, 20MS |
| RR 21 | 2 | 60MS- S |
| Annapurna 1 | 33+ | 50MS- S |
| Pasang Lhamu | 2 | 0 |
| Morocco | 33+ | 80S |
| Agra Local | 3 | 80S |

*0 (naught fleck)= Immune, ; (Fleck) =Very resistant, 1 (one)= Resistant with minute uredia, 2 = Moderately resistant, 3 = Moderately susceptible, 33+ = Susceptible, no chlorosis or necrosis, 3+ = No chlorosis

The varieties such as NL 852 and NL 853 were susceptible at seedling stage while moderately susceptible at adult plant stage in field conditions. Similarly, BL 1813 and NL 750 were moderately susceptible in glasshouse and resistant in field conditions. Many varieties such as BL 1699, BL 1854, BL 1897, Pak 81, Annapurna 1 and Annapurna 4 showed susceptibility in glasshouse as well as in field conditions. The diseases severity in Annapurna 1 was increased since last year due to appearance of new virulent race at Lumle. The two years data of 1997 and 1998 revealed that NL 776, WK 823, NL 731, NL 769, Pasang Lahmu were resistant to moderately susceptible to yellow rust (Table 2).

**Table 2. Yellow rust score in recommended, promising and susceptible varieties of wheat genotypes in wheat disease screening nursery at Lumle Agriculture Research Centre (1997 and 1998)**

| Variety | Yellow rust score, 1997 | Yellow rust score, 1998 |
|---|---|---|
| **A. Promising** | | |
| NL 776 | 0 | TMR |
| WK 810 | 0 | - |
| NL 769 | 0 | 20MS |
| WK 823 | 0 | 0 |
| NL 731 | 0 | 0 |
| NL 713 | 0 | 0 |
| Pak 81 | 40MS | 40-60MS |
| BL 1530 | 0 | - |
| NL 753 | 0 | 40MS-S |
| NL 783 | 0 | 20MS |
| NL 750 | 0 | 0 |
| BL 1694 | 0 | 20MS |
| **B. Recommended** | | |
| Annapurna 1 | 20MS | 60MS |
| Annapurna 4 | 5MS | 60MS |
| Pasang Lhamu | TMR | 0 |
| Kanti | 20MS | 30MS |
| RR21 | 0 | 50MS |
| **C. Susceptible** | | |
| Morocco | 80S | 80S |
| Agra Local | 80S | 80S |

## Yellow rust virulence monitoring

During 1995 and 1996 wheat season yellow rust differentials planted at Lumle Agricultural Research Centre revealed that the yellow rust pathogen races such as 3E0, 2E0 and 6EO were prevalent (Sharma and GC,1996). During 1997, some genotypes of wheat with *Yr9* gene were found infected with yellow rust. The *Yr9* virulent pathotype was picked up from Annapurna 1, NL 665 and facultative wheat and was confirmed as it gave susceptible reaction to differential Benno (Sharma, 1997).

Earlier, races 0E16, 2E0, 6E0, 6E16, 7E150, 7E158, 15E158 were recorded from different locations of Nepal (C. B. Karki, Personal Communication, Louwers *et al.*, 1992, Sharma *et al.*, 1995). The race 7E150 was reported to be widespread in Nepal. However, this race was found to be more prevalent in eastern parts of Nepal.

Several yellow rust samples collected from the western hills and tested at Regional Station Flowerdale revealed the presence of new virulent pathotype in Nepal as 3c reaction on differential Benno with the gene *Yr9* (Sharma, 1997). This new pathotype was designated as 46S119 and was found spreading during 1998 in western hills and was in high frequencies. The pathogen was virulent on Annapurna 1, NL 665 and other genotypes with *Yr9* background (Table 3). Varieties WK810 and WK685 were resistant to this race.

**Table3. Reaction of five genotypes containing *Yr9* gene to Nepalese *Yr9* virulent pathotype tested at Regional Station Flowerdale, Shimla during 1997**

| Variety | Reaction |
|---|---|
| Annapurna 1 | 3C |
| Annapurna 4 | 1pO; 1p3+ |
| BL 1530 | 1pO; 2pC |
| WK 810 | ;- |
| WK 685 | O;1p;-sr2 |

**Disease progression and epidemiological study in low and mid hills**

Yellow rust began to develop during mid February 1998 in the variety Paudur Local at LARC. The severity of the disease began to increase from the second week of March and was found to be increased rapidly from 17 March (Figure 1). The variety Annapurna 4, Paudur Local and Morocco had high yellow rust score during Mid April 1998. Similarly, NL 810, WK 823, NL 804 and BL 1530 had low to moderate rust development. In low hills and river basin of Chambas area, yellow rust began to develop during mid February 1998 (Figure 2). The severity of yellow rust in the variety Morocco was high during early March 1998 and its development and the disease progress was rapid up to the end of March 1998. The promising varieties such as NL 731, BL 1249, Rohini, NL 750, BL 1473 and NL 788 exhibited no or very low rust development. The variety NL 748 had moderate yellow rust during the end of March 1998 (Figure 2).

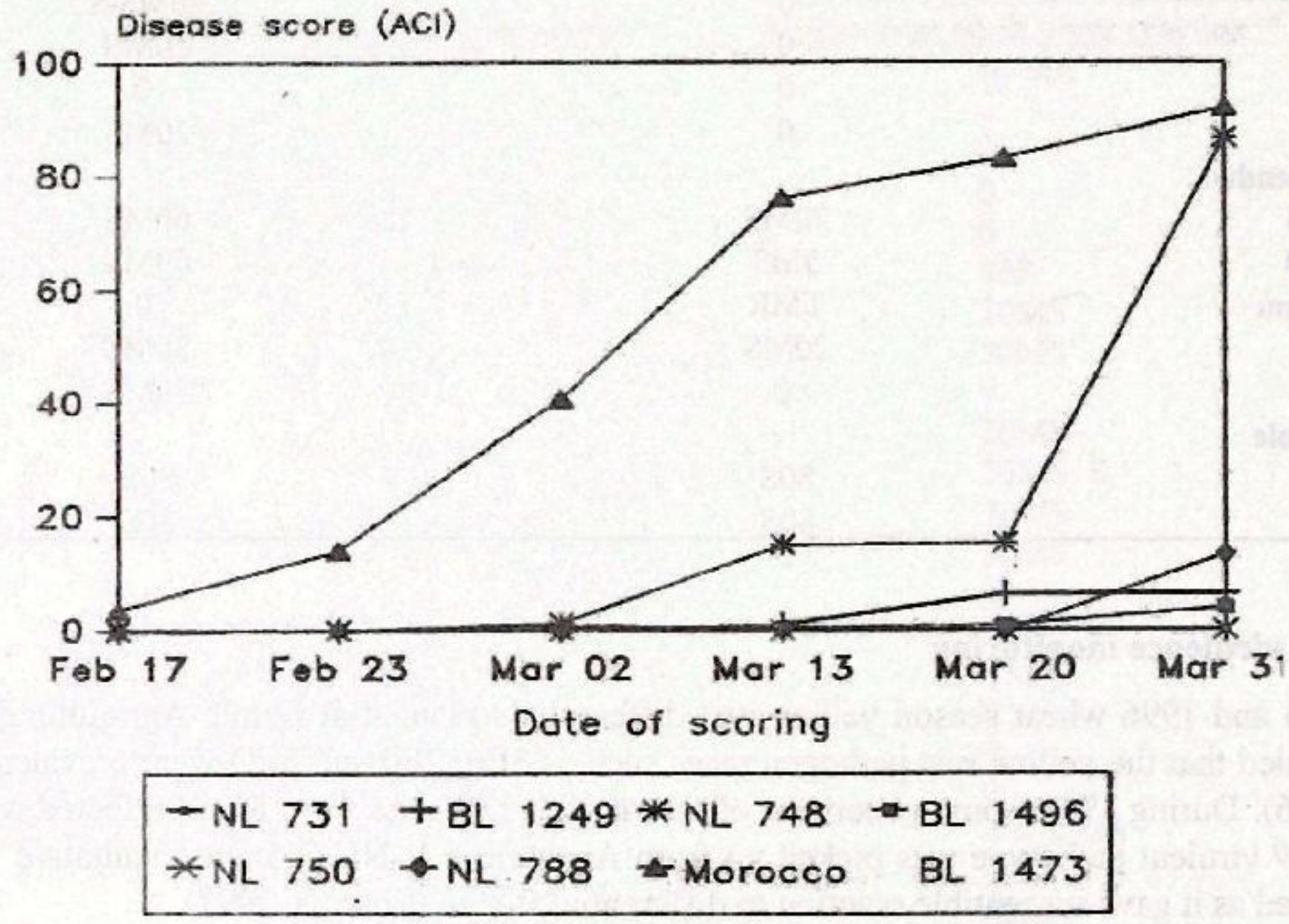


**Figure 1. Yellow rust disease progress in selected genotypes at LARC (1997/98)**

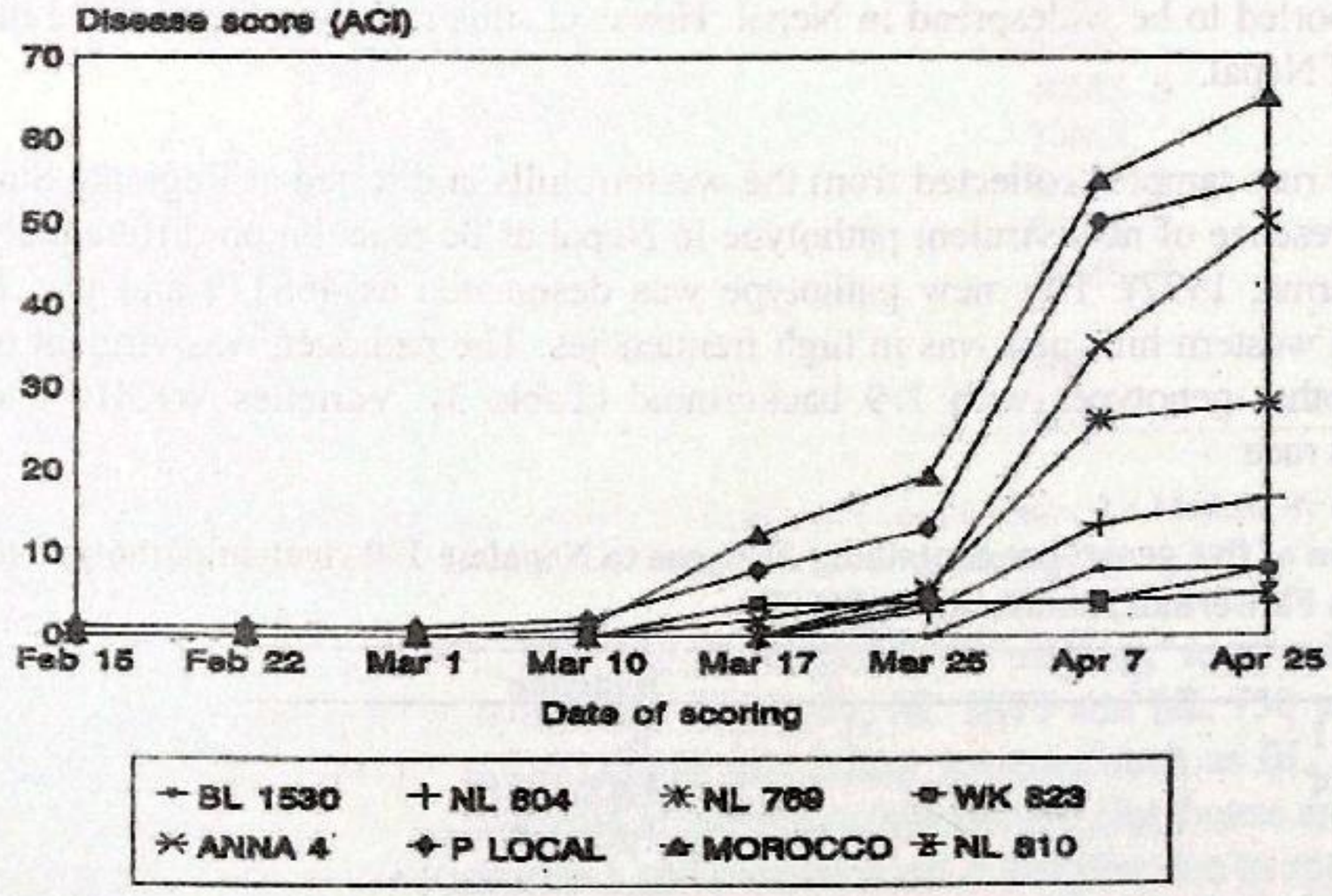


**Figure 2. Yellow disease progression in selected wheat genotypes at Chambas (465 m asl) (1997/1998)**

## CONCLUSIONS

As the outbreak of yellow rust was observed a careful monitoring of yellow rust covering wide area is needed for each year. As virulence of yellow rust for *Yr*9 gene is reported in Nepal, the varieties susceptible to this pathotype should not be promoted. New sources of resistant gene should be identified and used in breeding. Alternate varieties with diverse genetic background should be identified to replace Annapurna 4. Similarly the variety BL 1473 was found to be resistant to yellow rust disease in low, mid and high hills.

Farmers should be encouraged to cultivate that variety. During winter season, the promising varieties should be tested for yellow rust at seedling stage in natural condition at Lumle Agricultural Centre or Agricultural Centre, Kabre as they provide hot-spot environment.

## ACKNOWLEDGEMENTS

Authors are highly grateful to wheat research team at Agricultural Research Station, Lumle for continuous encouragement and support in carrying wheat pathological research at ARS, Lumle. Special thanks goes to Dr. S. K. Shrestha, Chief, Plant Pathology Division and Dr. C. B. Karki, Senior Scientist for their constant encouragement. The author is highly thankful to Dr. S. Nagarajan, Director of Wheat Research, DWR, Karnal, Dr S. K. Nayar, Head and Senior Scientist and Dr. M. Prashar Senior Scientist of Directorate of Wheat Research, Regional Station, Flowerdale, Shimla for providing facilities in analyzing wheat yellow rust samples of Nepal. The Author is highly grateful to late Dr. E. E. Saari and Dr. E. Duveiller, Regional Plant Pathologist, Regional office, Kathmandu, Nepal for their constant support..

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# GRAIN LOSSES IN THE FIELD AND THE STORAGE DUE TO RATS IN KATHMANDU VALLEY

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## ABSTRACT

Grain loss assessment in the field and the storage due to rats in three villages of Kathmandu valley was made during 1995-97. The movement of house rat in rice and wheat fields from farmers' houses was found up to 100 and 150 m, respectively. In the standing crops of rice and wheat the damage caused by the rats was estimated 575 kg/ha and 1132 kg/ha, respectively. The bait consumption was 9.4, 17.0, 19.0 and 25 gm/rat/night in spring, summer, autumn and winter, respectively. The number of rats caught per house was 1.2, 2.4, 3.3 and 4.0 in spring, summer, autumn and winter, respectively. The estimated house rat population per house in three villages Dadhikot, Lamatar and Thecho was 69.5, 89.5 and 95.6, respectively. It was estimated that the total grain loss due to rat damage in the farmers' storage house of Kathmandu valley was 2996.17 mt/year.

## INTRODUCTION

Rodents are the most important pests in farm houses as well as in crop fields. There are more than 6,000 different kinds of rodents; nearly 600 of these belong to the genus *Rattus* and are called "rats" in the world (Fall, 1977). In Nepal, mainly five species of rodents are identified namely *Rattus rattus, Rattus norvigicus, Mus musculus, Bandicota bengalensis* and *Bandicota indica*. Of them house rat *R. rattus*, field rat *R. bengalensis* and house mouse *Mus musculus* are of agricultural importance in the Kathmandu valley. They cause agricultural losses up to 15-25% every year. Generally the house rat live in farmers' houses and the field rat lives inside the burrow made in the field. However, the crop losses in the field occur not only by field rat but also by house rat. But the loss in the house storage occur by house rat only. These rats are nocturnal and fossorial in habit. Further, house rat lives inside the house as well as in field from 20 days before to crop harvest.

The objectives of the present studies were to find out the migratory behavior of rats between farmers' houses and fields, to quantify the grains losses in storage and standing crops of rice and wheat due to rodents damage and estimate house rat population and recovery rate after control by live wire traps.

## MATERIALS AND METHODS

### Estimation of house rat population and grain losses in storage

The studies were conducted at Khadkagaun of Dadhikot Village Development Committee (VDC) in Bhaktapur, Thulaghar of Lamatar VDC and Durikhel of Thecho VDC in Lalitpur in 1995, 1996 and 1997, respectively. Twenty-five households of each VDC were selected for the studies. Bait boxes measuring 30 x 25 x 20 cm length, breadth and height and with three holes on the three sides, one in center as a feeding cup holder were used. Two such bait boxes with known volume of ground rice were distributed to each 25 households. The boxes were set where rats move frequently around the

storage. The bait boxes allowed for feeding for 5 days. Every morning, the consumed volume of bait was measured. After that live-wire traps measuring 30 x 16 x 16 cm length, breadth and height with potato slice hung as a bait were given to the same households who had got the bait boxes. Each household got two traps.The traps were fixed in the storage house one meter apart where the bait boxes were set and kept for nine days. Every morning the trapped rats were collected and killed with carbon tetrachloride.

Based on the number of rats captured, consumed volume of bait and number of farm houses in Kathmandu valley, total grain loss was calculated using following equation:

$$\text{Total grain loss in one season (90 days)} = \frac{\text{No. of rats caputured+consumed volume of bait + number of farm house}}{1000 \times 1000} \times 90$$

**Estimation of recovery rate of house rats after control by live wire trap**

This study was conducted only in the Khadkagaun of Dadhikot VDC in Bhaktapur after the estimation of house rat population. For this, post baiting was done by setting two bait boxes with known quantity of ground rice in the same households. The bait boxes were set for 5 days. This post baiting process was followed-up for five times at an interval of two months from March. Based on the amount of rice consumed the recovery rate of living rat was estimated.

**Grain losses in the standing crops of rice and wheat**

About 30 hectares of rice field was selected at Serutar village in Bhaktapur district. The study was conducted 15 days before harvesting. Rat damage points were identified. Cut and non-cut tillers in three sampling quandrant measuring 1m x 1m for each damage point were counted. Also, distance of damage point from the nearest farm house for each plot was recorded. A similar study was made in wheat field covering 21 hectares at Dadhikot village in Bhaktapur District.

## RESULTS AND DISCUSSIONS

**Rat population and grain losses in farmers' houses**

Rat consumed volume of ground rice was 9.4, 17, 19 and 25 g per night per rat in spring, summer, autumn and winter, seasons, respectively (Fig. 1). The number of live rats was also found in similar trend, which were 1.2, 2.4, 3.3 and 4.0 rats/ farmer's house in spring, summer, autumn and winter, respectively (Fig. 2). The estimated rat population per house at Dadhikot of Bhaktapur was 69.5 ($y=-0.3326x+23.133$; $R^2=0.624$), Thulaghar of Lalitpur was 98.5 ($y=-0.4204x+41.431$; $R^2=0.8648$) and Durikhel of Lalitpur was 95.6 ($Y=-0.4251x+40.631$; $R^2=0.9101$). The actual number of trapped rats per house in different VDCs were as follows:

Khadkagaun, Dadhikot, Bhaktapur, 1995

| Trapping days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Trapped rat/day | 10 | 16 | 11 | 6 | 7 | 4 | 2 | 2 | 0 |

Thulaghar, Lamatar, Lalitpur, 1996

| Trapping days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Trapped rat/day | 24 | 18 | 12 | 13 | 10 | 5 | 2 | 0 | 0 |

Durikhael, Thecho, Lalitpur, 1997

| Trapping days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Trapped rat/day | 22 | 18 | 16 | 9 | 8 | 5 | 0 | 0 | 0 |

On the basis of above results and the numbers of farmers' houses in Kathmandu valley (1,55,000) the total numbers of rats estimated in four season spring, summer, autumn and winter were 16740000, 33480000, 46035000 and 55800000, respectively and thereby the grain losses in storage were 157.35, 569.16, 874.66 and 1395.00 mt, respectively. Thus, the total grain loss in the farmer's houses of Kathmandu valley was 2996.17 mt/year.

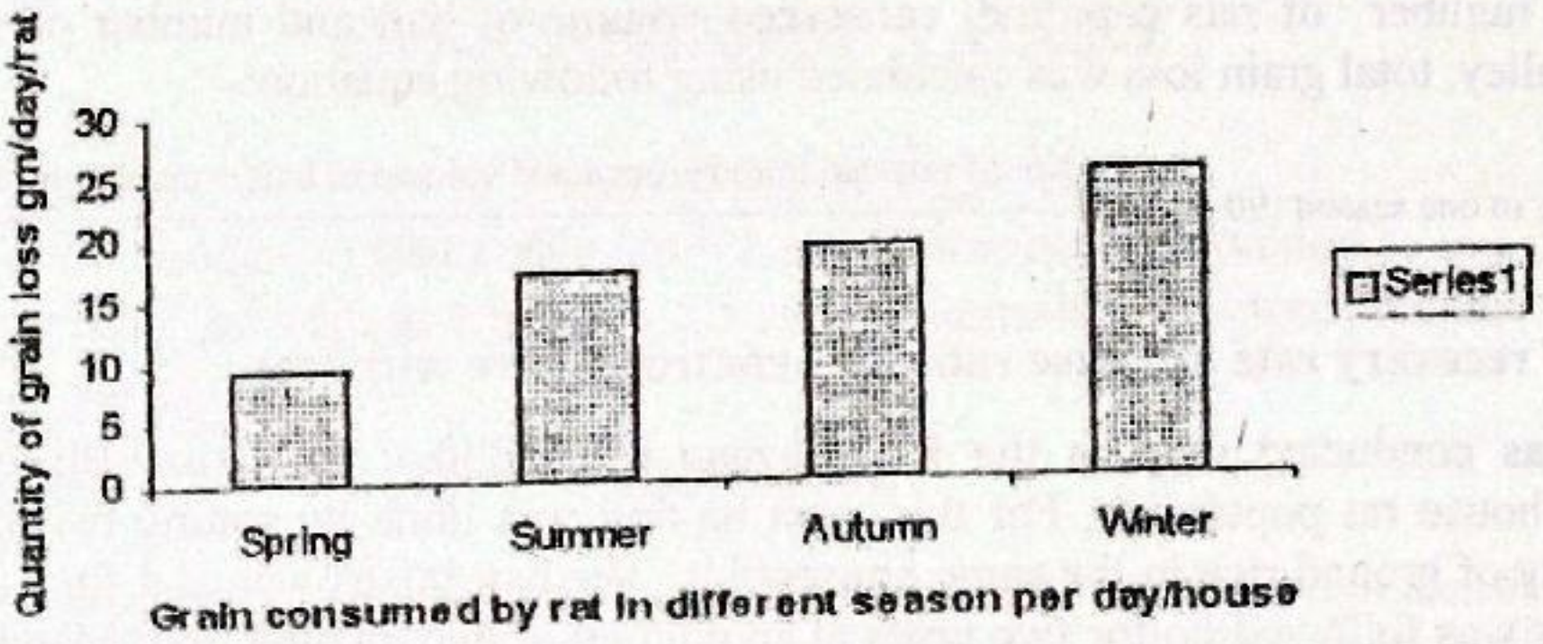


**Fig.1. Bait box with known volume bait test in farmer's house, 1995/98**

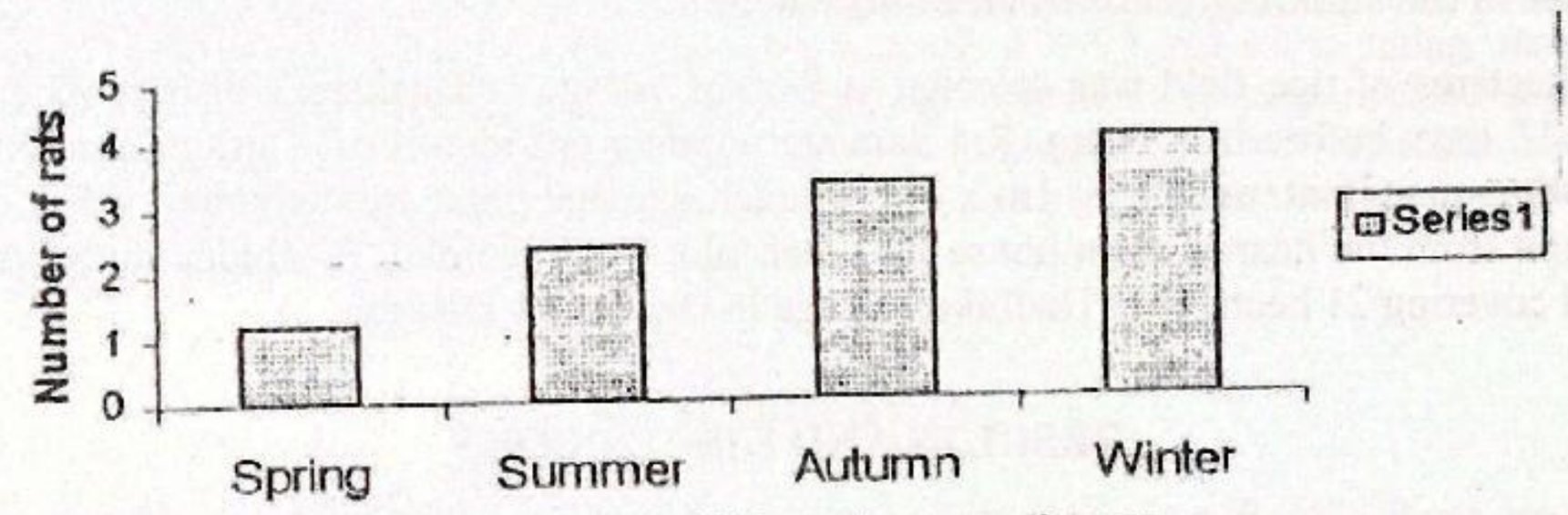


**Fig.2. Capture of rats by live wire traps in different season/farmer's house, 1995/96**

**Damage points and grain losses in standing crops of rice and wheat**

The maximum number of damage points was observed up to 50 meters away from residential house for both rice and wheat fields. However, the damage points were observed up to the distance of 150 m or more in the wheat fields (Table 1).

In the 30 hectares of rice field, 51 rat damage points, covering 1.5% of the total area were found 15 days prior to harvesting. An average of 33 cut tillers were counted out of 315 per $m^2$. On an average each tiller contained 1.748 gm of rice grain. The total rice grain loss due to rat damage was 57.5 gm/sq.m. and 575 kg/ha (Table 2).

**Table 1. Rat damage points and their distance from farmers' houses**

| Distance (meter) | Number of damage points | |
|---|---|---|
| | Paddy | Wheat |
| 50 < | 23 | 16 |
| 51 - 100 | 5 | 4 |
| 101 - 150 | 0 | 3 |
| 151 > | 0 | 3 |
| Total | 28 | 26 |

**Table 2. Rat damage in standing crop of rice and wheat**

| Crops | Damage points | Damage area (%) | Damage in quantity | |
|---|---|---|---|---|
| | | | Per sq.m. (gm) | Per hectare.(kg) |
| Paddy | 51 | 1.5 | 57.5 | 575 |
| Wheat | 26 | 1.2 | 113.2 | 1132 |

Similarly, in the 21 hectares of wheat field 26 rat damage points covering 1.2% of the total area were found. An average of 76.6 cut tillers out of 322.35 were counted per $m^2$. On an average each tiller contained 1.478 gm of wheat grain. The total grain loss due to rat damage was 113.2 $gm/m^2$ and 1132 kg/ha (Table 2).

**Recovery rate of rats after control by live wire trap**

The amount of grain consumed was 428.3 gm and 32.1 gm at pre-trapping and post-trapping, respectively indicating reduction of 83.4% of rats after pre-rapping. The average consumed quantity of ground rice was 6.8 gm/night/rat. Based on the consumed quantity of ground rice the recovery rate of live rats was calculated (Fig. 3). In the first follow-up after post-trapping the recovery rate was 16%. In second, third, fourth and fifth follow-up the recovery rate gradually increased and was 24%, 32%, 54% and 122%, respectively.

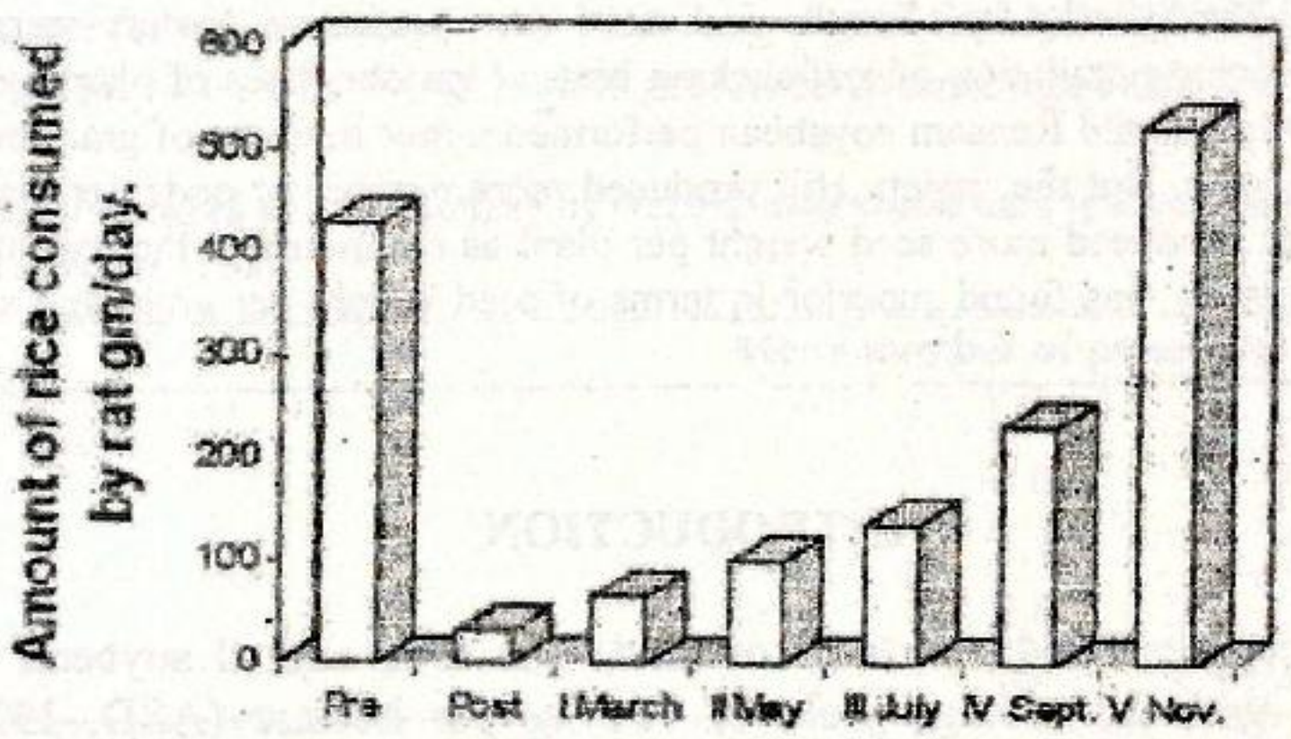


**Fig.3. Recovery rate of living rats after control with live type traps in Khadka Village**

## ACKNOWLEDGEMENTS

The author is grateful the Chief Entomologist Mr. B.K. Gyawali for providing the necessary facilities. Mr. P. Teli and Mr. S. M. Guvaju are acknowledged for their technical assistance. The author is also thankful to Mr. A. R. Sthapit for computer setting and typing.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# INTERACTION BETWEEN DATE OF PLANTING AND VARIETIES IN THE MANAGEMENT OF SOYABEAN PESTS

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## ABSTRACT

An experiment was conducted at Khumaltar, Lalitpur during wet-seasons of 1983 and 1984. The local cultivar Sathiya soyabean was found tolerant or non-preferred to the green stink bug (*Nezara antennata*) damages as compared to the exotic cultivars namely, Hill, Ransom and Lee. These soyabeans planted at four different time intervals showed variations in crowding and repulsion effect on the leaf feeding insect, *Chauliops fallax* and its predatory spiders, namely *Lycosa* sp., *Oxyopes* sp. and *Tetragnatha* sp. Results indicated that predatory spiders were capable of suppressing the growing population of leaf sucking bugs at various dates of planting of the tested soyabeans. The early planted Ransom soyabean performed better in terms of grain production per plant and per pod basis. But the variety Hill produced more number of pods per plant. The early planting of Ransom produced more seed weight per plant as compared to the rest of the planting dates. The local Sathiya was found superior in terms of seed weight per grain and seeds per pod basis.

## INTRODUCTION

In Nepal, soyabean occupies 21245 hectares of land. The total annual soybean production of the country is 15533 ton with an average yield of 731 kg per hectare (ASD, 1999). For this low productivity several factors are responsible. Insect pests are one of them. And a number of insect pests are known to attack soyabean (Gyawali, 1982). Population (Gyawali, 1986, 1987, and 1988) and yield loss (Gyawali, 1999) studies on *Chauliops fallax* Scott have been reported to reveal the basic features of the dynamics of its population in soyabean fields and thereby to prepare an ecologicial basis for the effective control of this pest which has not yet been established in the country.

One of the factors associated with insect pests and their natural enemies is the time of seeding which helps to escape the crop from pre-harvest loss. The objective of this study was to find out suitable date of planting for the management of soyabean pests.

## MATERIALS AND METHODS

The soil was well prepared. The pH of the experimental plot for vegetative stages ranged from 5.4 - 5.5, respectively at Khumaltar. Slacked lime was applied at the rate of 2.5 t/ha. Basal doses of chemical fertilizers $N_2$, $P_2O_5$ and $K_2O$ at the rate of 20: 20: 40 kg per ha were incorporated into the soil at the time of seeding. Seeds germinated after six days of seeding. Individual plot size used was 4x3 m. There were four replications per variety and date. Row to row and plant to plant spacings were 50 cm and 5 cm, respectively. Four varieties Ransom (V1), Hill (V2), Lee (V3) and Sathiya (V4) were used with four dates of planting during 1983. The planting dates were May 15 (D1), May

29 (D2), June 12 (D3) and June 26. During 1984, the dates of planting were May 30 (D1), June 10 (D2), June 21 (D3) and July 2 (D4). Each plot had 8 rows. Population of leaf sucking green bug, *Chauliops fallax* and predatory spiders were monitored twice a week using sweep net method. Ten sweeps per plot were taken in a diagonal fashion throughout the vegetative and reproductive growth stages of the crop. The number of insects and spiders recorded from the scouting were averaged on weekly basis. The numerical values for leaf sucking bugs and their predatory spiders were transferred to (log X+1) values. Iowa's patchiness regression was measured by dividing the mean crowding by mean population density. Two central rows from each plot were harvested to record agronomic traits. Moisture was adjusted at 14 percent for the grain weight.

Soyabeans planted on June 26, 1983 (D4) were also tested for feeding preference of green stink bug, *N. antennata* at the time of seed formation. Two plants each from the four varieties namely Ransom, Hill, Lee and Sathiya were caged using 80 mesh nylon nets. Ten adult *Nezara antennata* were introduced in each cage. Each variety was replicated five times along with control cage (no insect feeding was allowed).

## RESULTS AND DISCUSSION

### Soyabeans resistance to green stink bug

The feeding damage due to *N. antennata* on soybean pods showed punctures on seeds. The varieties identified as non preferred or tolerant to this bug were Sathiya followed by Hill and Ransom cultivars. But the variety Lee was found highly preferred to the bug (Table 1).

**Table 1. Number of punctures due to feeding of *Nezara antennata* on soyabean seeds planted on June 26 (D4), Khumaltar, 1983**

| Varieties | Mean number of punctures* |
|---|---|
| Lee | 13.8 |
| Ransom | 6.0 |
| Hill | 3.4 |
| Sathiya | 2.6 |
| Control | 0 |

*Average of five replications

### Crowding effect

Lloyd (1967) proposed a new parameter "mean crowding" which is defined as the mean number of insects in the same quadrate, and showed that the ratio of mean crowding to mean density in a series of population samples. Crowding of pest and natural enemies is indicated by the positive value of A in regression equation Y = A+BX. Similarly, repulsion effect is indicated by negative value of A. In this equation B is the density contageous coefficient. Density dependent mortality is influenced by the value of B. Density independent mortality alters the value of A but leave B unaffected. Positive correlations were found on June 12 (D3) 1983 planted soyabean indicating crowding effect of *C. fallax* (Table 2).

Similarly, the predatory spiders were observed with positive correlations on May 15 (D1) and June 12 (D3) 1983 planted soybean crops (Table 3). But soyabean cultivars namely, Ransom, Lee and Sathiya planted on May 30 (D1) and June 10 (D2), Ransom, Hill, Lee and Sathiya planted on June 21 (D3) and July 2 (D4) of 1984 showed positive correlations indicating crowding effect of *C. fallax* whereas the predatory spiders feeding on this bug were observed crowded on May 30 (D1) planted Sathiya; June 10 (D2) planted Ransom, Hill and Lee; June 21 (D3) planted Ransom and Sathiya; July 2 (D4) planted Lee and Sathiya varieties indicating positively correlated.

**Table 2. Association of *Chauliops fallax* on four varieties of soyabeans planted at different time intervals, Khumaltar, 1983-84**

| Dates | Varieties | Regression equation | Coefficient of determination ($R^2$) | Index of patchiness |
|---|---|---|---|---|
| 1983 | | | | |
| D1 | Ransom (V1) | -2.90677+15.8466X | 0.69237 | 9.7587 |
| D2 | Hill (V2) | -0.02699+0.6456X | 0.26098 | 0.5271 |
| D3 | Lee (V3) | -0.01894-0.17703X | 0.07098 | 0.3137 |
| D4 | Sathiya (V4) | -0.05204+0.0353X | 0.00479 | 0.2802 |
| 1984 | | | | |
| D1 | Ransom (V1) | -0.0251-0.5949X | 0.1563 | 0.7321 |
| | Hill (V2) | -0.01536-0.1151X | 0.1974 | 0.1557 |
| | Lee (V3) | -0.02883+0.3792X | 0.2430 | 0.4979 |
| | Sathiya (V4) | -0.04339+0.1469X | 0.02296 | 0.0302 |
| D2 | Ransom (V1) | -0.06023-0.1371X | 0.0299 | 0.3885 |
| | Hill (V2) | -0.03198-0.1668X | 0.0867 | 0.6513 |
| | Lee (V3) | -0.02883-0.3792X | 0.2430 | 0.4979 |
| | Sathiya (V4) | -0.02859-0.4041X | 0.7669 | 0.5589 |
| D3 | Ransom (V1) | -0.01821-0.6887X | 0.7769 | 0.7862 |
| | Hill (V2) | -0.01473-0.4656X | 0.5372 | 0.5383 |
| | Lee (V3) | -0.02074-0.0770X | 0.0214 | 0.1602 |
| | Sathiya (V4) | -0.00625-1.0104X | 0.7921 | 1.0432 |
| D4 | Ransom (V1) | 0.23801-2.4750X | 0.9145 | 1.4605 |
| | Hill (V2) | 1.03108-9.5166X | 0.9139 | 5.2141 |
| | Lee (V3) | -0.01918-0.9073X | 0.9798 | 0.9695 |
| | Sathiya (V4) | 0.03461-1.1445X | 0.8270 | 0.9491 |

**Repulsive effect**

Negative correlation was observed on May 15 (D1), May 29 (D2) and June 26 (D4), 1983 planted soyabeans indicating repulsive effect on *C. fallax* (Table 2). Similarly, during 1984 soyabean cultivar Hill planted on May 30 (D1) and June 10 (D2) showed repulsion on leaf sucking to this bug.

Crowding of *C. fallax* on soyabeans planted on June 12 (D3), 1983 was found effective association for the predatory spiders towards crowding tendency. But in 1984, crowding of *C. fallax* was associated to predatory spiders' crowding tendency on Sathiya planted on May 30 (D1) followed by June 10 (D2) on Ransom and Lee, June 21 (D3) on Ransom and Sathiya, July 2 (D4) on Lee and Sathiya.

**Effect on yield**

Early planting (D1) of Ransom and Lee produced more number of grains per plant as compared to Sathiya (Table 4). The D1 and D3 planting of Ransom produced more number of grains per plant as compared to the same variety on D2 and D4 planting. Varieties Hill and Lee produced significantly more number of grains per plant on D1 planting than D2, D3 and D4 plantings. The variety Ransom on D1 planting produced significantly more number of grains per pod as compared to Hill, Lee and Sathiya on D1 planting.

The varieties Hill and Lee produced significantly more number of pods per plant than Sathiya on D1 planting.

Table 3. Association of predatory spiders with *Chauliops fallax* on four varieties of soyabean planted at different time intervals, Khumaltar, 1983-84

| Dates | Varieties | Regression equation | Coefficient of determination ($R^2$) | Index of patchiness |
|---|---|---|---|---|
| 1983 | | | | |
| D1 | Ransom (V1) | -0.03875-0.11795X | 0.0095 | 0.3320 |
| D2 | Hill (V2) | -0.26427+1.09148X | 0.4813 | 0.0493 |
| D3 | Lee (V3) | 0.00631-0.88559X | 0.9745 | 0.9152 |
| D4 | Sathiya (V4) | -0.17659+0.52459X | 0.5402 | 0.2112 |
| 1984 | | | | |
| | Ransom (V1) | -0.24216+0.60684X | 0.3543 | 0.2469 |
| D1 | Hill (V2) | -0.16871+0.12139X | 0.0195 | 0.4207 |
| | Lee (V3) | -0.04876-0.09795X | 0.0186 | 0.1988 |
| | Sathiya (V4) | -0.00322-0.09555X | 0.02569 | 0.1046 |
| | Ransom (V1) | -0.2328+0.5904X | 0.3403 | 0.2112 |
| | Hill (V2) | -0.0547-0.3186X | 0.1844 | 0.5962 |
| D2 | Lee (V3) | 0.7427-3.07512X | 0.5852 | 1.0759 |
| | Sathiya (V4) | -0.1093+0.034X | 0.0011 | 0.3496 |
| | Ransom (V1) | 0.1705-1.214X | 0.5554 | 0.6708 |
| | Hill (V2) | -0.1114+0.2388X | 0.0531 | 0.2402 |
| D3 | Lee (V3) | -0.1642+0.5840X | 0.3758 | 0.0201 |
| | Sathiya (V4) | 0.0489-0.6156X | 0.4828 | 0.4793 |
| | Ransom (V1) | -0.2467+1.0425X | 0.8162 | 0.0335 |
| | Hill (V2) | -0.1990-0.6064X | 0.3312 | 0.0816 |
| D4 | Lee (V3) | 0.0016-0.1980X | 0.0541 | 0.1927 |
| | Sathiya (V4) | 0.00447-0.3258X | 0.0689 | 0.3077 |

The seed weight per grain of Sathiya was significantly more than the Hill on D1 planting. Sathiya also produced significantly more seed weight per grain on D1 planting than the same variety planted on D2, D3 and D4 plantings.

Ransom on D3 and D4 plantings produced significantly more seed weight per pod than Hill planted on D1, D2 and D3 plantings and also Lee on D3 planting.

Soyabean cultivars Ransom and Lee planted on D1 produced significantly more seed weight per plant than Ransom, Hill, Lee and Sathiya planted on D2, D3 and D4 plantings.

Ransom, Hill and Lee produced significantly more number of grains per plant than Sathiya (Table 5). But the number of grains per pod was significantly more in Ransom than Hill, Lee and Sathiya, whereas the number of pods per plant was significantly more in Hill than the Ransom and Sathiya.

The weight of seeds per grain was significantly more in Sathiya than Ransom, Lee and Hill. But the weight of seeds per pod was found significantly more in Ransom and Sathiya than Lee and Hill. Similarly, the weight of seeds per plant basis was significantly more in Ransom and Lee than Sathiya and Hill.

The number of grains per plant on D1 planting was found significantly more than D2, D3 and D4 plantings (Table 6). But the number of grains per pod was found more on D4 planting.

**Table 4. Yield[1/] parameters of four soyabean varieties planted at four dates, Khumaltar, 1983 - 1984**

| Varieties | Dates | Number of grains/ plant | Number of grains/pod | Number of pods/plant | Weight of seed/grain (g) | Weight of seeds/pod (g) | Weight of seeds/plant (g) |
|---|---|---|---|---|---|---|---|
| Ransom ($V_1$) | D1 | 64.6a[2/] | 2.0a | 34.0ab | 0.13cde | 0.26abc | 8.4a |
| | D2 | 29.4c | 1.6abcde | 16.8cd | 0.13cde | 0.20abcde | 3.6cde |
| | D3 | 36.2ab | 1.9ab | 18.0cd | 0.11ef | 0.27a | 4.8bcd |
| | D4 | 24.8c | 1.8abc | 14.1cd | 0.15abc | 0.27a | 3.6cde |
| Hill ($V_2$) | D1 | 61.2ab | 1.3e | 47.8a | 0.12ef | 0.15de | 7.3ab |
| | D2 | 35.7c | 1.8abcd | 19.9bcd | 0.09g | 0.16cde | 3.4de |
| | D3 | 21.7c | 1.6abcde | 13.7cd | 0.09g | 0.14e | 2.1e |
| | D4 | 23.2c | 1.7abcde | 14.5cd | 0.10fg | 0.17abcde | 2.4de |
| Lee ($V_3$) | D1 | 65.1a | 1.4cde | 45.7a | 0.14bcd | 0.17abcde | 9.1a |
| | D2 | 32.0c | 1.5 bade | 21.5bcd | 0.13cde | 0.19abcde | 4.2cde |
| | D3 | 23.3c | 1.4de | 15.7cd | 0.12def | 0.16bcde | 2.8de |
| | D4 | 18.2c | 1.6abcde | 11.9cd | 0.16ab | 0.24abcd | 2.8de |
| Sathiya ($V_4$) | D1 | 37.1bc | 1.5bcde | 25.0bc | 0.17a | 0.25abc | 6.3abc |
| | D2 | 32.0c | 1.6abcde | 18.0cd | 0.14bcde | 0.22abcde | 4.7bcd |
| | D3 | 18.0c | 1.8abc | 10.0d | 0.13bcde | 0.24abcd | 2.4de |
| | D4 | 18.1c | 1.9ab | 9.7d | 0.14bcd | 0.26ab | 2.6de |

1/ Average of four replications
2/ In a column means followed by the same letter are not significantly different at 5 percent level (Duncan's Multiple Range Test)

**Table 5. Effect of interaction on different varieties of soyabean[1/], Khumaltar, 1983-84**

| Varieties | No. of grains/plant | No. of grains/pod | No. of pods/plant | Wt. of seed/grain (g) | Wt. of seeds/pod (g) | Wt. of seeds/plant (g) |
|---|---|---|---|---|---|---|
| Ransom (V1) | 155.0a[2/] | 7.3a | 83.0b | 0.54b | 0.99a | 20.31a |
| Hill (V2) | 142.0a | 6.3c | 95.9a | 0.40c | 0.63c | 15.17b |
| Lee (V3) | 139.0a | 5.9d | 94.7ab | 0.55b | 0.80b | 18.79a |
| Sathiya (V4) | 105.0b | 6.8b | 62.6c | 0.58a | 0.97a | 15.98b |

1/ Average of four replications and four dates of samplings
2/ In a column means followed by the same letter are not significantly different at 5 percent level (Duncan's Multiple Range Test)

**Table 6. Effect of interaction on different dates of planting of soyabean[1/], Khumaltar, 1983-84**

| Date | No. of grains/plant | No. of grains/pod | No. of pods/plant | Wt. of seed/grain (g) | Wt. of seeds/pod (g) | Wt. of seeds/plant (g) |
|---|---|---|---|---|---|---|
| D1 | 228.0a[2/] | 6.22c | 152.5a | 0.55a | 0.99a | 30.94a |
| D2 | 129.1b | 6.50bc | 76.2b | 0.48c | 0.97a | 15.90b |
| D3 | 99.1c | 6.64ab | 57.4c | 0.49c | 0.80b | 12.04c |
| D4 | 84.2c | 6.95a | 50.2c | 0.54b | 0.63c | 11.38c |

1/ Average of four replications and four varieties
2/ In a column means followed by the same letter are not significantly different at 5 percent level (Duncan's Multiple Range Test), D1 = May 15 (in 1983) / May 30 (in 1984), D2 = May 29/June 10, D3 = June 12/June 21, and D4 = June 26/July 2.

Number of grains per pod was found more on D3 and D4 plantings than D1 and D2 plantings, whereas the number of pods per plant was more on D1, D2, D3 and D4 plantings. The weight of

seeds per grain and per plant was found significantly higher on D1 planting than D2, D3 and D4 plantings, whereas the weight of seeds per pod was found significantly more on D1 and D2 plantings than D3 and D4 plantings.

**Iowa's patchiness regression**

Index of patchiness is a ratio between mean crowding and mean population density (Iowa, 1968). It is also referred as Iowa's patchiness regression. Patchiness of *C. fallax* was observed 9.96 on May 15 planting of 1983 followed by Hill (5.21) on July 2 of 1984 planting whereas the patchiness of predatory spiders was on susceptible variety Lee (1.08) when planted on June 10, 1984. It seems that patchiness of *C. fallax* was very high during 1983 as compared to 1984 planting of soyabean. Probably it is due to low precipitation in 1983. Predatory spiders performed low patchiness as compared to the phytophagous pest, *C. fallax*.

**Coefficient of determination ($R^2$)**

The coefficient of determination measures the contribution of the linear function of *k* independent variables to the variation in Y and is expressed in percentage (Gomez and Gomez, 1984). The coefficient of determination ($R^2 = 0.967233$) for predatory spiders was observed highest on Ransom soyabean planted on July 2, 1984 whereas *C. fallax* showed highest value of coefficient of determination ($R^2 = 0.9835085$) on Hill cultivar planted on June 10, 1984.

**Ecosystem analysis**

Several species of spiders namely, *Lycosa* sp., *Oxyopes* sp., and *Tetragnatha* sp. were found colonizing on soyabean ecosystem. These spiders were predatory in nature. They were found preying on leaf sucking bug, *C. fallax*. This is a predominant species of leaf sucking bugs in the mid-hill region of Nepal. The relationship between *C. fallax* and predatory spiders was highly associated in terms of pest crowding and repulsion effect as indicated in Fig. 1-4 of 1983 and Fig. 6-21 of 1984. The population densities of predatory spiders were observed much higher than that of *C. fallax*. In both the years, the population of *C. fallax* was suppressed by the predatory spiders in soya-ecosystem (Fig. 1-4) and (Fig. 6-21). None of the treatments showed increase in population of *C. fallax* in the presence of predatory spiders. In both the years, spiders were able to suppress the increasing population of *C. fallax*. From this study, it has been assumed that the population of *C. fallax* will not increase at damaging level until and unless indiscriminate use of pesticide is done. Therefore, naturally occurring biological control agents are sufficient to suppress the pest population. The population density of *C. fallax* was affected by the abiotic factors such as temperature, relative humidity and rainfall. Conducive temperature and relative humidity helped *C. fallax* to colonize on different cultivars of soyabean planted at different time intervals. The effect of migration and immigration of these bugs is influenced by rainfall. The year 1983 was observed drier (Fig. 5) as compared to 1984 (Fig. 22) in terms of rainfall. The effect of rainfall on phytophagus insects and predatory spiders was observed higher during 1983 as compared to 1984 followed by lower relative humidity. The population density of *C. fallax* was reduced during 1984 due to more rainfall as compared to relatively less rainfall during 1983. It is difficult from two years data to establish the effect of rainfall, relative humidity, and temperatures on the population of pests and their natural enemies (Fig. 5 and Fig. 22).

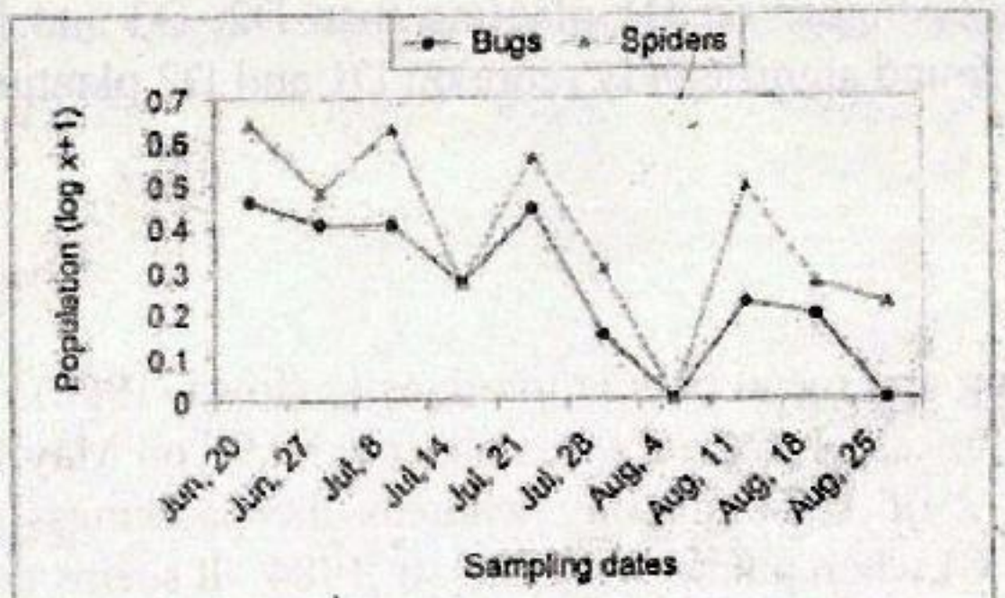


Fig. 1. (D1) May 15, 1983 planting

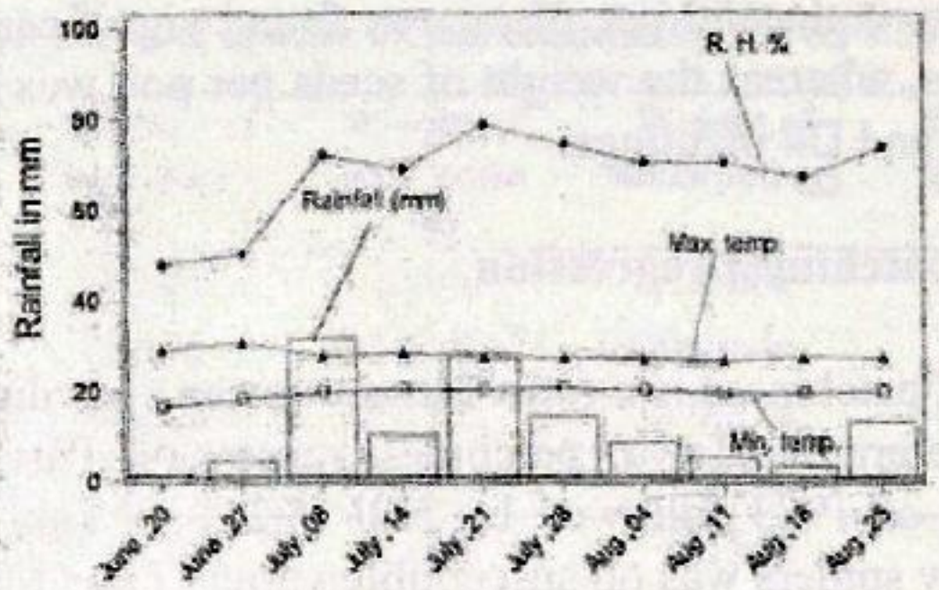


Fig. 5. Average weekly weather record during the sampling period at Khumaltar, 1983

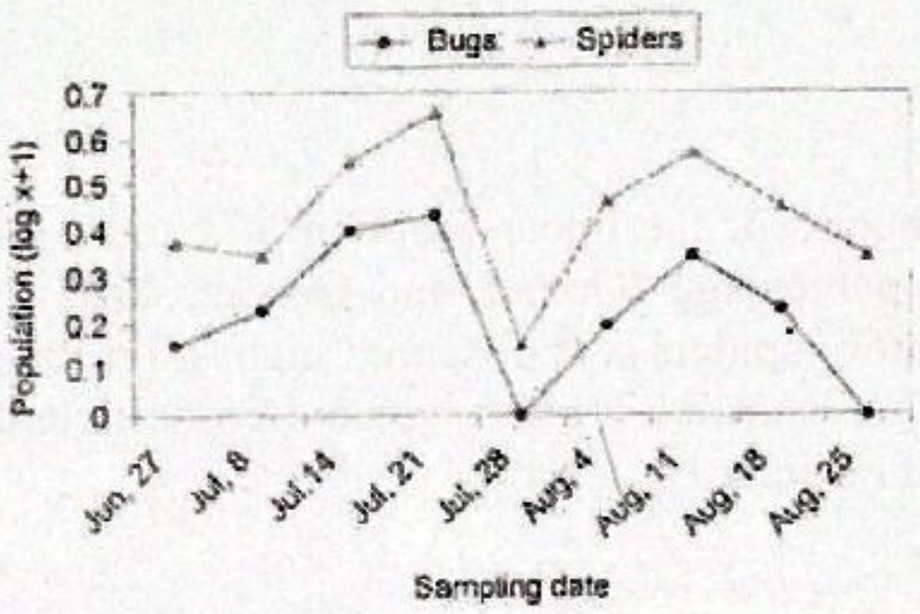


Fig. 2. (D2) May 29, 1983 planting

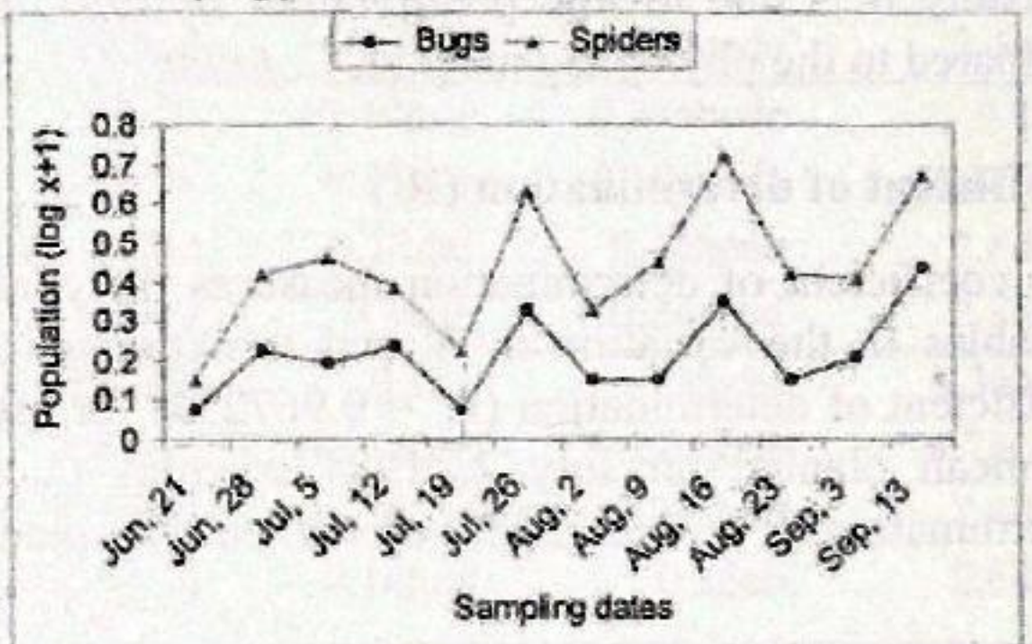


Fig. 6. (D1V1) Variety Ransom planted on May 30, 1984

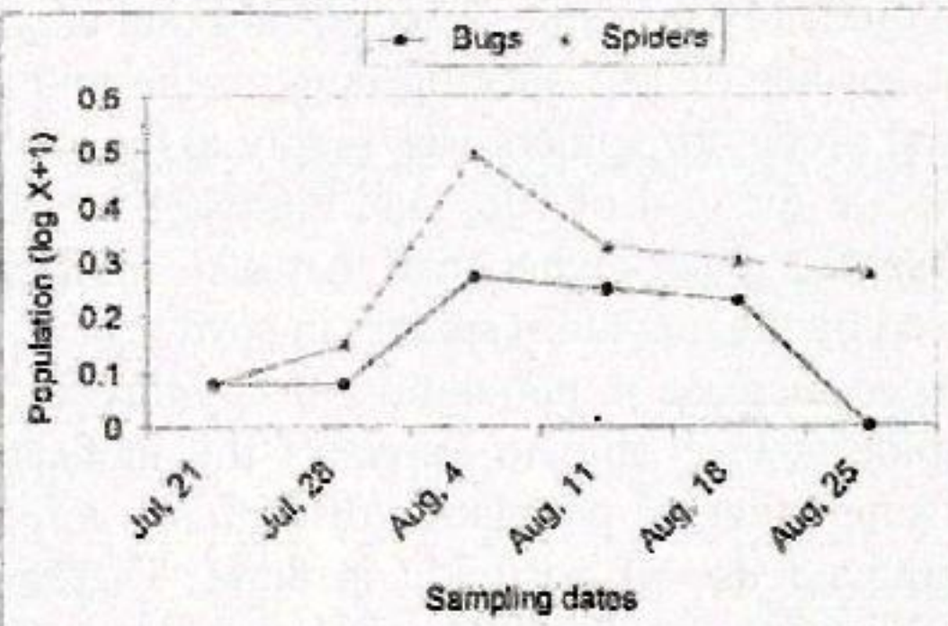


Fig. 3. (D3) June 12, 1983 planting

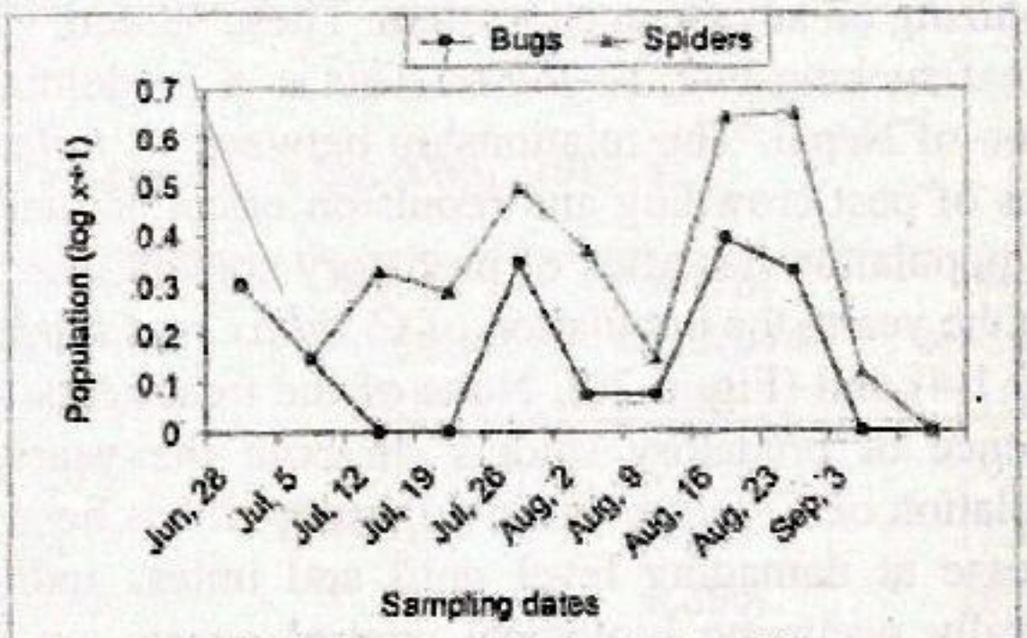


Fig. 7. (D1V2) Variety Hill planted on May 30, 1984

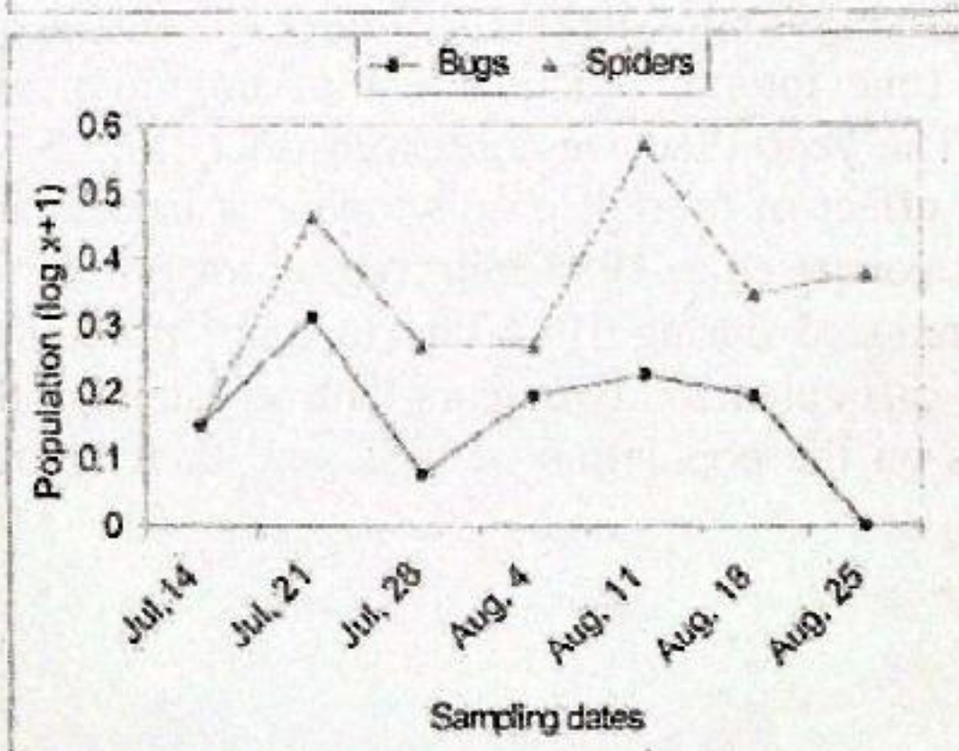


Fig. 4. (D4) June 26, 1983 planting

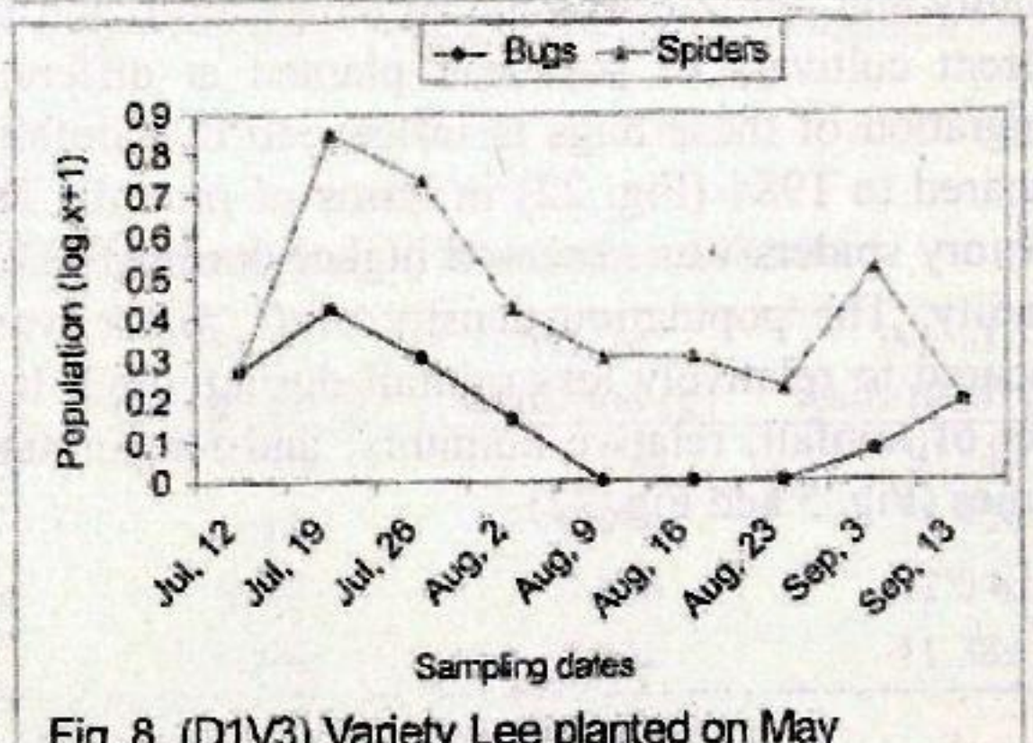


Fig. 8. (D1V3) Variety Lee planted on May 30, 1984

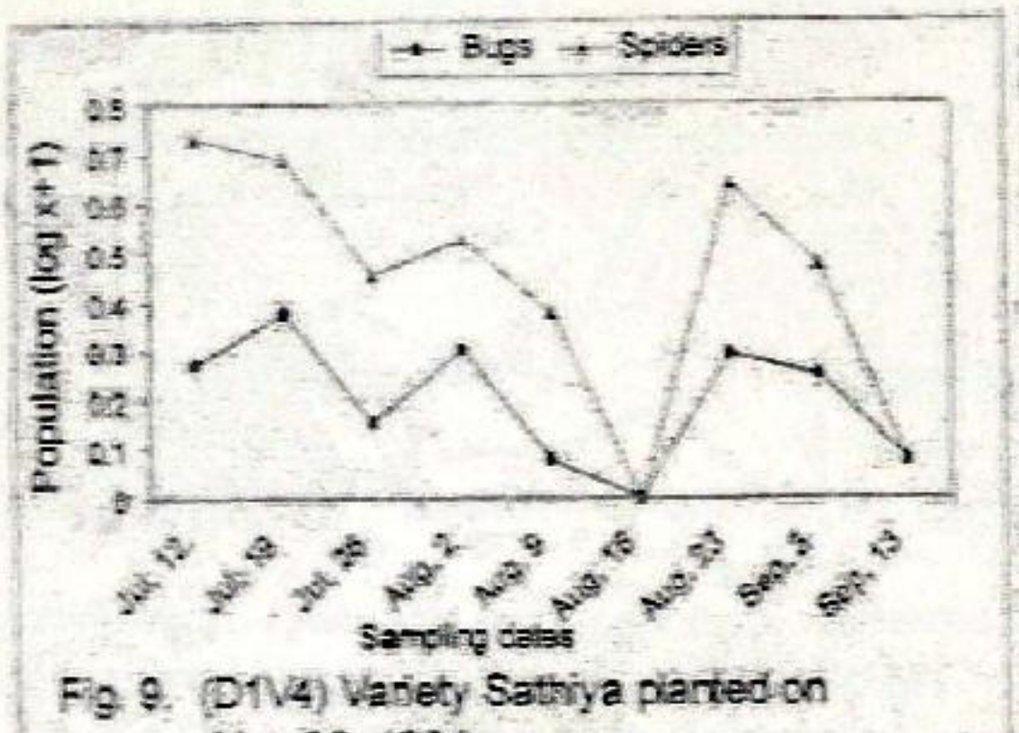


Fig. 9. (D1V4) Variety Sathiya planted on May 30, 1984

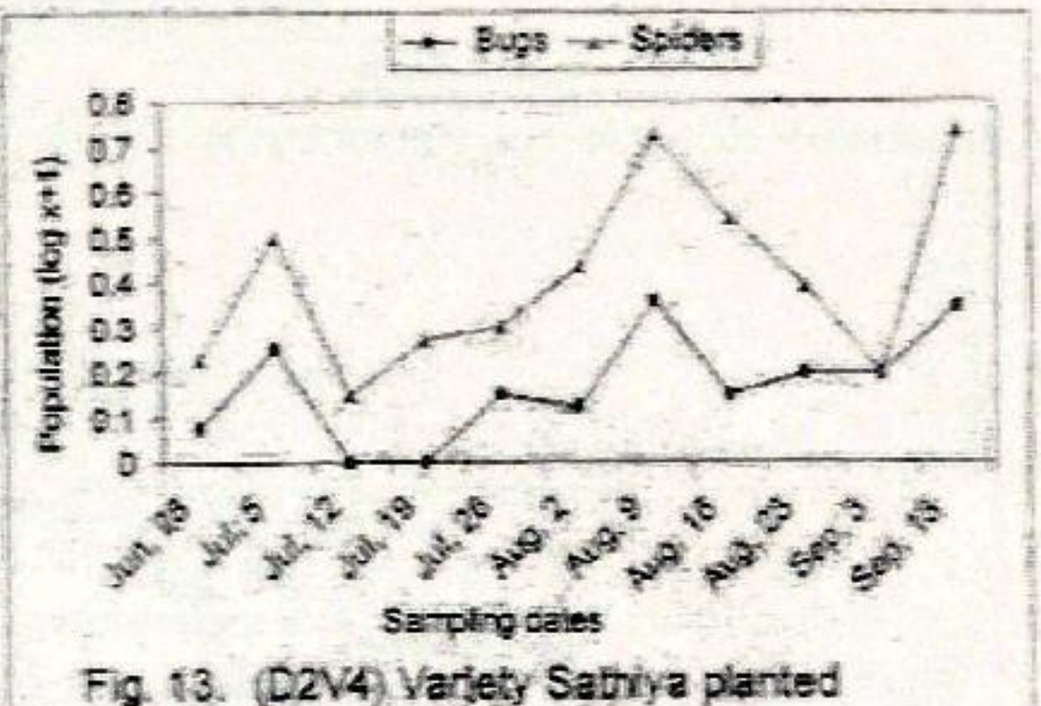


Fig. 13. (D2V4) Variety Sathiya planted on June 10, 1984

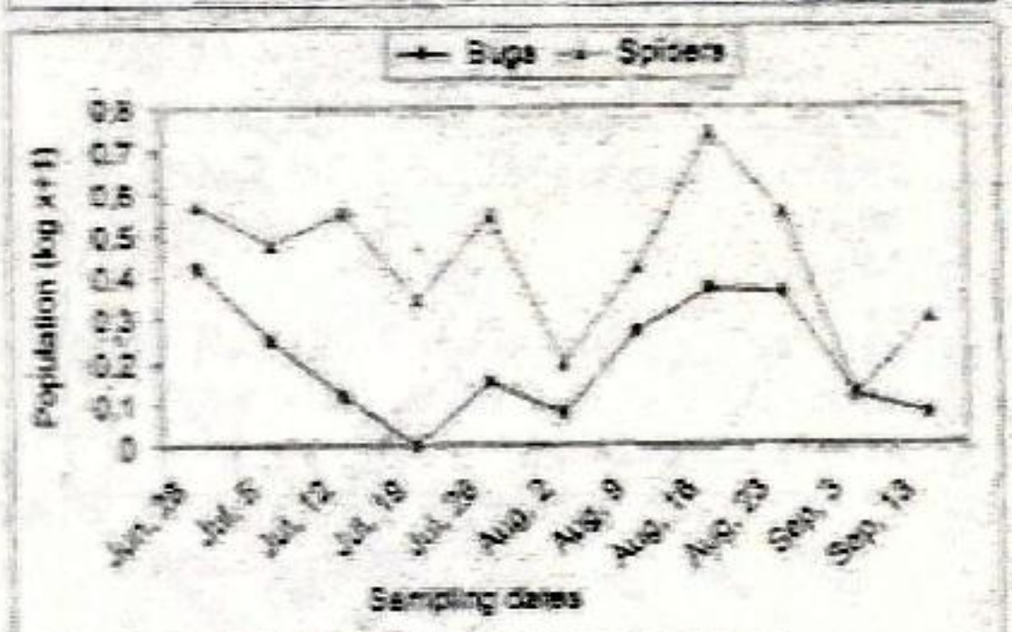


Fig. 10. (D2V1) Variety Ransom planted on June 10, 1984

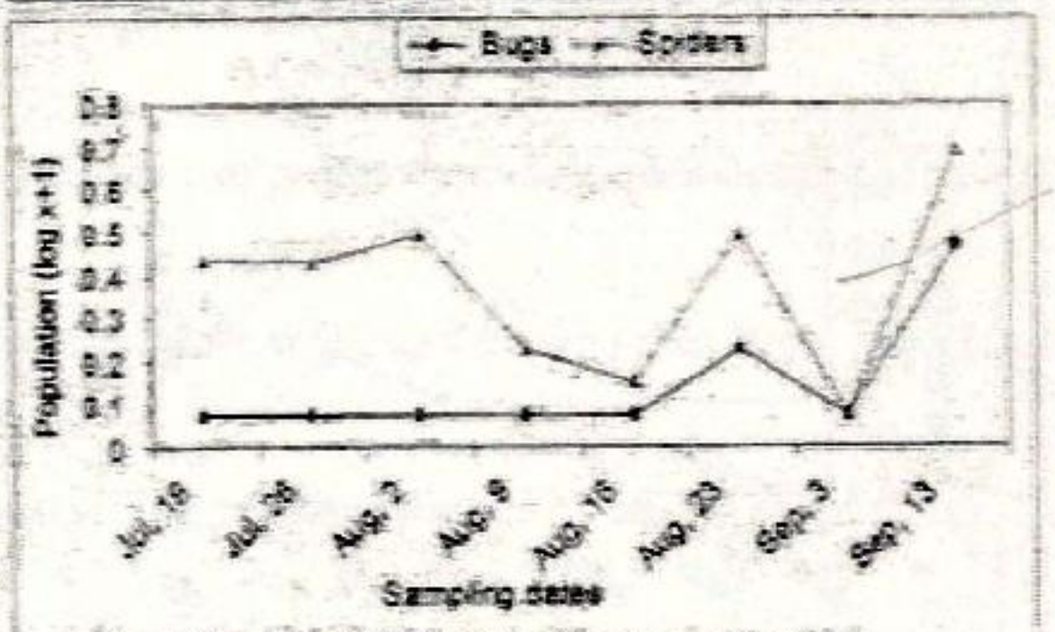


Fig. 14. (D3V1) Variety Ransom planted on June 21, 1984

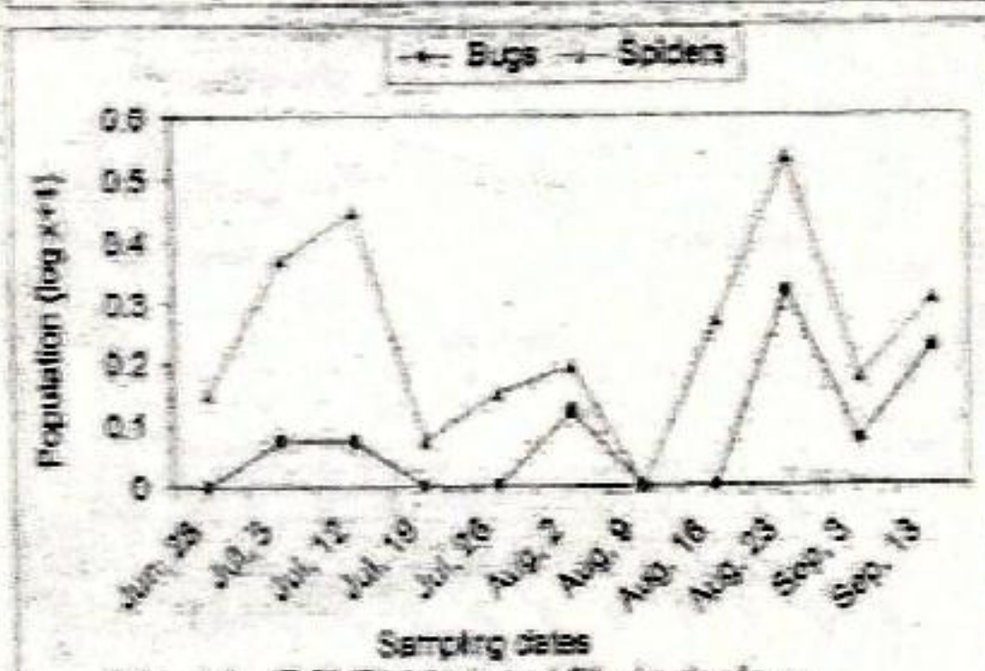


Fig. 11. (D2V2) Variety Hill planted on June 10, 1984

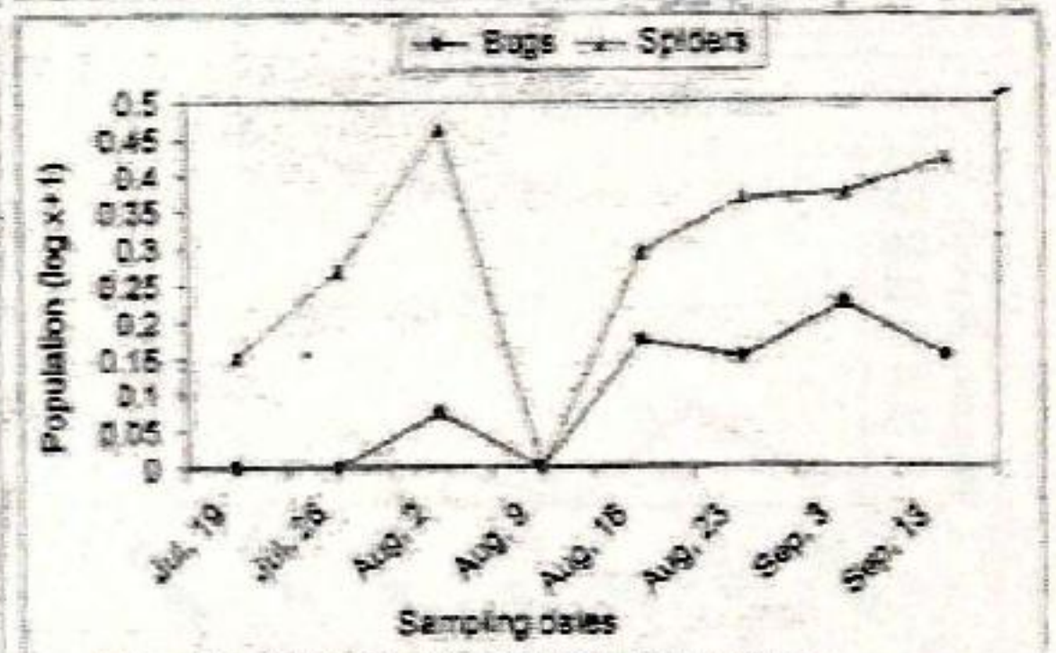


Fig. 15. (D3V2) Variety Hill planted on June 21, 1984

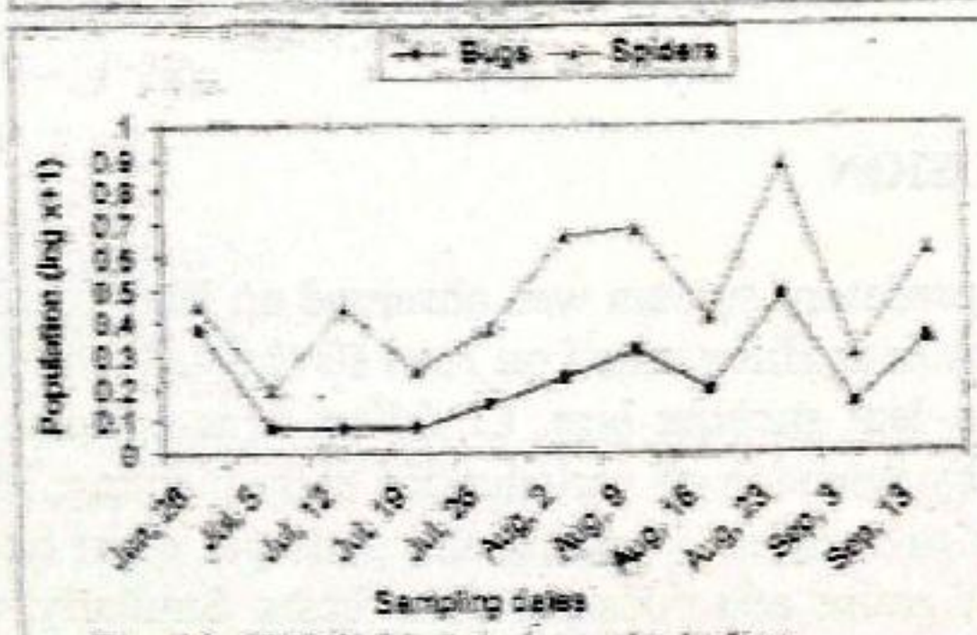


Fig. 12. (D2V3) Variety Lee planted on June 10, 1984

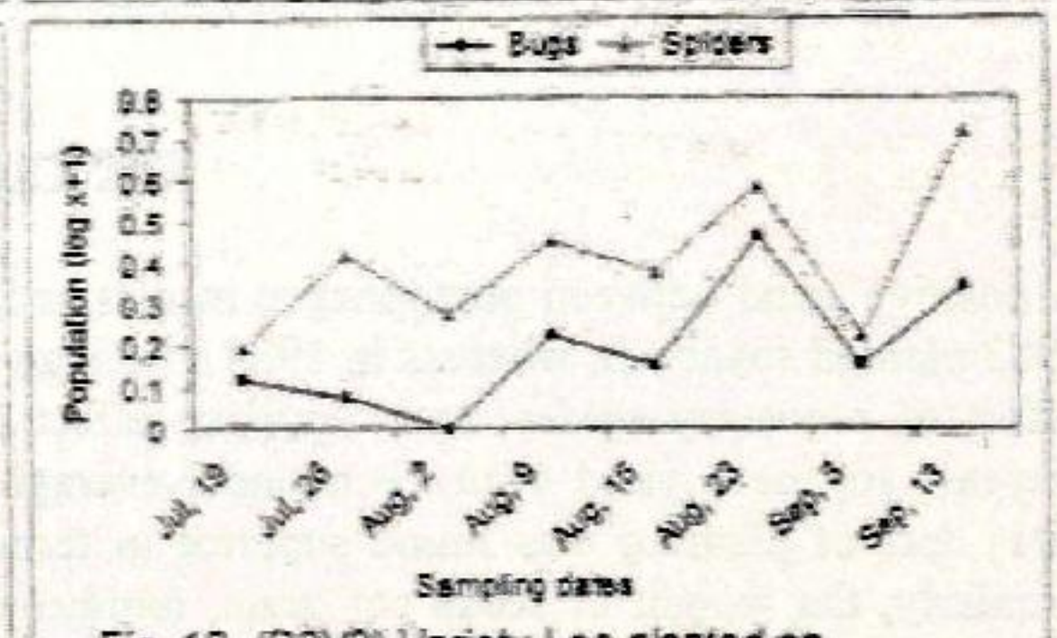


Fig. 16. (D3V3) Variety Lee planted on June 21, 1984

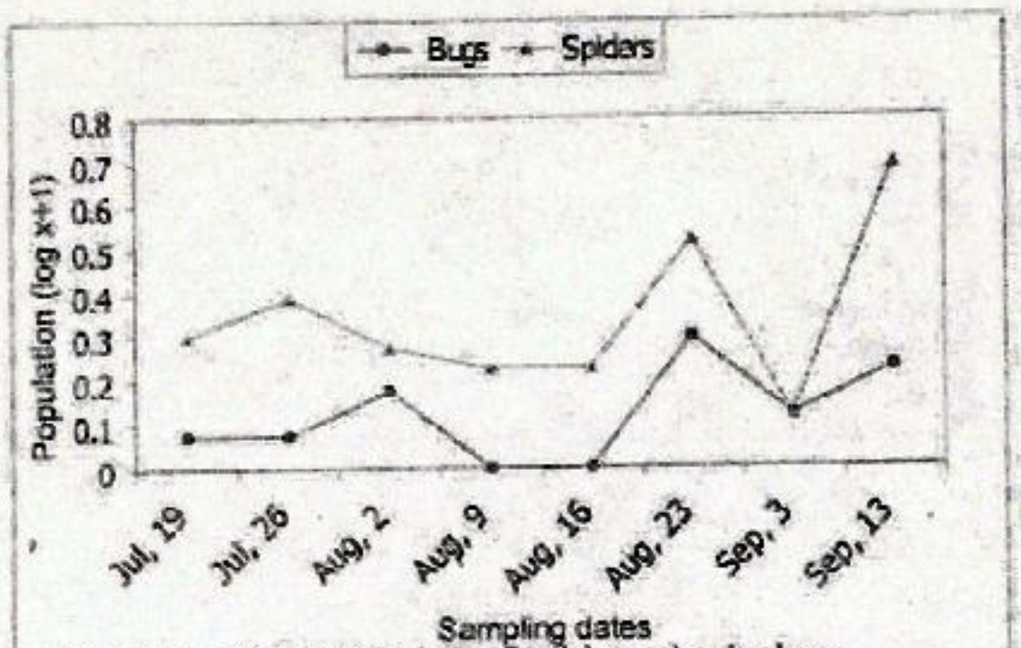


Fig. 17. (D3V4)Variety Sathiya planted on June 21, 1984

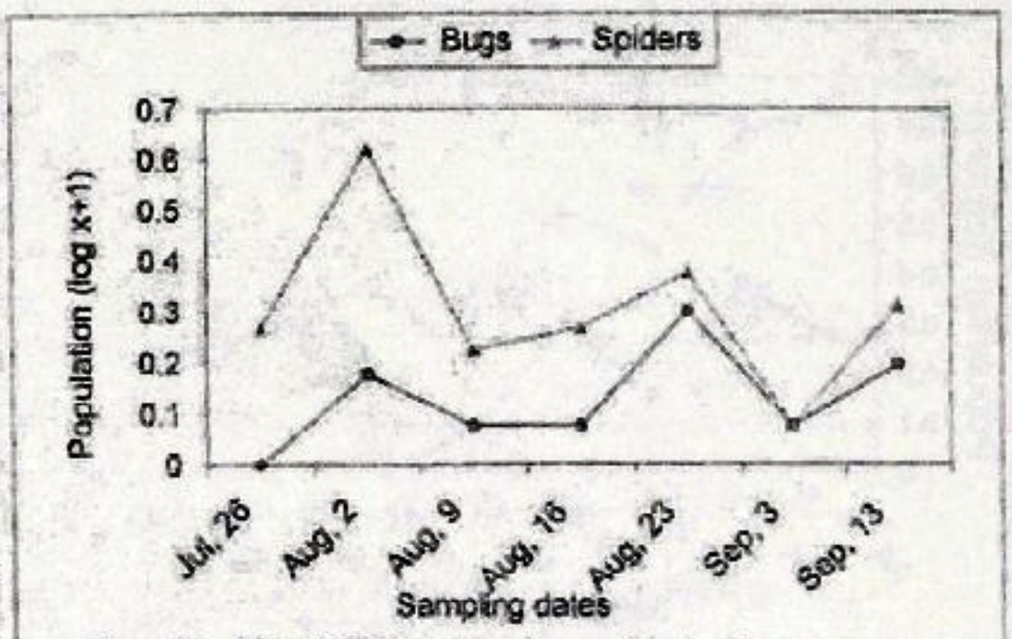


Fig. 20. (D4V3) Variety Lee planted on July 2, 1984

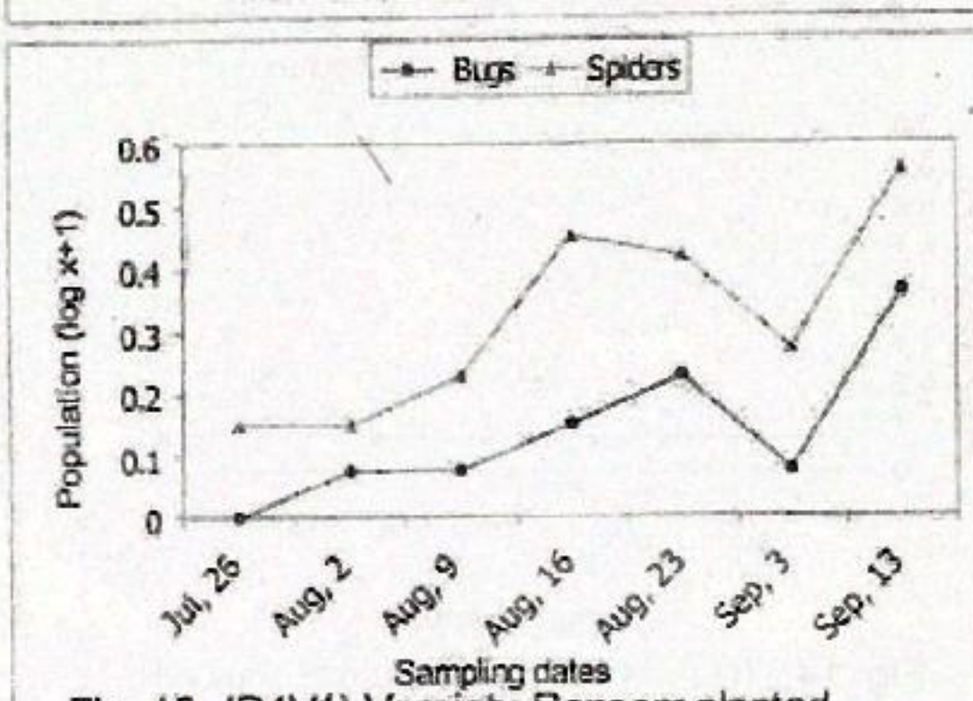


Fig. 18. (D4V1) Varaiety Ransom planted on July 2, 1984

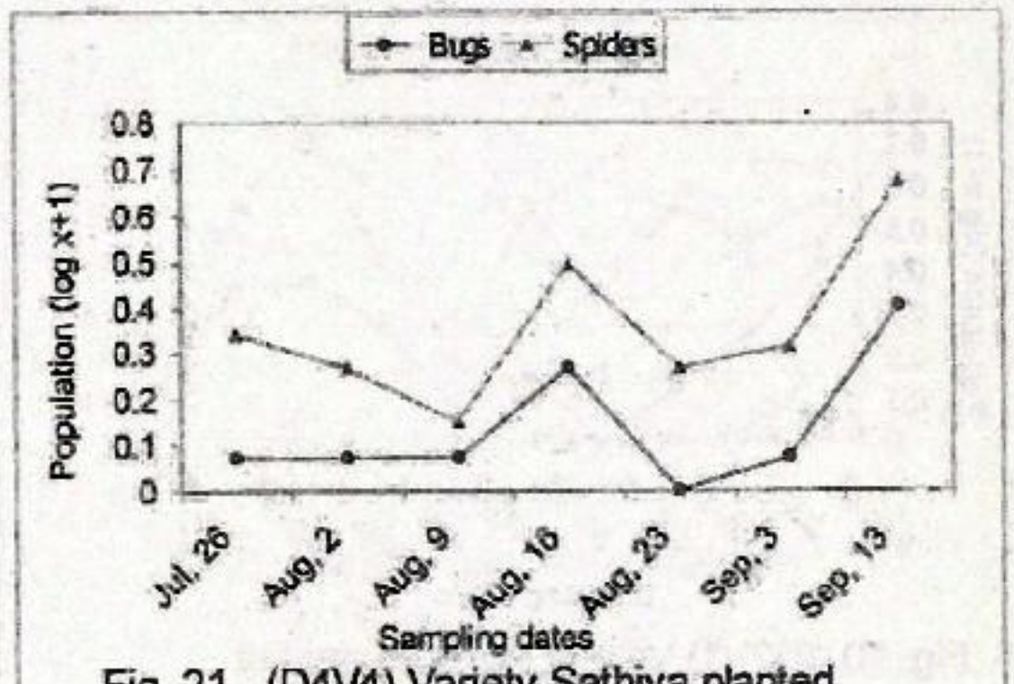


Fig. 21. (D4V4) Variety Sathiya planted on July 2, 1984

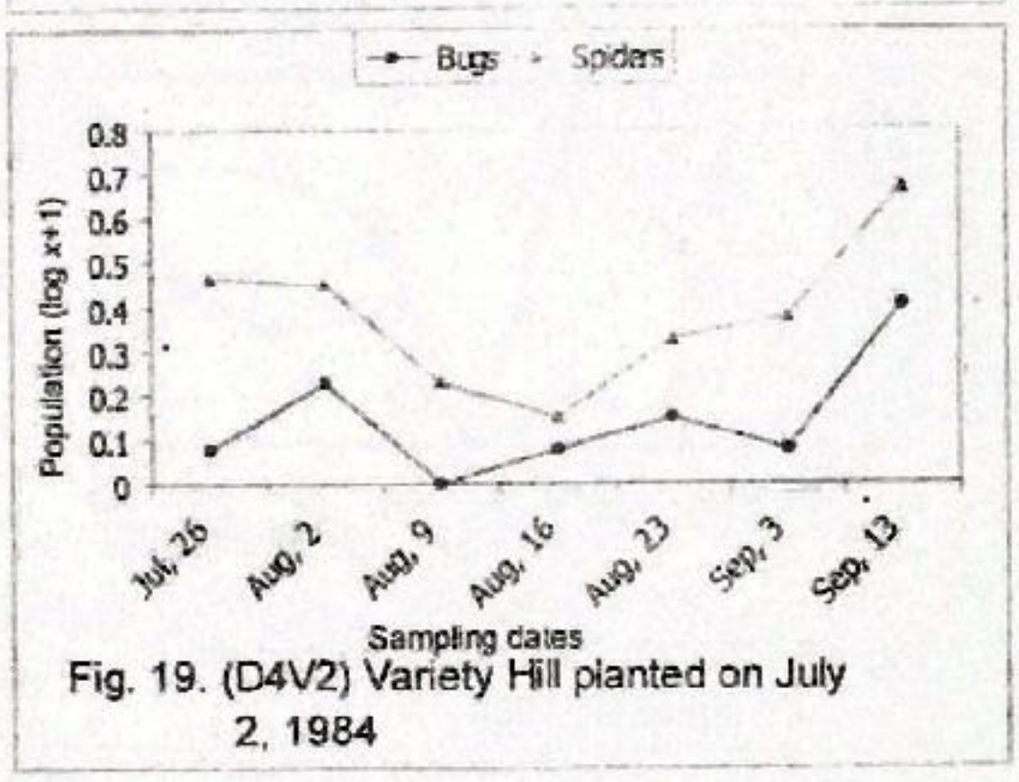


Fig. 19. (D4V2) Variety Hill planted on July 2, 1984

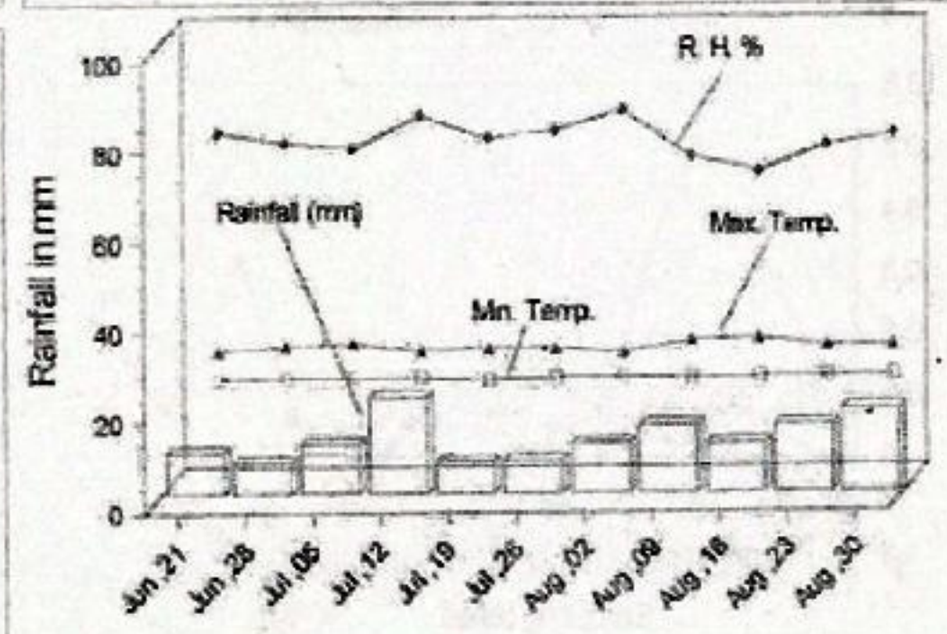


Fig. 22. Average weekly weather record during the sampling period at Khumaltar, 1984

## CONCLUSION

A positive trend between phytophagus insects and predatory spiders was observed on May 15 (D1) 1983 planted soyabean, whereas in 1984 soyabean cultivar Hill planted on June 10 showed crowding effect of predatory spiders and repulsive effect on leaf sucking bug, *C. fallax*. It is possible to increase soyabean yield from the national average by selection of varieties for early planting. First (D1) date of planting was found superior in terms of number of grains and pods per plant basis. Similarly, the weight of seeds per grain, number of grains and pods per plant basis. Similarly, the weight of seeds per grain, pod and plant was significantly better than the first (D1), second (D2) and third (D3) dates of planting, respectively. Natural enemies such as predatory spiders are better agents for the control of *C. fallax* of soyabean in agro-ecosystem. Predators will be effective in suppressing the build up of population of *C. fallax* till chemical pesticides are applied.

## ACKNOWLEDGEMENTS

The author expresses his deep gratitude to Prof. F. P. Neupane, for his valuable comments and suggestions.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# MAJOR CONSTRAINTS AND MANAGEMENT PRACTICES IN THE PERFORMANCE OF *Apis cerana* F. AND *Apis mellifera* L. IN KATHMANDU VALLEY

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## ABSTRACT

Traditional beekeeping is a cultural heritage in Nepal. Among available four species of indigenous honeybees, *Apis cerana* is the only cultivated one. The exotic honeybee *A. mellifera* is also becoming popular. At present, both cultivated species have been practiced in modern beehives. But major constraints and management practices on honeybee production have not been identified under major agro-ecological conditions. Thus, the study has been initiated to identify these constraints and their management practices. Four colonies of each species were kept under observation. Based on three years observations, *A. mellifera* was found susceptible to mites from February to April and November/December. Thai Sacbrood disease (TSB) appeared in *A. cerana* during April to August and November/ December. Where as European Foulbrood (EFB) appeared in *A. mellifera* during February to June and August. Number of queen cell formation and thereby swarming in February/March and September/October was higher in *A. cerana*. An appropriate feeding time during food shortage has been identified in both species. In addition, mortality of honeybees due to pesticide poisoning was observed. The management practices of the identified constraints have been discussed.

## INTRODUCTION

Traditional beekeeping is a cultural heritage in Nepal and has been practiced since time immoral. It is an exclusive non-land based activity and helps in developing sustainable agriculture and conservation of natural ecosystem through pollination. Asian hive bee *Apis cerana* F., the rock bee or giant bee *A. dorsata* F., the Himalayan honeybee *A. laboriosa* and the little bee *A. florea* F. are the most common honeybees found in Nepal. Except *A. cerana* all other species are in wild condition. However, honey is being extracted from all these wild species. In some parts of Nepal, *A. cerana* is found in wild condition as well. Among the different strains of *A. cerana*, the Jumla strain has been reported to be most prolific in honey production (Verma, 1992).

Modern beekeeping in Nepal is still in infant stage. In fact it was initiated only 15 years back with the introduction of movable frame hives to rear *A. cerana* (Kafle, 1992). But the process of modernization is still limited to the farmers. As a result most of the farmers are still following the same traditional method as their forefathers used to do indicating perhaps to the insufficiency of the institutional support to this sector. Those who have adopted modern methods are also facing many problems such as frequent swarming, absconding, diseases and pests, robbing and pesticide poisoning.

Exotic honeybee *A. mellifera* L. was introduced officially in April 1994. However, it was being introduced by some beekeepers in late seventies. Each year the demand for *A. mellifera* is increasing and accordingly many private organizations are engaged at present in its multiplication and distribution. Although this species seems to be very popular in foot hills and inner Terai of Nepal,

beekeepers have not been able to benefit much due to insufficient management practices. What seems lacking is the study to identify the condition and the required management practices under which the species perform well. As a result the beekeepers are in a dilemma which of the species adopts well in their farm condition. If apiculture is to be developed as a viable economic enterprise all these problems need to be well addressed. Realizing this Entomology Division initiated this study with the objective of identifying major constraints and addressing management practices in the performance of *A. cerana* and *A. mellifera*.

## MATERIALS AND METHODS

This experiment was initiated at Khumaltar from September 1995. Four healthy colonies each of *A. cerana* and *A. mellifera* with same age of queen bee and equal number of bee frames were kept under observation. Later on, additional four colonies were added in the observation. Observations were made at seven days interval. During each observation, problems were documented and efforts were made to solve them.

In case of mite attack on *A. mellifera* colonies, 1 ml of 85% formic acid soaked with cotton piece per frame was kept on the bottom board of brood chamber during cold weather and three application of sulphur dust in an alternate day at the rate of 1 gm per frame was used during warm weather. For the control of Thai Sacbrood disease on *A. cerana*, synthetic antibiotic and indigenous plant pesticide was used. At first, 250 mg tetracycline dust mixed with 500 ml sugar solution per colony was given and later on, 5 gm Bhaicare powder mixed with 500 ml sugar solution per colony was fed. Three feedings of 250 mg tetracycline dust mixed with 500 ml of sugar solution per colony was given every alternate day for the control of European Foulbrood in *A. mellifera*. During dearth periods, artificial feeding of sugar solution was provided to both species depending upon the food shortage in the colony. During swarming, frequent checking was done and unnecessary queen cells were destroyed. Activities such as spraying of water, spreading of dust and grass pieces and narrowing the entrance gate were done to reduce robbing. In case of heavy robbing, colonies were shifted to safe places. During severe pesticide poisoning also the colonies were shifted to safe area.

## RESULTS AND DISCUSSION

### Mite appearance and their control

Two species of mite, *Varroa jacobsonii* Oudemans and *Tropilaelaps clareae* Delfinado and Baker were found attacking on *A. mellifera* colonies. In the first two years, *V. jacobsonii* was observed where as in the third year *T. clareae* was found very serious. Moreover, *V. jacobsonii* appeared in both species of honeybees but *T. clareae* was associated mainly with *A. mellifera*. The effect was serious during the month of November followed by March. The infested *A. mellifera* colonies were significantly damaged. Though mites were seen on *A. cerana* colonies also, their effect was not critical as in *A. mellifera*. The main symptom of mite attack in *A. mellifera* were punctured capping of brood cell inside the colony, restless crawling and staggering of honeybees around the hives, mite infested dead larvae outside the hive entrance and disabled bees with rudimentary wings and legs around the hive. It was observed up to five mites infestation in an individual brood cell.

Application of 1 ml of 85% formic acid per frame at seven days interval was found to be effective on controlling mites during winter where as application of sulphur dust on one day interval at the rate of 1 gm per frame was found to be effective to control mites in other period. Appearance of mite at different dates of the year in *A. mellifera* colonies is shown in Table 1.

**Thai Sacbrood appearance and their control**

Thai Sacbrood (TSB) disease was found very destructive to *A. cerana*. It was first observed in one colony nearby and it spread in the experimental colonies after some time. All colonies of *A. cerana* were infected by TSB during April to August and November/December. The punctured capping at sealed brood was seen at first and when the capping was opened dead larvae in an upright position were found. The dead larvae were watery and formed a sac-like structure when pulled out of cell by forceps. This disease was observed more in older larvae than in younger ones. The dead larvae were found lying on the lower side of cell without adhering tightly to the cell wall and were also decolorized.

Tetracycline dust at the rate of 250 mg and mixed with 500 ml of sugar solution per colony was given to control it. But it was not found to be effective. So, 5 gm Bhaicare powder mixed with 500 ml of sugar solution per colony was given to control this disease and this treatment was found comparatively better. Appearance of TSB at different dates of the year in *A. cerana* colonies is shown in Table 1.

**European Foulbrood appearance and their control**

European Foulbrood (EFB) was found very destructive to *A. mellifera*. However, in 1995/96 it was not observed in *A. mellifera* colonies but it appeared in February to June and August in other two years. All the *A. mellifera* colonies were infected by the disease. During its infection lots of dead larvae were seen outside the hive entrance. This disease was observed more in younger larvae than in older ones. Unsealed dead larvae of almost of the same age were also observed in the comb cells. Later, they decomposed and as a result turned black and gave bad smell.

Three feeding of 250 mg tetracycline dust mixed with 500 ml of sugar solution in one day interval was found effective to control EFB. Appearance of EFB at different dates of the year in *A. mellifera* colonies is shown in Table 1.

**Table 1, Appearance of mite, Thai Sacbrood and European Foulbrood at different dates of the year in the colonies of *Apis cerana* and *Apis mellifera***

| Year | 1995/96 | 1996/97 | 1997/98 |
|---|---|---|---|
| Mite in *A. mellifera* | Nov 24, 27<br>Dec 1, 4, 5<br>Mar 3, 13, 17, 21<br>April 4 | Nov 15, 17, 19, 25, 27, 29. | July 17, 19, 21<br>Oct 29, Nov 5, 18<br>Feb 4, 6, 8<br>March 2, 4, and 6 |
| Thai Sacbrood in *A. cerana* | April 10, 12, 15<br>July 14, 16<br>Aug 13 | | Nov 1, 2, 3, 7<br>Dec 4, 6 |
| European Foulbrood in *A. mellifera* | _ | Mar 29, 31<br>April 2<br>May 6, 8, and 11<br>June 23, 25, 27 | Aug 21, 23, 25<br>Feb 9, 11, 13 |

**Dearth period and artificial feeding**

December, January and February during winter season and June, July and August during rainy season were identified as dearth period. During that period sugar solution (250 ml water boiled and cooled and mixed with 250 gm of sugar) was fed artificially to both honeybee colonies. However, pollen substitute was not needed when colonies were examined. Reserve pollen was found sufficient in the colonies but scarce of nectar was observed. The three years observation data suggested that *A. mellifera* need four to five feedings where as *A. cerana* needs only two to four feedings during that period. The dates of artificial feeding for both honeybee species are shown on Table 2.

## Number and period of queen cell formation

Maintenance of appropriate honeybee population is very important and it was done by destroying unnecessary queen cells at regular interval. The number of queen cell was found high in *A. cerana* than *A. mellifera*. Upto 12 queen cells were found in a single frame of *A. cerana*. However, the average number of queen cells were found 8 and 5 in *A. cerana* and *A. mellifera*, respectively. Similarly, swarming tendency was low in *A. mellifera* than in *A. cerana*. The swarming period varied from February to March and September to October in both species. The average number of queen cells and their formation period in both species are shown in Table 3.

**Table 2. Artificial feeding dates for *Apis cerana* and *Apis mellifera* during dearth period in different years**

| Year | *Apis cerana* | | *Apis mellifera* | |
|---|---|---|---|---|
| | **Winter season** | **Rainy season** | **Winter season** | **Rainy season** |
| 1995/96 | Dec 25<br>Jan 6 & 25<br>Feb 12 | July 19 | Dec 25<br>Jan 6 & 25<br>Feb 12 | July 16 & 19<br>Aug 23 |
| 1996/97 | Dec 23<br>Jan 13 & 18<br>Feb 2 | July 12 & 27<br>Aug 13 | Dec 23<br>Jan 4, 13 & 25<br>Feb 2 | June 23<br>July 6, 12 & 30<br>Aug 11 & 23 |
| 1997/98 | Dec 22 & 30<br>Jan 6 & 18<br>Feb 2 | July 2 & 31<br>Aug 17 & 23 | Dec 22 & 30<br>Jan 4, 20 &<br>30Feb 3 | June 19 & 23<br>July 2, 16 & 31<br>Aug 2 & 11 |

**Table 3. Number of queen cells and their formation period in *Apis cerana* and *Apis mellifera* in different years**

| Year | *Apis mellifera* | | *Apis cerana* | |
|---|---|---|---|---|
| | **Average no.** | **Period** | **Average no.** | **Period** |
| 1995/96 | 3.66 | Feb 27 - Mar 10 | 4.00 | Mar 5 – 12 |
| 1996/97 | 6.00 | Feb 23 - Mar 10 | 9.33 | Feb 23 - Mar 11 |
| 1997/98 | 5.40 | Sep 17 - 25<br>Feb 20 - Mar 23 | 8.24 | Sep 26 - Oct 21<br>Feb 26 - Mar 29 |
| Average of three years | 5.02 | | 7.19 | |

## Robbing

Robbing tendency was observed during dearth periods in both species. But it was severe during December/January and July of 1995/96 and in November and June of 1997/98. It could probably due to varying weather condition over the years. In 1995/96 robbing was done by *A. mellifera* to *A. cerana* but during 1997/98 both species were found robbing to *A. cerana* colonies. However, it was very difficult to distinguish it whether it was from the experimental colonies or from the apiaries nearby. When the robbing took place in the weaker colonies of *A. cerana*, it destroyed completely within a short period of time. During November 1997/98, robbing occurred in all the colonies of *A. cerana*, but only some strong colonies defended it. This problem was reduced by spraying water or dusting. It was also reduced to some extent by narrowing the entrance gate. In 1997/98, due to continuous and severe robbing, the honeybee colonies were shifted to other foraging area.

## Pesticide poisoning

Pesticide poisoning is another serious problem to honeybees and it occurred every year. In March 1997, all the experimental colonies were badly affected. In general strong colonies were affected more than the weaker ones. The symptoms of pesticide poisoning observed were dead or dying

honeybees extending their tongue/proboscis, abnormal movement, spinning in round, crawling around, disability to fly. Pesticide effect was also seen inside the brood chamber. The younger larvae of same age were found dead inside their cell. Aggressive behaviour and attack of guard bees to the forager of the same colony were also observed during the pesticide poisoning. In case of severe pesticide poisoning, the honeybee colonies were shifted to other foraging area.

Yellow jacket wasp, *Vespa sp.* was observed during the summer and autumn season. *A. cerana* honeybees were found defending against these predatory wasps in some extent but *A. mellifera* honeybees were helpless. Ants, wax moths and black fork-tailed birds were also observed during the study.

## CONCLUSION

Though this experiment is a preliminary nature, some of the major constraints in the performance of *A. mellifera* and *A. cerana* have been identified in Kathmandu conditions. Some management practices have also been identified to overcome the problems encountered. However, problems vary with ecological regions. Realizing this and to address the major constraints identified Entomology Division has proposed to do systematic study in the eco-regions of the country as well.

## ACKNOWLEDGEMENTS

Authors are highly grateful to Mr. D. N. Manandhar, Chief and Mr. B. K. Gyawali, Senior Scientist, Entomology Division, NARC for providing all the facilities and continuous encouragement to conduct this study. We would like to thank sincerely to other senior scientists and technical officers of Entomology Division for providing their suggestions and deep interest in our study. Our appreciation and thanks goes to Mr. J. D. Neupane, Mr. S. P. Nepal and Mr. J. B. Tamang, Mr. T. Pokheral for sincere help to collect information during the course of study.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# MINIMISING POST-HARVEST LOSS OF MAIZE UNDER FARMERS' STORAGE CONDITIONS IN THE EASTERN HILLS OF NEPAL

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## ABSTRACT

An experiment was carried out to identify the effectiveness of *Acorus calamus* (Bojo) against weevil in stored maize cobs under mid and low altitude conditions. *A. calamus* rhizome powder and *Acorus calamus* rhizome pieces were applied at the rate of 30 gm/kg grain and placed at the bottom, middle and top layers of maize cobs in the *Kunio* storage system. No treatment was given for control. The study results indicated that *Acorus* powder was effective in minimizing *Sitophilus* weevils in maize stored in the *Kunio* system. The application of *Acorus* pieces was not as effective as powder. The use of powder in the *Kunio* storage system can reduce weevil infestations from 51% to 5.4% at mid altitude and from 98.6% to 10.5% at low altitude. A second trial using cobs stored in plastic buckets showed a similar reduction in weevil infestation from 60.3% (control) to 6.8% at mid altitude and from 100% to 14.5% at low altitude. Grain weight loss was also minimized from 6.11% to 0.68% at mid altitude and from 11.8% to 1.28% at low altitude in cobs stored in the *Kunio* system, while it was 10% to 1.4% and 15.9% to 2.3% at mid and low altitude, respectively in the cobs stored in plastic buckets. The effectiveness of *Acorus* material was compared with the untreated control, which was representative of farmers' storage conditions. The results clearly indicated that *Acorus* powder could reduce weevil infestation in maize stored under farmers' conditions resulting in a significant increase in the quantity of food available for household consumption. A gross estimate of the benefits from the application of *A. calamus* powder in maize storage systems in the mid and low altitudes indicates a savings in grain weight loss of nearly 81,000 metric tons with a value of NRs 810,000,000.00.

## INTRODUCTION

Maize is a staple food for hill farmers. In the eastern hills of Nepal, it ranks first in area cultivated and second in productivity among cereal crops. The major maize cultivation areas in the eastern hills are in the mid and low altitudes (<1700 m). Maize is normally harvested in August and then stored in cribs for up to nine months. The environmental conditions during this period in the mid altitude areas are favourable for the development of weevils. Favourable conditions for progeny development are warm temperatures (15-35°C), high relative humidity (>70%) and high grain moisture content (>12%). Since storage losses caused by weevils are serious in the mid and low hill areas, the focus of this study was diverted to these agro-ecological zone.

There is evidence of considerable grain loss during the storage of maize both in terms of quantity and quality. Grain losses in the store occur as the result of many factors, including insect pests, diseases and rodents. The damage and loss caused by these factors in Nepal has been estimated by a number of scientists (2-30% on a weight basis). Among the insect pests, the *Sitophilus* weevil has been identified as the major factor responsible for reducing the quality and quantity of maize grain in the eastern hills of Nepal. In a survey of farmer perceived priority pest problems conducted jointly by Pakhribas Agricultural Centre (PAC) and the Natural Resources Institute (NRI-UK), it was found that weevils in stored maize were the farmers' priority concern in terms of insect pests (Duwadi *et al.*, 1995). Lama

Sherpa *et al.* (1997) reported that one of the major reasons for rejecting high yielding maize varieties by farmers in eastern Nepal was due to the problem of storage losses caused by weevils. Similarly, Paneru (1996) reported storage losses due to weevils up to 31% in maize. Golob (1994) reported that maize stored in cribs becomes extensively damaged by insects, ears examined on several farms (after eight months on the crib) were heavily infested by *Sitophilus* weevils. All the ears examined were heavily damaged and 50% or more losses in the cribs were recorded. Heavily infested grain is fed to animals; although the quantitative weight loss from 100% damaged grain may only be 10-20%, the real loss for human consumption may approach 100%. A study on the post harvest storage situation in the eastern hills indicated that losses up to 20% in terms of weight and market price were reported by farmers in maize (Ghimire *et al.*, 1996).

These conditions demonstrate the need to identify appropriate alternatives to chemical pesticides and expensive grain storing technology. Nepalese farmers have a long tradition of using plant materials to protect their produce from weevils. Farmers are either already using or are very interested in using alternatives to pesticides. The identification of effective methods of weevil control based on available, renewable resources using a low cost approach that is compatible with nature is highly desirable. A low external input storage system will make farmers independent of chemical supply difficulties in the market. A weevil control method based on local knowledge, which requires low financial and energy input could be easily adapted to the local social norms and ecology making it more easily adaptable. As most of the post harvest activities including harvesting, storing and processing are done exclusively by women special attention needs to be given to gender issues so that the technology is simple and easy in its application.

A program designed to promote the use of cheap indigenous materials to protect home stored maize grain from weevil damage was initiated by PAC in 1991. The application of household lime (dusting and dipping treatments) was found to be partially effective in reducing weevil infestation in maize in crib storage systems (Paneru *et al.*, 1997). The use of *Acorus calamus* (Bojo) powder (50 g per kg of shelled maize) however, was found to be the most effective material against weevils (as effective as the control treatment malathion) identified in the program. It is believed that this locally available plant material will be equally effective in crib systems as it has been in bin storage systems. The present work proposes to test the effectiveness of *A. calamus* rhizome products against weevil infestations in maize cob storage systems under farmer conditions.

*A. calamus* is available from the foothills to high altitude (2200 m) particularly on swampy lands and near water sources. Farmers are already familiar with this plant and it is thought that the use of this plant material could be an alternative of pesticides in maize storage systems and would allow farmers to make use of locally available resources rather than those which have to be imported. This technology would also help to minimize the risk of indiscriminate use of chemical insecticides and pesticides and the potential for environmental pollution and the resurgence of secondary pests as well as reduce the danger of potential health hazards to humans. The direct beneficiaries will be the maize growers in the mid and low hill environments of the eastern region of Nepal as well as other similar hill areas in Nepal and neighboring countries.

The objective of the present study is to identify appropriate methods of applying *A. calamus* to minimize storage losses in maize cobs when stored in the *'Kunio'* storage system and in maize cobs stored in plastic buckets and develop recommendations.

## MATERIALS AND METHODS

### Site selection

Mid (1450 to 1500 m asl) and low altitude (750 m asl) sites were chosen by a team comprised of the PAC Technical Research Coordinator, Entomologist, Technical Officer and Technical Support staff. The team visited different locations including Guthitar, Dhankuta, Patle, Kagate and Hile to select

sites and grain stores to carry out the experiment. The team decided to rent 3 rooms at Patle on a south facing aspect and 3 rooms at Guthitar, Dhankuta in south facing aspect, which had more or less similar conditions except altitude.

**Selection of maize cobs**

In the experiment, both white and yellow varieties of local maize cobs were used. Prior to selecting the maize cobs, the maize cribs were thoroughly examined to ensure the selection of weevil free maize cobs by the team. Fifteen maize cobs, both white and yellow were randomly taken from the maize crib. None of these cobs showed any evidence of weevil attack during examination. Maize cobs (both white and yellow) purchased for the experiment were packed in jute bags and covered with a polythene sheet to protect them from secondary weevil infestation during transport to the experimental sites. During the laboratory examination of randomly selected maize cobs from each crib, the following observations were recorded.

| Observations | Yellow maize | White maize |
|---|---|---|
| Mean germination (%) | 97 | 97 |
| Mean moisture (%) | 17.9 | 18.8 |
| Thousand grain weight (g) | 355 | 352 |
| Mean grain weight per cob (g) | 91 | 94 |
| Weevil infestation (number) | 0 | 0 |

**Preparation of *Acorus calamus***

The rhizomes of *A. calamus* were collected from the fallow marshy land of farmers nearby PAC (1700 m asl). The freshly collected rhizomes were washed with tap water and all existing root hairs were removed. The rhizomes were chopped into pieces (approximately 1 cubic cm) and these pieces were dried in the shade. Some pieces were used directly while the remaining pieces were ground in a flour mill to prepare a powder. The moisture content of the dried pieces was 4.5% and the powder 7.8% at the time of final preparation. The fresh rhizome had initial moisture content of 77.7%. These products were packed in polythene bags and stored in a plastic bucket for approximately one week under laboratory room conditions (18° C) at PAC.

**Treatments**

**A. Kunio system**

1. White maize cobs + *Acorus* pieces at a rate of 30 gm/kg grains
2. White maize cobs + *Acorus* powder at a rate of 30 gm/kg grains
3. White maize cobs (untreated control)
4. Yellow maize cobs + *Acorus* pieces at a rate of 30 gm/kg grains
5. Yellow maize cobs + *Acorus* powder at a rate of 30 gm/kg grains
6. Yellow maize cobs (untreated control)

**B. Plastic bucket system**

1. White maize cobs + *Acorus* pieces at a rate of 30 gm/kg grains
2. White maize cobs + *Acorus* powder at a rate of 30 gm/kg grains
3. White maize grains + *Acorus* powder at a rate of 30 gm/kg grains
4. White maize cobs (untreated control)

These treatments (A and B) were tested under both low and mid altitude conditions.

**Implementation of experiment**

The effectiveness of the chopped pieces and powder of *A. calamus* rhizome was separately tested on farmers' local white and yellow maize using an application rate of 30 gm per kg of maize grains. For this, the amount of grains in the unshelled cobs was estimated from the grains shelled from fifteen randomly cobs of each variety. The mean grain weight of the 15 cobs randomly taken from the pile of each variety was taken as the standard for estimating the number of grains on the experimental maize cobs to fix the dosage for each treatment.

The selected rooms were cleaned and plastered with a mixture of mud, cowdung and water. After seven days the rooms were completely dried and a locally made bamboo mat (75 x 75 cm) was placed in all selected rooms. The *Kunio* was made on this bamboo mat using a total of 300 cobs in each *Kunio*. A separate *Kunio* was made for each of the six treatments and three replications. Maize cobs without any treatment were used as the control. The calculated *Acorus* pieces (819 gm/*Kunio*) was applied in three layers i.e. bottom, middle and top level of each *Kunio*. Each *Kunio* was 45 cm in height and located 30 cm from its neighboring *Kunio*. The *Acorus* powder (846 gm/*Kunio*) was applied at the bottom, middle and top layers of each *Kunio*. The *Kunios* were inoculated with a total of one hundred adult weevils placed in the middle of each *Kunio* from 4 different aspects (25 each). Each individual *Kunio* was then covered with a polythene sheet keeping the upper part of the sheet open. This was done to check weevil movement from one *Kunio* to another and to minimize the direct overlapping of the volatilising effect of the *Acorus* among the treatments. Commercial rodent traps using food preferred by rats (chocolate, wheat bread) were also placed to avoid rat problem. The temperature and relative humidity of each storage room was recorded daily.

The effectiveness of the *Acorus* material was also tested by using a bucket storage system. Both maize cobs and maize grains (white maize only) were placed into 50 litre capacity buckets. Thirty cobs were placed in each plastic bucket. The calculated *Acorus* pieces (85 gm/30cobs) were placed at bottom, mid and top layer. Similarly, *Acorus* powder at the rate of 85 gm/30 cobs was placed at the bottom, mid and top layer in each bucket. One bucket was filled with 5 kg of shelled grains and thoroughly mixed with *Acorus* powder at a rate of 30 gm/kg grains. A total of forty adult weevils were exposed in each bucket. The buckets were covered using the bucket lid and sealed using packing tape. There were 3 replications both at the mid and low altitude sites. This experiment was started on 25 and 27$^{th}$ January 1998 at the mid and low altitude sites, respectively to test the effectiveness of *A. calamus* against maize weevil and was completed in June after 5 months.

**Observation**

Three cobs were randomly selected from 3 locations within each *Kunio* (low, mid and upper levels) at 30-day intervals by the same person. The sample was carried to the PAC plant protection laboratory where the grains were shelled and the bored grains in each sample counted by placing the grains on a light box where the bored grains were easily visible. The weight and moisture percentage of the bored and un-bored grains were recorded for each sample. The percentage of grains bored by weevils and the grain weight loss were calculated using the above data. After adjusting the moisture content of the initial and final 1000 grain mass to the standard moisture content of 12% the difference in grain weight loss was calculated.

**Analysis**

Since the percentage data were derived from count data such as number of grains bored and not based on the randomly selected sample of cobs, the recorded data (% grains bored) were not uniformly distributed. As the data was in the range of 4 to 99% an arc sine or angular transformation of the data was done. The transformed data were analysed using a factorial ANOVA for three factors (altitude, variety and treatment) in a randomised complete block design. As the percent grain weight loss data were lying within the range 0.5 to 16%, thus no transformation was done for these data and the recorded data was directly analysed as a factorial ANOVA.

## RESULTS AND DISCUSSION

### Maize storage under *Kuniyo* conditions

During the 5 month experimental period, 50% of the untreated white and 51% of the untreated yellow maize grains were bored by weevils at mid altitude while more than 90% of the grains were bored on the untreated controls at low altitude. Less than 6% of the grains were bored by weevils in the cobs treated with *Acorus* powder at mid altitude although more than 30% of the grains were infected in the cobs treated with *Acorus* rhizome pieces. Similarly, in the low altitude site less than 11% of the grains were bored by weevils in the cobs treated with *Acorus* powder while more than 74% were bored in the cobs treated with *Acorus* rhizome pieces (Table 1).

**Table 1. Mean percentage grains bored by weevils in the *Kuniyo* storage system**

| Treatment | 0 day | 30 days | 60 days | 90 days | 120 days | 150 days |
|---|---|---|---|---|---|---|
| Mid altitude | | | | | | |
| White maize + *Acorus* piece | 0 | 3.5 | 9.9 | 14.2 | 23.8 | 34.4 |
| White maize + *Acorus* powder | 0 | 0.8 | 1.9 | 2.6 | 4.0 | 5.4 |
| White maize + control | 0 | 11.7 | 22.6 | 27.0 | 37.2 | 50.0 |
| Yellow maize + *Acorus* piece | 0 | 2.2 | 5.3 | 8.9 | 16.6 | 29.1 |
| Yellow maize + *Acorus* powder | 0 | 0.9 | 1.7 | 2.6 | 4.1 | 5.8 |
| Yellow maize + control | 0 | 9.5 | 17.1 | 22.3 | 34.6 | 51.1 |
| Low altitude | | | | | | |
| White maize + *Acorus* piece | 0 | 5.8 | 13.6 | 36.1 | 59.1 | 78.5 |
| White maize + *Acorus* powder | 0 | 1.2 | 3.0 | 4.3 | 7.0 | 10.8 |
| White maize + control | 0 | 18.2 | 35.9 | 57.4 | 79.3 | 98.7 |
| Yellow maize + *Acorus* piece | 0 | 5.1 | 14.5 | 37.3 | 55.6 | 74.6 |
| Yellow maize + *Acorus* powder | 0 | 0.8 | 2.7 | 3.9 | 6.9 | 10.5 |
| Yellow maize + control | 0 | 16.6 | 36.4 | 54.8 | 78.8 | 97.0 |

The percentage grains bored at 150 days were statistically analysed after transformation of the data into arc-sine. The analysis of variance table showed that the altitude significant 0.001% level to cause the infestation of grains by weevil. But variety was not significant. *Acorus* powder was the superior treatment at both altitudes over *Acorus* pieces and the untreated control. The maize cobs treated with *Acorus* rhizome powder had a lower percent of grains bored by weevil. Less than 6% were bored by weevils at mid altitude and less than 11% at low altitude where a very high 51 and 97% of the grains were bored on the untreated cobs at mid and low altitude, respectively, (Table1).

At mid altitude, the grain weight losses for white and yellow untreated cobs were 5.94 and 6.11%, respectively while it was 11.8% at low altitude. The grain weight losses in the cobs treated with *Acorus* powder at both altitudes and for both maize varieties were less than 2%. The grain weight losses ranged from 3.46% to 9.36% for the cobs treated with *Acorus* rhizome pieces. Grain weight losses recorded for the different treatment levels were statistically analysed.

Analysis of variance indicated that the altitude factor was highly significant at less than a 0.001% level (with an F value 234.9 and 14% CV). Similarly, treatments were highly significant at less than a 0.001 level (F value 339.3 and 14% CV) to cause grain weight losses in the tested cobs. *Acorus* rhizome powder was the superior treatment over *Acorus* rhizome pieces and the untreated control. It was the principal factor to reduce the grain weight losses caused by weevils (Table 2).

**Maize storage in the bucket system**

The trend of percent grain bored by weevils was increased over time but the rate of the increase was significantly governed by the nature of the treatment given to the cobs (Table 3). The rate of increase of percent bored grains was negligible in the cobs treated with *Acorus* rhizome powder for both varieties (yellow and white) and both altitudes (low and mid). It was up to 7 and 15% at mid and low altitude, respectively during the 5 months period. During this period, 27 and 90% of the grains were bored by weevils at mid and low altitude, respectively in the cobs treated with *Acorus* rhizome pieces. In the untreated control, 60% and over 90% of the grains were infested by weevils at mid and low altitudes, respectively. The percentage grains bored by weevils during the period for the different treatments were statistically analysed. The analysis of variance indicated that the altitude factor was highly significant at less than 0.001% level (with an F value 90.2 and CV 16.3%) and similarly, the treatment factor was also highly significant at less than 0.001% level (with an F value of 106.3 and CV 16.3%) in determining the grain infestation caused by weevils. The *Acorus* rhizome powder was the superior treatment over *Acorus* rhizome pieces and the untreated control to reduce the infestation of weevils on the cobs and grains (Table 3).

**Table 2. Mean percentage grain weight loss and germination percentage in the *Kunio* storage system**

| Treatments | Mean final % grains bored | Initial grain weight | Mean final infested grain weight | Grain weight loss | Initial germination % | Final germination % |
|---|---|---|---|---|---|---|
| Mid altitude | | | | | | |
| White maize + *Acorus* piece | 34.4 | 325 | 312 | 4.2 | 97 | 52 |
| White maize + *Acorus* powder | 5.4 | 325 | 323 | 0.7 | 97 | 88 |
| White maize + control | 50.0 | 325 | 306 | 5.9 | 97 | 41 |
| Yellow maize + *Acorus* piece | 29.1 | 331 | 320 | 3.4 | 97 | 56 |
| Yellow maize + *Acorus* powder | 5.8 | 331 | 329 | 0.7 | 97 | 86 |
| Yellow maize + control | 51.1 | 331 | 311 | 6.1 | 97 | 37 |
| Low altitude | | | | | | |
| White maize + *Acorus* piece | 78.5 | 325 | 295 | 9.4 | 97 | 14 |
| White maize + *Acorus* powder | 10.8 | 325 | 321 | 1.3 | 97 | 82 |
| White maize + control | 98.7 | 325 | 287 | 11.8 | 97 | 0 |
| Yellow maize + *Acorus* piece | 74.6 | 331 | 302 | 8.9 | 97 | 16 |
| Yellow maize + *Acorus* powder | 10.5 | 331 | 327 | 1.3 | 97 | 79 |
| Yellow maize + control | 97.0 | 331 | 292 | 11.8 | 97 | 2 |

**Table 3. Mean percent grains bored by weevils in the plastic bucket storage system**

| Treatments | 0 days | 30 days | 60 days | 90 days | 120 days | 150 days |
|---|---|---|---|---|---|---|
| Mid altitude | | | | | | |
| White maize + *Acorus* piece | 0 | 2.67 | 3.6 | 4.4 | 9.5 | 27.2 |
| White maize + *Acorus* powder | 0 | 0.77 | 1.4 | 1.7 | 3.4 | 6.8 |
| White maize grain + *Acorus* powder | 0 | 0.00 | 1.0 | 1.3 | 2.9 | 4.7 |
| White maize + control | 0 | 6.47 | 9.6 | 11.6 | 24.7 | 60.3 |
| Low altitude | | | | | | |
| White maize + *Acorus* piece | 0 | 2.10 | 9.4 | 28.7 | 50.3 | 90.9 |
| White maize + *Acorus* powder | 0 | 1.80 | 2.8 | 4.1 | 6.9 | 14.5 |
| White maize grain + *Acorus* powder | 0 | 0.00 | 2.4 | 3.9 | 5.4 | 8.8 |
| White maize + control | 0 | 3.93 | 11.7 | 24.8 | 83.9 | 100.0 |

In the untreated control, grain weight losses of 10% and 16% were observed at mid and low altitude, respectively. It was up to 2.3% in the cobs treated with *Acorus* rhizome powder. Similarly, it was 4.5 and 13.5% at mid and low altitude, respectively in the cobs treated with *Acorus* rhizome pieces. Minimum grain weight losses were recorded on the grains treated with *Acorus* rhizome powder. These grain weight losses recorded over all treatment levels were statistically analysed. The analysis of variance indicated that the altitude factor was highly significant at less than a 0.001% level (with an F value.of 89 and CV 17.3%). Similarly, the treatment factor was highly significant at less than 0.001% level (with an F value of 168.8 and CV 17.3%). The treatment factor was the principal factor in determining percent grain weight losses caused by weevils (Table 4).

**Table 4. Mean percentage grain weight loss in the plastic bucket storage system**

| Treatments | Mean final % grains bored | Initial grains weight | Mean final infested grain weight | Grain weight loss | Initial germination % | Final Germination % |
|---|---|---|---|---|---|---|
| Mid altitude | | | | | | |
| White maize + *Acorus* piece | 27 | 325 | 311 | 4.5 | 97 | 42 |
| White maize + *Acorus* powder | 7 | 325 | 321 | 1.4 | 97 | 87 |
| White maize grain + *Acorus* powder | 5 | 325 | 323 | 0.8 | 97 | 88 |
| White maize + control | 60 | 325 | 293 | 1.0 | 97 | 27 |
| Low altitude | | | | | | |
| White maize + *Acorus* piece | 91 | 325 | 281 | 13.5 | 97 | 4 |
| White maize + *Acorus* powder | 15 | 325 | 318 | 2.3 | 97 | 76 |
| White maize grain + *Acorus* powder | 9 | 325 | 320 | 1.5 | 97 | 84 |
| White maize + control | 100 | 325 | 273 | 15.9 | 97 | 0 |

**Maize storage in Thangro**

A pair plot trial was set up to test the efficiency of *Acorus* rhizome powder in a *Thangro* storage structure (maize crib located outside). *Acorus* rhizome powder was not found to be effective against weevils (*Sitophilus* sp.) in maize cobs stored in a *Thangro* at either the mid or low altitude sites. More research is needed on the application method under *Thangro* storage conditions as in this experiment most of the rhizome powder was washed away by rain or rendered ineffective due to chemical degradation as a result of exposure to the external environment. A number of modifications have been considered to the *Thangro* structure (top of the *Thangro* thatched using locally available material and covered with polythene sheet) that could make the use of *Acorus* an effective treatment under farmer conditions for *Thangro* storage structures. However, these modifications will need further research (practicality, cost effectiveness) and field tested.

**Economic implications**

As the majority of the hill farmers store their maize cobs using a *Kunio* storage system an attempt has been made to quantify the benefits that farming households would obtain if this technology were to be widely adopted. Small farmers store their maize using the *Kunio* storage system while all other maize growers store their maize cobs for periods up to 1-3 months using the *Kunio* system before they place the maize cobs in a *Thangro* or hang them on their house balcony. Weevil contamination takes place under the *Kunio* system in house before storage in a Thangro. Within the house, weevils remain in infested maize waiting for the newly harvested maize cobs. When the findings of this experiment are applied to maize in the *Kunio* storage system it will minimize weevil infestations which will reduce the losses occurring to stored maize grain in terms of weight loss and quality loss, important aspects which determine the amount of food available for household consumption. The findings will also help ensure that the household has better quality seed for planting the following season.

The hills contain approximately 1,300,000 households, which are growing maize in the mid and low altitudes. These farmers produce around 1,038,226 mt annually for various needs such as food for household consumption, feed for cattle, animals, chicken and for sale in local markets. The above mentioned households will be benefited from these research findings. Grain weight losses during storage by weevils was found to be 6to 12% at mid and low altitudes, respectively in the eastern hills of Nepal. When these figures are applied to data for the total hill production of maize, the size of the loss in terms of maize grain is approximately 80,981 metric tons annually. The monitory value of this loss due to weevils (@ Rs.10/kg of maize) is approximately Rs. 809,810,000 (Table 5).

**Table 5. Annual total maize production, monitory value, weight losses and its monitory losses by weevil infestation in stored maize**

| Production | Production (mt) | Value in NRs ('000) | Annual weight losses due to weevil infestation in stored maize grain | | Annual monitory loss in NRs |
|---|---|---|---|---|---|
| | | | 6% wt. loss (mt) | 12% wt. loss (mt) | |
| National production | 1,331,060 | 13,310,600 | | | |
| Hills Production (Total) | 1,038,226 | 10,382,260 | | | |
| Hills-Mid Altitude (70%) | 726,758 | 7,267,580 | 43,605 | | 436,050,000 |
| Hills-Low Altitude (30%) | 311,468 | 3,114,680 | | 37,376 | 373,760,000 |
| Total for Hills | 1,038,226 | 10,382,260 | | | |
| Total weight loss = 80,981 mt; Total value = NRs. 809,810,000 | | | | | |

(Source: Production data taken from statistical information on Nepalese Agriculture 1983,1994-95, HMG/MOA Agriculture Statistical Division, Kathmandu, Nepal).

The application of the results of this research will allow farmers in the mid and low altitude areas of the hills to reduce weevil infestations and thereby grain weight losses from the levels indicated above to 0.68% and 1.28%, respectively. The amount of grain saved as a result of the application of *Acorus* powder will range from 43,605 m. tons in the mid hills to 37,376 m. tons in the low hills. The monitory value of this grain savings ranges is Rs 802,060,000 (Table 6).

The study clearly indicated that the technology is both appropriate and effective and will benefit maize growers in the hills of Nepal. This technology will result in the savings of large quantities of food for household consumption.

**Table 6. Annual savings of grain (weight and monetary value) with the application of *Acorus calamus***

| Production Area | Annual loss due to weevils (mt) | Grain saving due to application of *Acorus calamus* (mt) | Monetary value of grain saving (NRs.) |
|---|---|---|---|
| Hills, mid altitude | 43,605 | 43,308 | 433,080,000 |
| Hills, low altitude | 37,376 | 36,898 | 368,980,000 |
| Total grain saved = 80,206 mt; Total value of grain savings =NRs. 802,060,000 | | | |

Most of the post harvest activities including harvesting, storing and processing are done exclusively by women. Special attention needs to be given to gender issues, thus any new technology should be simple and easy for application by both males and females. A most important and useful world slogan is to minimize the use of pesticides in the agriculture field and in the store. Many of these chemicals are toxic and affect human health as well as create various types of pollution and are not friendly to the environment. The urgent need is to minimize the use of pesticides and promote the use of different locally available materials, mechanical and biological pest management practices in the field and store, which will be better for human health and will avoid environmental pollution and damage.

The results of this project will help farmers save grain and at the same time minimize the use of pesticides, which are imported from other countries. It will also give farmers access to a locally available natural resource, which will not have to be purchased using scarce cash resources. This will also encourage import substitution and save foreign exchange. It will also help increase the earning capacity of rural farm households by increasing the quality and quantity of food grain in storage. It will help increase their standard of living by allowing cash that was normally diverted to purchase additional food to be used for other productive purposes.

## CONCLUSION

*Acorus* powder was superior to the rhizome pieces to reduce weevil infestation in stored maize cobs under both mid and low altitude conditions. This experiment indicated that the *Acorus* powder treatment can minimize grain infestation not only on grains but also on cobs stored under both the *Kunio* storage system and the bucket storage system. The response of *Acorus* powder to minimize weevil infestation was similar for both white and yellow varieties of maize. This experiment indicated that *Acorus* powder simply applied at 3 layers within the *Kunio* at the rate of 30 grams per kg grains can reduce weevil infestation from 51% to 5.37% at mid altitude and from 98.7% to 10.5% at low altitude. In the bucket system, the reduction in grain infestation was from 60.3% (control) to 6.8% at mid altitude and from 100% to 14.5% at low altitude. Grain weight loss was minimized from 6.11% to 0.68% at mid altitude and from 11.8% to 1.3% at low altitude in the cobs stored in the *Kunio* system. In the bucket system, the weight loss decreased from 9.9% to 1.4% and 15.9% to 2.3% at mid and low altitude, respectively. These are all encouraging results indicating that locally available *Acorus* material has the properties to minimize weevil infestation on maize cobs.

Based on this finding, this experiment now needs to be repeated for further verification of this result before making a recommendation for *Acorus* powder as a control against weevil in stored maize at the farmers' level. This experiment was terminated within 5 months but the storage period of maize cobs usually continues for up to 9 months. Thus, while repeating this experiment next year, it will need to be conducted for at least 9 months. This will also allow for obtaining further information on the response of *Acorus* powder against weevil during this period. The cost of this method of treating maize cobs with *Acorus* in terms of labour and materials also needs to be analysed.

The dose of *Acorus* material also needs to be examined. The current dose of 30 gm/kg grain is high and may result in difficult collection and preparation of the *Acorus*. It could also result in the rapid extinction of the local resources. If further funding is available, research on identifying the minimum effective dosage level will be carried out. Likewise, the propagation of *Acorus* by farmers will also be examined as *Acorus* is also an important cash crop for other medicinal purposes.

## ACKNOWLEDGEMENTS

The author is very grateful to Dr. K. R Regmi, Chief of ARS - Pakhribas for his encouragement to carryout this project; Mr. F. E. Tollervey, former Director, PAC, for supporting the work; Mr. J. Abington, Director, HARP for and funding; Mr. P. G. Rood, Research Adviser, ARS - Pakhribas, for developing the methodology preparing final report; Mr. V. R. Duwadi, Ph D research fellow, for his suggestions on the implementation and monitoring during study; Mr. R. C. Mahato, Technician, for his assistance in data recording; Mr. D. P Dhakal, Technical Officer, for data recording; and Mr. A. S. R. .Bajracharya, Technical Officer for computer work.

Grateful thanks are also due to Dr. D. N. Sah, for his guidance. All the technical staff of Plant Protection Research Programme, ARS, Pakhribas are highly appreciated for their help during the experiment. Special thanks goes to Mr Ram B Paneru, Entomologist, Entomology Division, Khumaltar, for his guidance and support to complete this HARP pilot test experiment. I also want to

thank Mr. D. N. Manandhar, Chief, Entomology Division and Dr. S. L. Joshy, Senior Scientist, Entomology Division for their guidance and help.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# POTENTIALITY OF BEEKEEPING IN YARSHA WATERSHED

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Yarsha watershed encompasses four village development committees viz. Namdu, Gairemudi, Kabre and Mrige. The total area of the watershed is about 5338 ha and the altitude ranges between 1000 and 3000 metres above sea level (masl). The vegetation within the watershed area is highly diverse. The lower altitude area is dominated by *Shorea robusta* and *Pinus roxburghii* and the higher altitude dominated by *Quercus* species. About 50% of the total land is cultivated as Bari and Khet. The population density is 184/km$^2$. Agriculture is the main occupation of more than 84% of the people, as many as 95% of the farmers have small land holdings ranging from 0.5 to 2.0 ha each (Bhattia *et al.*, 1992).

Maize, millet, paddy, wheat and potato are the major crops and buffaloes, cattle and goats are the main livestock of this area. Agrosilvipasture is the main agroforestry system and in higher altitudes some of them adopt *bookma* system. Most of the farmers practice *in situ* manuring system and they follow traditional and indigenous farming system. The rainfall is high in higher altitude (Source-People and Resource Dynamic Project data -1997).

The population and the environment are under severe economic and ecological stress. National development strategies are therefore being reoriented with major emphasis on food, income, nutrition and ecological security, especially for the underprivileged ones. In this task People and Resource Dynamic Project (PARDYP), a watershed management research and development project, has been working in two watersheds, one in Kavrepalanchowk and the other in Dolakha district of Nepal. PARDYP has been playing an important role in that regards.

Beekeeping is a non-land based farming activity and offers specific advantages for developing sustainable agriculture. It does not compete with other farming systems for resources. It has been noted that in comparison to all other land-based activities beekeeping faces less constraints because of mountain specific features such as inaccessibility, fragility and marginality. Other characteristics such as diversity, niche and people's adaptation experiences are more conducive to beekeeping. It also helps in the conservation of forest and grassland ecosystems because honeybee renders essential ecological services such as cross-pollination and propagation of plant species thereby maintaining biological diversity (Verma, 1992).

Beekeeping is an important income generating source in the hills and mountain areas for small and marginal farmers, landless labourers and other weaker section of the society living under subsistence level. The product of beekeeping such as honey, beeswax, royal jelly and pollen provide both nutritious food and cash income. Beekeeping creates off-farm employment and diversifies the economy. It does not require high investment, and inputs require for beekeeping are mostly simple and locally available. Honeybees also play an important role to increase productivity of agricultural, horticultural and fodder crops through cross pollination.

There are at present two species of honeybee being kept by the farmers in Yarsha watershed areas. Among these most of the farmers are keeping *Apis cerana* and one farmers has *Apis mellifera*. *A. cerana* has many valuable characteristics of biological and economic importance. Verma (1990) reported that these are less prone to attacks of wasps and has high level of resistance to nosema

diseases and the parasitic Asian mites. This species can exist with other native bee species and requires little chemical treatment of colonies to control epidemics. Moreover, this bee species is an excellent crop pollinator. The recent reports by Pratap and Pratap (1997) show that the mountain races of this bee are highly cold resistant and resemble *A. mellifera* in behaviour and productivity. However, this native bee species has not yet become popular amongst beekeepers because of several behavioural characteristics. These include the frequent swarming and absconding tendency to rob, production of large number of laying workers and lower honey yields. These negative traits show eco-geographical variations depending upon the sub species/geographic eco-type and management efficiency of the beekeepers.

Survey results of 1998 show that more than 16 farmers are involved in beekeeping. The total hive observed in survey were 97, including 31 local. There are more in numbers, which could not include in this survey. Total honey yield estimated from survey was 3791 manas (approx.1.75 manas=1 litre ) (Table 1). The yield per one household ranged from 12 manas to 3200 manas.

**Table 1. Beekeeper farmers at Yarsha shed and rough estimate of honey yield**

| Farmer's Name | Address | No. of improved hives | No. of local hives | Total hives | Yield * (mana) | Rate/ mana (Rs.) | Gross earning | Harvesting times |
|---|---|---|---|---|---|---|---|---|
| Gopal Dahal | Mirge-9 | 2 | 16 | 18 | 288 | 70 | 20160 | 2 |
| Rine Sherpa | Mirge-9 | 9 | | 9 | 90 | 70 | 6300 | 2 |
| Datemba Sherpa | Mirge-9 | - | 4 | 4 | 48 | 70 | 3360 | 2 |
| Min Bdr. Dahal | Mirge-9 | - | 2 | 2 | 20 | 70 | 1400 | 2 |
| Ram Kaji Dahal | Mirge-7 | 3 | - | 3 | 30 | 70 | 2100 | 2 |
| Punya Pd. Dahal | Mirge-7 | 2 | - | 2 | 22 | 70 | 1540 | 2 |
| Krishna Pd. Dahal | Mirge-7 | 1 | - | 1 | 12 | 70 | 840 | 2 |
| Harka Man Tamang | Mirage-2 | 2 | - | 2 | 20 | 70 | 1400 | 2 |
| Tara Kumar Pakhrin | Mirge-2 | 2 | - | 2 | 21 | 70 | 1470 | 2 |
| Prem Kumar Pakhrin | Mirge-2 | - | 2 | 2 | 20 | 70 | 1400 | 2 |
| Samer Bdr. Tamang | Mirge-1 | 45 | - | 45 | 3200 | 70 | 224000 | 2 |
| Jaya Prasad Dhungel | Namdu-3 | - | 7 | 7 | 20 | 70 | 1400 | 2 |

* Approximatey 1.75 manas = 1 litre

**Beekeeping for sustainable mountain crop productivity and honeybee forage**

In order to achieve food self-sufficiency in mountain areas it is important to shift towards a biologically-based agriculture, which includes increased photosynthetic efficiency, biological nitrogen fixation, efficient nutrient uptake and biological cross pollination instead of making substantial use of chemical fertilizers, biocides, irrigation facilities and heavy machinery (Verma, 1992).

Honeybees play an important role in enhancing the productivity level of mountain crops such as temperate fruits, vegetables, oils, fodder and spice seeds. It has been proved that cross pollination of entomophilous crops by honeybee is one of the most effective and cheapest methods of increasing yield and improving the quality of seed and fruit produced (Verma,1992; Pratap, 1992)

There are 12 registered community forest user groups in the Yarsha watershed. Total area covered by community forest is 1681 ha which is about 32% of the total watershed area (5338 ha). This community forest user group programme included planting of several multipurpose plant species, including bee forage plants. Since the agro-climatic conditions of the area vary from mid hills to high hills there is potential of migrating bee colonies from one location to another in order to exploit the floral resources in different agro-climatic zones.

From preliminary survey and informal discussion with farmers different types of bee flora were observed in Yarsha watershed. The watershed has very rich and diverse bee flora such as vegetable crops, temperate fruits, agricultural crops, grasses, shrubs, bushes, forest and avenue trees (Table 2).

Among the cultivated crops, *Litchi chinensis, Psidium guajava, Citrus* spp., *Mangifera indica, Carica papaya,* various cucurbits and *Brassica* species of vegetables, *Raphanus sativus, Daucus carota, Allium cepa, Zea mays, Fagopyrun esculentum, Pyrus* spp., *Lycopersicon esculentum, Solanum melongena* are important sources of both pollen and nectar.

Table 2. Bee forage calender for Yarsha watershed

| English/Local name | Botanical name | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Banana | *Musa sapientum* | | | | | | | | • | | | | |
| Citrus | *Citrus sinensis* | | | • | | | | | | | | | |
| Guava | *Psidium guajava* | | | • | | | | | | | | | |
| Mango | *Mangifera indica* | | | • | | | | | | | | | |
| Lemon | *Citrus aurantifolia* | | | • | | | | | | | | | |
| Pear | *Pyrus communis* | | | • | | | | | | | | | |
| Peach | *Prunus persica* | | | • | | | | | | | | | |
| Plum | *Prunus domestica* | | | • | | | | | | | | | |
| Wild pear | *Pyrus pashia* | | | • | | | | | | | | | |
| Wild rose | *Rosa brunonii* | | | • | | | | | | | | | |
| White clover | *Trifolium repens* | | • | • | | | | | | | | | |
| Rhododendron | *Rhododendron arboreum* | | | • | | | | | | | | | |
| Litchi | *Litchi chinensis* | | | • | | | | | | | | | |
| Thakal | *Cirsium wallichii* | | | | | • | | | | | | | |
| Jamane | *Mahonia acanthifolia* | | | | | • | | | | | | | |
| Kaphal | *Eriobotrya elliptica* | | | | • | | | | | | | | |
| Sal | *Shorea robusta* | | • | | • | | | | | | | | |
| Lady's finger | *Abelmoschus esculentus* | | | | • | | | | | | | | |
| Pyauli | *Reinwardtia indica* | | | | • | | | | | | | | |
| Banmara | *Eupatorium glandulosum* | | | | • | | | | | | | | |
| Chutro | *Berberis asiatica* | | | | • | • | | | | | | | |
| Ghangharu | *Pyracantha crenulata* | | | | | • | | | | | | | |
| Hade bayer | *Zizyphus mauritiana* | | | | | • | | | | | | | |
| Painyu | *Prunus cerasoides* | | | | | | | | | • | • | | |
| Bohari | | | | | • | | | | | | | | |
| Bakaino | *Melia azadirachta* | | | | • | | | | | | | | |
| Lankuri | *Fraxinus* sp. | | | | • | | | | | | | | |
| Pummelo | *Citrus grandis* | | | | • | | | | | | | | |
| Mauwa | | | | | • | | | | | | | | |
| Aankha Tarul | | | | | • | | | | | | | | |
| Kainyo | *Callistemon lanceolatus* | | | | • | | | | | | | | |
| Kali Aangeri | | | | | • | | | | | | | | |
| Chilaune | *Schima wallichii* | | | | • | | | | | | | | |
| Ipilipil | | | | | • | | | | | | | | |
| Kag Bhala | | | | | • | | | | | | | | |
| Aangeri | | | | | • | | | | | | | | |
| Pandel | | | | | • | | | | | | | | |
| Timur | | | | | • | | | | | | | | |
| Golthe Jamun | | | | | • | | | | | | | | |
| Jambu | | | | | • | | | | | | | | |
| Phadin | | | | | | | | | | | | | |
| Singhaball | | | | | • | | | | | | | | |
| Lapsi | *Choerospondias axillaris* | | | | | | | | • | • | | | |
| Bhimsen Pati | | | • | | | | | | | | | | |
| Rudilo | | | • | | | | | | | | | | |
| Pouwale | | | | | | | | | | • | • | | |
| Mirre grass | | | | | | | | | | | • | | |
| Sunhemp | *Crotalaria* sp. | | | | | | | | | • | • | | |
| Bamboo | | | | | • | | | | | | | | |
| Aainselu | | | | • | | | | | | | | | |

### Women and beekeeping

Women are the most neglected and under privileged group in rural communities. At Yarsha watershed an attempt is being made to uplift the social and economic status of women by involving fund raising activities through co-operatives. Beekeeping can be one of the income generating activities, which can help to raise the socio-economic status of rural women. Beekeeping work is not heavy and women can easily perform all the hive management operations. It provides flexibility in terms of time, gainful employment close to home, nutritional benefits for children and financial independence for housewives.

## CONCLUSION

Beekeeping in Yarsha watershed has increased in the last few years and is now established as a source of income. *Apis cerana*, a local bee species suitable to the area, will become the favoured species for small scale beekeeping in Yarsha watershed where a low capital investment is important. The initial investment in this enterprise is very low as compared to any other productive activity. Beekeeping can support the emphasis of HMG/N to alleviate poverty in the ninth five year plan with little support or subsidy in the initial years. Beekeeping can be a useful activity/occupation for the landless and poor households. It has a good scope in the Yarsha areas where forage for the bees is available.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# REPRODUCTIVE BIOLOGY, EFFECT OF DIETS ON GROWTH AND RELATION BETWEEN DRY WEIGHT OF EYE LENS AND AGE OF HOUSE RAT (*Rattus rattus*) UNDER LABORATORY CONDITIONS

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## ABSTARCT

Reproductive biology of house rat (*Rattus rattus*) was studied under laboratory conditions at Khumaltar during 1995-97. Successful mating was found up to 90, 80, 90 and 70% in spring, summer, autumn and winter season, respectively. Gestation period was 20-23 days with the birth rate of 4–13 and sex ratio of 1:1. Male rat became sexually matured 11 weeks after birth while it took 13 weeks for female rat. Among tested diets continuous feeding of rat with K-diet-1+cod liver oil up to 55 weeks was found superior to increase body weight. The relation of dry weight of eye lens was found directly proportional to the age of the rats.

## INTRODUCTION

House rat (*Rattus rattus*) is the most important pest in farm house and crop field. This species is widely distributed in Nepal. It is nocturnal and fossorial in habit. House rat is prolific in nature and it is estimated that one pair of rats is capable of reporducing more than 2000 off-spring in a year (Mechan, 1984). The rat lives for 2-3 years; oestrous cycle 3-7 days; actual heat period 24 hours; promiscuous mating habit; gestation period 20-23 days; post partum heat 4-96 hours; sometimes super-foetation occurs. Female rat becomes reproductively matured at 11-13 weeks of age. They come into oestrous immediately after giving birth and may become pregnant again within 2 days of delivering their litter. A female rat generally produces 4-13 litters at a time. However, such data are not available in the Nepalese context.

The objectives of the present studies were to find out breeding nature with some reproduction biology, effect of diet on growth rate, and relation between dry weight of eye lens and age of house rat.

## MATERIALS AND METHODS

### Reproduction and growth

House rat (*Rattus rattus*) trapped from farm house by live wire traps were reared in a cage (one rat per cage) in the laboratory for 25 days. The reason to keep them for a period of 25 days was to determine whether they were already pregnant from the field or not. This way unpregnant female rats were separated and kept in a special mating cage with a matured male for 10 days. Pregnancy of each female rat was checked by pressing the abdominal cavity by thumb (palpation). Those, which were not pregnant in 10 days, were kept again with another matured male for the same period. Those female rats, which did not become pregnant this time, were discarded. After checking the pregnancy, each pregnant female was separated from the male and reared in a cage until parturition. The newly

born young rats were reared together with mother rat up to 28 days. Then young rats were separated from the mother rat and reared in pair (1:1) of male and female or single or mass in the same litter. Male and female rats were killed with carbon tetrachloride in every week of age and examined reproductive organs to determine whether they were sexually matured or not.

**Effect of different diets on growth**

Three different kinds of diets such as K diet 1, K diet 1+Cod lover oil, and K diet 2 were used for this study. The composition of the diets is given in Table 1. Feeding of both male and female rats with the above diets started when the rats were 4 weeks old and it was continued up to 55 weeks old. Body weight was taken every week.

**Relationship between dry weight of eye lens and age**

Rats of known age were killed with carbon tetrachloride and removed the eye balls within 24 hours. The removed eye balls were kept in 10% formalin solution for a month at room temperature. Then after eye balls were washed in distilled water and extracted eye lens. The eye lens were placed in a filter paper to remove excess water, packed in a piece of paper with proper labelling and dried in an oven at 80°C for 48 hours. After that weight of the eye lens was taken using an electronic balance.

**Table 1. Composition of diet for the rearing of house rat *Rattus rattus***

| Ingredients | Composition of diet % | | |
|---|---|---|---|
| | K diet 1 | K diet 1+ Cod liver oil | K diet 2 |
| Whole wheat meal | 52.2 | 46.4 | 52.0 |
| Ground gram | 27.9 | 24.8 | 27.1 |
| Skimmed milk | 9.0 | 8.0 | 9.0 |
| Sodium chloride | 0.9 | 0.8 | 0.9 |
| Cod-liver oil | - | - | 1.0 |
| Chicken feed | 10.0 | 20.0 | 10.0 |
| Total | 100.0 | 100.0 | 100.0 |

## RESULTS AND DISCUSSION

**Reproduction and growth**

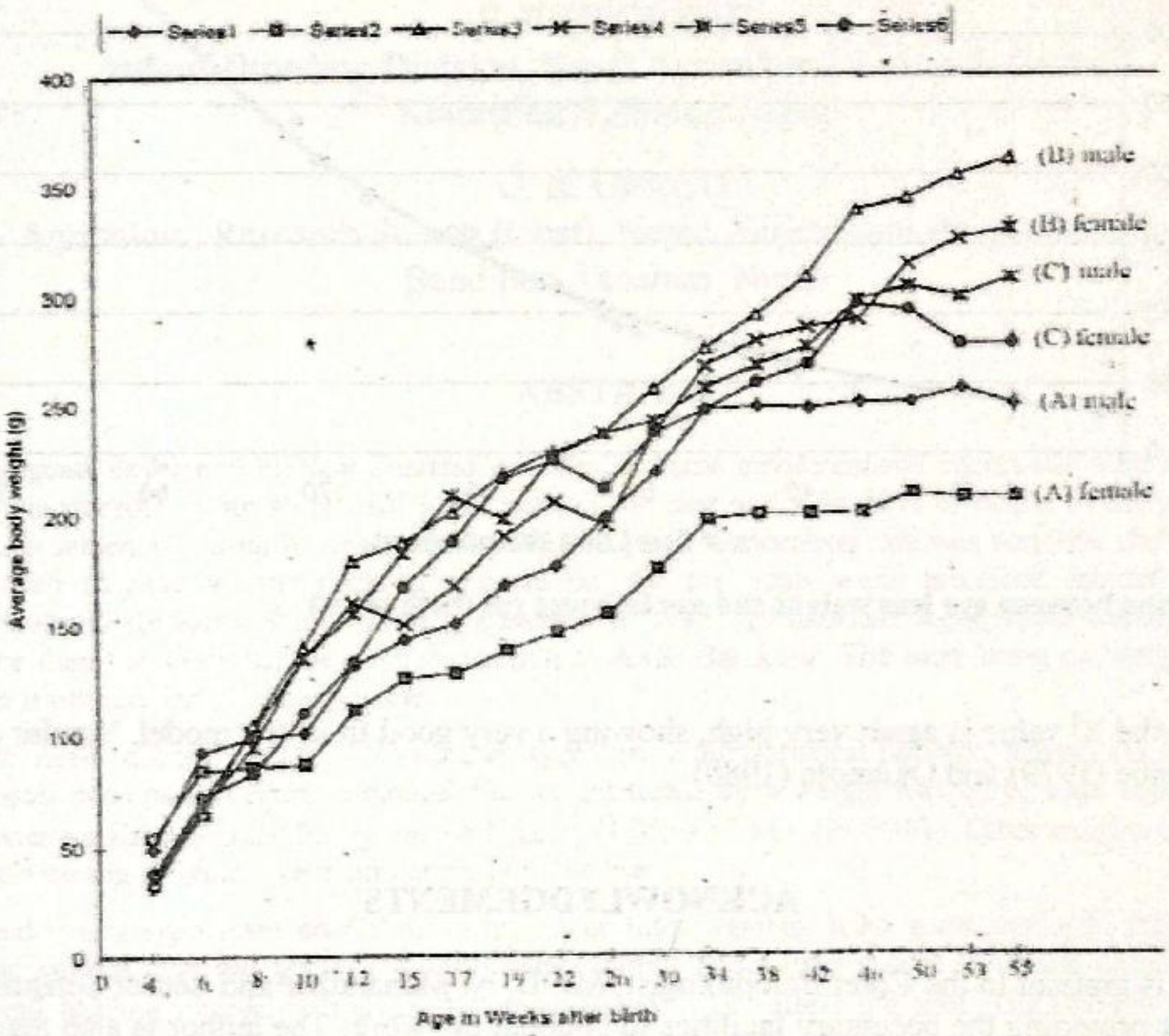
The sucessful mating was 90% in spring, 80% in summer, 90% in autumn and 70% in winter (Table 2). The mother rat gave birth 20-23 days after mating. One mother rat produced 4-13 litters at a time with a ratio of 1:1 (male and female). One-day-old young rat attained the body weight of 5-7 gram. The young rat after 8-12 days of birth were found fully hairy and eyes opened. The increase in body weight of male and female rats was found almost same up to 7 weeks. After that the male gained more body weight than the female ones. Male rats became sexually matured after 11 weeks while for female it took 13 weeks.

**Table 2. Percent of successful mating at different season**

| Season | No. of pair rats kept in mating cages | Successful mating | Successful mating percentage |
|---|---|---|---|
| Spring | 21 | 19 | 90 |
| Summer | 21 | 17 | 80 |
| Autumn | 21 | 19 | 90 |
| Winter | 21 | 15 | 70 |

**Effects of different of diets on body growth**

The effect of three kinds of diet on growth rate in house rat is shown in Fig. 1. Of the three diets tested K diet 1+Cod-liver oil followed by K diet 2 was found superior in increasing body weight of both male and female rats. The effect of K diet 1 was least effective. The increased growth rate was observed up to the age of 34 week with all three diets, up to 46 week with K diet 1 + cod liver oil and K diet 2, and up to 55 week with K diet 1+ cod liver oil. Since cod liver oil is expensive K diet 2 was used for rearing house rats.




(A) K diet 1, (B) K diet 1 + Cod-liver oil, (C) K diet 2
(A) male + female, (B) male + female (C) male + female

**Fig.1. Effect of different diet composition on the growth curve in laboratory rearing house rats *Rattus rattus***

**Relationship between dry weight of eye lens and age**

Exponential growth functions were fitted for the age of rats against eye lens weight (as X- variable). The estimated equation for both the sexes are as follows:

Female age = 12.2 $e^{0.04\ eye}$ ($R^2$=0.98)
Male age = 12.8 $e^{0.04\ eye}$ ($R^2$=0.99)

The coefficient of determination (R-squared values) shows high degree of fits of the models. However, the differences between the two sexes were not statistically significant. Therefore, a pooled analysis for both the sexes was carried out and found as follows:

Both sexes age = 12.6 $e^{0.04\ eye}$ ($R^2$=0.98) (Fig. 2).

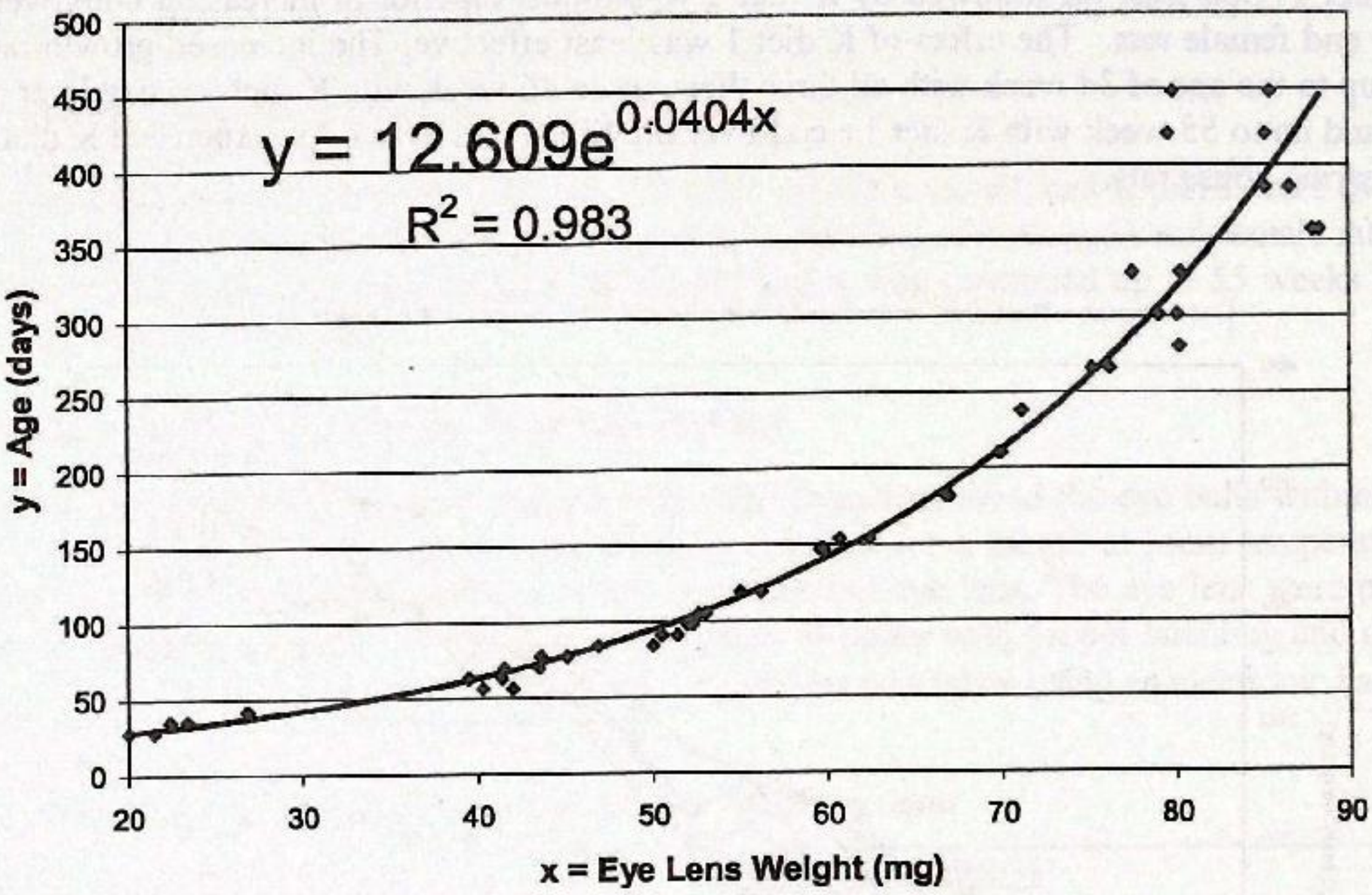



**Fig. 2. Relation between eye lens weight and age in house rat (both sexes)**

Expectedly the $R^2$ value is again very high, showing a very good fit of the model. Similar results were found by Yobe (1979) and Okamoto (1980).

## ACKNOWLEDGEMENTS

The author is grateful to the Chief Entomologist, Mr. D. N. Manandhar and Senior Scientist Mr. B. K. Gyawali for providing the necessary facilities to conduct the work. The author is also thankful to Mr. P. Teli and Mr. S. M. Guvaju for their technical Assistance. Sincere thanks are due to Mr. A. R. Sthapit for computer setting and typing.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# COMPARATIVE PERFORMANCES OF HILL GOAT AND ITS CROSSBREED WITH KIKO GOATS

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## ABSTRACT

Kiko goats developed in New Zealand suitable for harsh environmental conditions were imported for crossbreeding with Khari/Hill goats both in the east and west hills of Nepal in early 1990's. Frozen semen was used for inseminating the hill goats. Conception rate was very low and hence it was felt to have all the goats at one station. All the goats were, therefore, handed over to Agricultural Research Station (Goat), Bandipur in 1993 by Pakhribas Agricultural Centre (PAC). Since then the study has been implementing at ARS, Bandipur. The monitoring on weight traits, litter traits and dam traits was made.

Data obtained from 1990 to 1997 were analyzed using the statistical package, Harvey (1990) based on least squares procedure. Amongst the weight traits, birth weight was only found significantly heavier for Kiko (2.09±0.03 kg) than hill goats (1.65±0.57 kg) ($P<0.001$). Other weights (pre- and post-weaning weights ) were similar for both the breeds.

Breed was a significant source of variation for litter weights. Kiko goats produced the heavier litter weights than hill goats ($P<0.001$). Breed didn't affect litter size at birth and weaning. The overall kidding interval was 312±11.4 days. Breed didn't affect the trait. The overall gestation length was found well within a range (146.5±0.35 days) reported in the literature.

The results revealed that Kiko goat was similar with hill goats, so far in weight traits and some of the reproductive traits (litter size) are concerned. They were better than the hill goats in terms of litter weights. This indicated that Kiko dams have better maternal ability. Unlike the previous studies where Khari/Hill goats were crossed with Indian Breeds (Jamunapari, Beetal and Barbari), the results of this study was encouraging as the productivity level of Kiko was similar or better than hill goats in the hills of Nepal. However, its cost effectiveness over the local breed (as it requires a lot of investment in importing exotic breeds in the country) should not be ignored while recommending the breed for its suitability.

## INTRODUCTION

Goats are one of the most economic livestock species in the hills of Nepal. They have very important role to play in hill farming system. They are one of the important sources of cash income for the farmers in the hills. They rank second next to buffaloes for income generation in the eastern hills (Gatenby *et al.*, 1990). They are mainly kept for cash, meat and manure. Hill/Khari goats located in the low and mid hills are one of the principal breeds of goats in the country. They are prolific and have a kidding interval substantially shorter than one year (Oli, 1987; Neopane, 1997). However, they have lower finish weight as compared to other exotic breeds, including the Indian breeds. The improvement in weight can be made either by selecting within the breed or crossbreeding local goats with improved breeds of larger body size.

Goats of Indian origin (Jamunapari, Beetal and Barbari), which have been distributed in Nepal over the past decades, have not proven to be superior to the local goats under hill conditions (Oli 1987; Neopane, 1997).

Kiko goats which were developed by crossing selected goats from the large feral goat population in New Zealand with dairy breeds (Anglo Nubian, British Saanen, and British Togenburg) have good growth rate, high twinning rate and perform well on hill pasture with minimum supplementation (Batten, 1987). The purpose of the study was to assess the performance of crossbreed goats (local with Kiko) for improving the productivity (improve growth rate and finish weight while maintaining the prolificacy of local goats).

## MATERIALS AND METHODS

Frozen semen of Kiko goats from two sire lines (Samuel and Shebang) were imported from New Zealand in collaboration with Koshi Hill Livestock Development Project (KHLDP) and Nepal Agricultural Research Council (NARC) in 1989 and 1990. Hill goats at Pakhribas Agriculture Center (PAC) and Agriculture Research Station (ARS, Goat), Bandipur were inseminated with frozen semen by cervical method in 1990 and 1991.

Estrous synchronization and super ovulation was done using pregnant mare serum gondotrophin (PMSG) and vaginal sponge (40 mg Flugestone Acetate) as reported earlier by Aryal *et al.*, (1992).

Few crossbreeds were produced at both places because of low conception rate. These numbers were not adequate for separate evaluation study. All the crossbreed goats were, therefore, handed over to ARS, Bandipur by PAC in 1993. Since then, the study has been implementing at ARS, Bandipur.

The animals were grazed for 5 to 6 hours on pastureland. The pasture areas consisted of local grasses, fodder trees and palatable weeds. The goats were given a small amount of concentrate ration at a rate of 250 g per head per day.

The animals were housed during the night. The male kids were separated from flock after 5 or 6 months in order to avoid unwanted mating. The kids were allowed to suckle the dams up to the age of 4 months. They were then weaned from their mothers.

The animals were monitored for weights at different ages (0, 4, 6, 9, 12 months), litter traits (litter size and weights at birth and weaning, kidding interval, gestation length) and dam traits (age and weight at first service). The data were collected regularly and put onto a computer in Dbase IV. The data obtained were analyzed using the statistical package, Harvey (1990) based on least squares procedures.

## RESULTS AND DISCUSSION

### Conception

The conception rates of artificial insemination (AI) on goats were low at both the places (Table 1). The overall conception rate was 24% and the value ranged from 12 to 44%. This value is lower than the literature reported. Corteel *et al.* (1988) reported at 57 % conception rate in goats using frozen semen where semen were deposited in the cervix. Bowen (1988) reported a 56% kidding rate using cervical AI on goats.

### Weight traits

The least squares means of weight traits are presented in Table 2. The table shows that the breed had a significant effect on birth weight ($P<0.001$). Kiko crossbreed goats were heavier than the local goats at birth. Neopane and Sainju (1995) working with the same herd (including few records) also reported a significant effect of breed on birth weight.

Kiko crossbred could not however, perform better than the local in terms of weights after birth. Breed was not a significant source of variation for 4 month (weaning weight) 6 month and 12 month weight.

**Table 1. Conception rate of goats on artificial insemination in Nepal**

| Location | Insemination | | No of does | | Conception rate (%) |
|---|---|---|---|---|---|
| | Phase | Date | Inseminated | Parturated | |
| Pakhribas | I | 1990 | 26 | 8 | 31 |
| | II | 1991 | 42 | 8 | 19 |
| Bandipur | I | 1990 | 17 | 7 | 44 |
| | II | 1991 | 24 | 3 | 12 |

**Table 2. Body weights (kg) of Kiko crossbreed and Hill goats (Values are least squares means ± standard errors)**

| Traits | Kiko | N | Local | N | Overall | N | Significance |
|---|---|---|---|---|---|---|---|
| Birth weight | 2.09±0.03 | 174 | 165±0.06 | 61 | 1.87±0.03 | 235 | *** |
| Weaning weight | 9.23±0.24 | 126 | 8.49±0.34 | 61 | 8.86±0.21 | 187 | NS |
| 6 month weight | 10.9±0.33 | 88 | 10.5±0.39 | 61 | 10.7±0.25 | 149 | NS |
| 12 month weight | 17.5±0.54 | 63 | 17.3±0.55 | 61 | 17.4±0.39 | 124 | NS |

N = Number of goats

## Reproductive traits

Reproductive traits are presented in Table 3. The table shows that breed had a significant effect on litter weights at birth and weaning ($P<0.01$) but non-significant for litter size at birth and weaning. This was similar to earlier report where Neopane and Sainju (1995) reported that Kiko dams yielded 21 percent higher litter weight than the local dams at weaning. Litter weight at weaning is a dam trait, which reflects the maternal ability of the dam. The results suggested that Kiko dams have better maternal ability than the local goats.

The kidding interval was longer in Kiko than local but the difference was not significant. The overall kidding interval (312 days) was shorter than one year. Although the gestation length was significantly longer in Kiko than the local, the overall value (146 days) was well within the range reported by Devendra and McLeroy (1982) from extensive review of the literature.

Breed did not affect the age at first service. The overall value was 474 days (longer than one year). The value for local goat (459 days) was longer than the value (374 days) reported by Neopane (1997) for local Hill goats. Breed was a significant source of variation for weight at first service. Kiko crossbreed goats were heavier than the local at the age of first service. This can be explained by the fact that Kiko crossbreed attained the age a month later than the local.

**Table 3. Litter and reproductive traits of Kiko crossbreed and Hill goats (Values are least squares Mean±Standard Errors)**

| Traits | Kiko crossbreed | N | Local | N | Overall | N | Significance |
|---|---|---|---|---|---|---|---|
| Litter size at birth (nos.) | 1.42±0.05 | 128 | 1.52±0.06 | 68 | 1.47±0.04 | 196 | NS |
| Litter weight at birth (kg) | 3.05±0.09 | 128 | 2.67±0.11 | 68 | 2.86±0.07 | 196 | ** |
| Litter size at weaning (nos.) | 1.26±0.05 | 91 | 1.38±0.06 | 61 | 1.32±0.04 | 152 | NS |
| Litter weight at weaning (kg) | 11.7±0.41 | 88 | 9.64±0.49 | 61 | 10.7±0.33 | 149 | ** |
| Kidding interval (days) | 325.2±13.0 | 88 | 299.3±16.1 | 54 | 312.3±11.4 | 142 | NS |
| Gestation length (days) | 148.4±0.041 | 127 | 144.8±0.52 | 67 | 146.5±0.35 | 194 | *** |
| Age at first service (days) | 489.1±29.8 | 38 | 459.3±36.8 | 21 | 474.2±21.9 | 59 | NS |
| Weight at first service (kg) | 18.9±0.74 | 22 | 15.6±0.78 | 20 | 17.3±0.52 | 42 | ** |

NS = Nonsignificant, ** = $P<0.01$, *** = $P<0.001$

## CONCLUSION

The results revealed that Kiko goat was similar with Hill goats in terms of weight traits and some of the reproductive traits (litter size). They were better than the Hill goats in terms of litter weights. This indicated that Kiko dams have better maternal ability. Unlike the previous studies where Khari/Hill goats were crossed with Indian breeds (Jamunapari, Beetal and Barbari), the results of this study was encouraging as the productivity level of Kiko was similar or a better than Hill goats in some respects. The Kiko as a new and exotic breed showed some potential for goat production in the hills of Nepal. However, its cost effectiveness over the local breed (as it requires a lot of investment in importing exotic breeds in the country) should not be ignored while recommending the breed for its suitability.

## ACKNOWLEDGEMENTS

We are thankful to Messrs. G.R. Khakurel and R. Khanal from ARS, Bandipur and Mr. R. B. Magar from ARS, Pakharibas, Dhankuta for their input in the study.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# BUNNIES PRODUCTION AND KINDLING MORTALITY OF DIFFERENT STRAINS OF ANGORA RABBIT

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## ABSTRACT

A study was conducted on British, German, Chinese and Russian Angora rabbits on kindling mortality at Swine and Avian Research Program, Khumaltar. The results showed that British, Chinese, German and Russian Angora rabbit weaned 4.85±1.35, 4.77±1.31, 3.61±1.96 and 3.25±2.5, respectively. Similarly, the mortality rates of the bunnies were found 24.4%, 23.2%, 29.0% and 35% for British, Chinese, German and Russian Angora rabbit, respectively. The overall mortality in the flock was 27%.

## INTRODUCTION

Angora rabbit, a microlivestock is gaining popularity among the farmers for wool production purpose in the hills and mid-hills of Nepal. The hills and mid-hills of the country are rich in natural vegetation, which is a source of dietary feed to this animal. At present, there are nearly 32000 Angora rabbits of different strains farmed across the country for wool production purpose. Due to the small size of Angora population and the new species of animal to the farmers, its contribution to the agriculture GDP has not been accounted.significantly in the country. This can probably be the reason that the planner, government authority and the farmers also have not given a proper and due consideration to the rabbit farming to improve the farming economy in the community.

Kindling management and its effect on mortality is one of the important aspects, which determines the prospect of Angora rabbit rearing. Mismanagement of this animal at kindling stage and in general is a major problem in the rabbitary for their mortality. The mismanagement includes hypothermia, inadequacy of milk supply, bad mother and presence of aliens and vermins. Besides, ignorance in the proper breeding management, poor level of nutrition, bad housing and the physical bruising also contribute to increase the kindling mortality.

## MATERIALS AND METHODS

Angora Rabbit Unit was established at Swine and Avian Research Program in the fiscal year 2051/52 BS. Since then, the unit has been rearing German, British, Russian and Chinese Angora rabbit for research purpose. These rabbits were kept in bamboo and steel hutches. They were fed with the grass available around the farm and water was provided ad-libitum. Also, pellet concentrate from the Cattle Feed Plant, Hetauda was given as per the standard recommendation. Wool was shorn manually with the help of simple scissors four times a year. The rabbits were medicated as per need. Data on breeding, kindling, medication, feeding and the mortality were recorded.

## RESULTS AND DISCUSSION

Table 1 presents the results so far obtained at the Angora Rabbit Unit of SARP, Khumaltar. Of the four strains of Angora rabbits investigated, German strain gave the highest bunnies production (70) followed by Chinese (56), British (45) and Russian (20). Also, the litter size of Russian Angora was smaller than of the other three strains. The litter sizes of British, Chinese and German Angora were more or less same.

**Table 1. Bunnies production, litter size, weaning size and their mortality of different strains of Angora rabbit**

| Strains | Rabbit (N) | Total | Total died | Litter size | Weaning size | Mortality |
|---|---|---|---|---|---|---|
| British | 4 | 45 | 11 | 6.42±1.61 | 4.85±1.35 | 24.4 |
| Chinese | 7 | 56 | 13 | 6.22±1.39 | 4.77±1.31 | 23.20 |
| German | 8 | 70 | 20 | 6.36±3.10 | 3.63±1.96 | 29.0 |
| Russian | 2 | 20 | 7 | 5±1.41 | 3.25±2.5 | 35 |
| Grand Total | 21 | 191 | 51 | | | 27 |

The mortality of bunnies recorded ranged from 23% in Chinese strain to 35% in Russian strain. The overall mortality was 27%. In a similar study conducted at Pakhribas Agricultural Centre (PAC), Dhankuta, Neopane *et al.* (1995) found the highest mortality rate (33%) in German Angora followed by British (22%), and Russian Angora (26%) with an overall mortality of 27%. Another study by Neopane (1998) at PAC reported that the mortality percent was 64, 50 and 65 for British, German and Russian Angora, respectively. The author reported that of the total mortality, 52% was due to mismanagement (inadequacy of milk, bad housing, hypothermia, bad mother and intruders) and 8% was due to various diseases.

In general, Angora rabbits are easy to manage and do not suffer from serious diseases if their minimum requirements like feeding, housing and sanitation are adequately provided. Panday and Dhubhadel (1996) reported that the mortality rate should not exceed 10% for the economical farming of Angora rabbit for wool production purpose.

## CONCLUSION

The Angora rabbit is popular among the farmers in hills and mid-hills for a small-scale farming. The farming is effective in low input management system. Kindling mortality is a major constraint to increase the population size for higher wool production purpose. Poor management practices are responsible for higher mortality rate.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# EVALUATION OF GENETIC RESISTANCE IN THREE NATIVE SHEEP BREEDS OF NEPAL AGAINST *HAEMONCHUS CONTORTUS* INFECTION

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## ABSTRACT

The genetic resistance of three native Nepalese sheep breeds namely Kage, Baruwal and Lampuchhre was studied against *Haemonchus contortus* infection by primary and challenge infection of *H. contortus* larvae. The parasitological, hematological and biochemical responses of these breeds indicated that Kage breed was relatively superior to the Baruwal or Lampuchhre breeds against *H. contortus* infection. The Kage lambs have lower worm establishment, lower worm burden and low faecal egg counts that the other two breeds at primary and challenge infection. Similarly, these animals lost less weight to infection than the other breeds indicating their superior ability to withstand the effects of worm infection.

## INTRODUCTION

Throughout the tropics and subtropics, production losses in small ruminants due to haemonchosis are substantial. The disease is primarily controlled by the frequent and often indiscriminate application of anthelmintics. This has led in many parts of the world to the development of resistance to commonly available anthelmintics (Craig, 1993). Though considerable advance have been made towards the development of vaccine against this parasite (Munn *et al.*, 1993), none is yet available for commercial application. There is, therefore, an urgent need for alternative approaches for the control of haemonchosis that will reduce dependence on anthelmintics.

One such possibility is to exploit the genetic variability in susceptibility of different sheep breeds to the infection of this parasite, which is expressed as reduction in the rate of establishment of ingested larvae or in the survival of adult parasites and the phenomenon is generally measured by comparing faecal egg counts or worm burdens (Gruner, 1991). This phenomenon was first documented by Stewart *et al.* (1937). Since then, many breeds, for example the Red Maasai (Preston and Allonby, 1978), Scottish Blackface (Abbott *et al.*, 1985), have been recognised as possessing superior resistance to *H. contortus* infection. Similarly, resistant individuals within a breed have been identified and resistant lines have been established by selective breeding (Gray, 1987). Lambs bred for resistance to *H. contortus* were also found to exhibit a high degree of resistance against *T. colubriformis* or *T. circumcincta* infection (Gray *et al.*, 1992).

*H. contortus* has been found to be one of the main worm species present in sheep and goat population of Nepal raised under the sedentary or migratory managements. Infection with this parasite has been recorded to be prevalent throughout the country at altitudes below 2300 masl (Joshi, 1995) causing considerable losses in the productivity of these animals (Joshi, 1996). In Nepal, different sheep breeds are raised in different parts of the country and information on their inherent genetic resistance

to *H. contortus* infection is not available so far. Hence, this study was undertaken to evaluate the genetic resistance of three native sheep breeds against *H. contortus* infection, which would be of considerable value to develop worm control program for endemic *H. contortus* infection areas.

## MATERIALS AND METHODS

### Animals and their management

Three native sheep breeds, namely Kage, Baruwal and Lampuchhre were included in this study. These breeds are reared in different eco-zones of the country under different management systems. Baruwal and Lampuchhre are the predominant sheep breeds reared under migratory management system in the high mountainous areas and Terai, respectively. Kage animals are found in the lower hill areas and managed under sedentary management (LMP, 1993).

Nineteen pure bred male Kage lambs of 2-3 months of age were purchased from a government farm and from individual farmers in the remote village of Syangja and Parbat districts. Similarly, seventeen 4-5 months old male Baruwal lambs were purchased from various migratory flocks of Ghandruk village and nine 7-8 months old Lampuchhre lambs were procured from the flock of the Terai region. The animals were brought to Lumle Agricultural Research Centre (LARC now Agriculture Research Station, Lumle) and treated with fenbendazole (Pancur:Hoechst) at double the recommended dose-rate and reared indoors on a slatted floor under conditions that precluded nematode infection. The lambs were fed ad-libitum on tree leaves and supplemented with a cattle concentrate ration (Hetauda Feed Mill, Hetauda, Nepal) at the rate of 250 gm/day/lamb with free access to drinking water. The feed was gradually changed to a specially formulated ration (ME= 8.15 MJ/Kg DM, CP=8.92%) containing rice straw, molasses, cattle concentrate and mineral mixture (Milkmin: Sarabhai, India). Before infection, lambs were weighed at monthly intervals and faecal examination carried out at 15 day intervals.

### Infective larvae

Infective larvae were obtained by culturing the faeces of donor lambs infected mono-specifically with a local strain of *H. contortus*. Larvae were harvested within a week of use and stored at 4°C. They were kept at room temperature for 18 hours before use.

### Experimental design

At the beginning of the experiment, lambs were 11 to 14 months of age and had been reared indoors under helminth free conditions for a period of 9 months. Lambs were weighed, ear tagged and randomly allocated to either infected, control or challenge control groups. The experimental design is shown in Table 1 and the number of animals used in each breed in different groups is given in Table 2.

**Table 1. Experimental design used for each breed**

| Days post infection | Infected group (Group 1) | Control group (Group 2) | Challenge control (Group 3) |
|---|---|---|---|
| 0 | Infected with 10,000 *Haemonchus contortus* L3 | - | - |
| 21 | PM | - | - |
| 63 | FBZ | FBZ | FBZ |
| 70 | Challenged with 10,000 *H. contortus* L3 | - | Challenged with 10,000 *H. contortus* L3 |
| 91/92 | PM | PM | PM |

(PM = Post-mortem, FBZ = Fenbendazole @ 10 mg/kg body weight)

At day 0, each lamb in group one was given 10,000 L3 by mouth. Larvae were washed down the throat by one or two squirts of water from the same syringe. At 21 days post infection, the worm establishment from the primary infection was determined by slaughtering a subset of lambs in each infected group as shown in Tables 1 and 2. On day 63, all infected and control lambs were treated with fenbendazole at 10 mg/kg body weight and on day 70, all previously infected lambs and challenge control group in each breed were given a challenge infection of 10,000 *H. contortus* larvae. All lambs in the infected and challenge control groups were slaughtered on day 91 and day 92.

**Table 2. Number of animals in each group**

| Breeds | Total number of animals | Group-1 infected | | Group-2 control | Group-3 Challenge control |
|---|---|---|---|---|---|
| | | Infected | Slaughtered at 21 dpi* | | |
| Kage | 19 | 10 | 3 | 5 | 4 |
| Baruwal | 17 | 9 | 3 | 5 | 3 |
| Lampuchhre | 9 | 5 | 2 | 2 | 2 |

Note: * = Animals slaughtered from infected group on 21 days post infection (dpi).

### Parasitological techniques

Faecal egg counts were carried out at weekly intervals by a modified Mcmaster method (MAFF, 1986). Additional egg counts were carried out daily from 15 days post infection (dpi) to 21 dpi following primary and challenge infection. At 90 dpi, the total faecal output over 24 hours was collected from each infected lamb using a faecal collection bag held in place by a harness. At necropsy, total worm burdens were determined by the methods as described in MAFF (1986).

Following primary infection, lambs were weighed at weekly intervals. Clinical signs were recorded and veterinary care provided as and when necessary. Blood samples were collected in EDTA and plain vacutainer tubes at weekly intervals and packed cell volume and haemoglobin concentration were determined by microhaematocrit and haemoglobin kit (Randox Laboratory Manual, 1993) methods, respectively and eosinophil percent by differential leucocyte count method.

### Analysis of results

The relative resistance of each breed to *H. contortus* infection was determined by comparing the changes in the parasitological and haematological parameters between the infected groups during primary and challenge infection periods. These parameters were also compared with the respective control groups in each breed.

Mean percent establishment was calculated as follows: number of worms recovered / number of larvae inoculate X 100; and percent protection as: 100 X 1- (number of worms recovered in previously infected lambs/ number of worms recovered in corresponding challenge control lambs). The effect of breed and infection on the arithmetic mean faecal egg counts, body weight, haematological and biochemical parameters was analysed by analysis of variance or students' test using Minitab Statistical Package (Version 8) or Graph Pad Instat (Version 2).

## RESULTS

### Clinical

From one week following the initial infection, animals showed inappetance, tenesmus, grunting, teeth grinding and diarrhea. These symptoms gradually subsided in all animals by the third week of post infection. Uninfected controls showed no clinical abnormality. On challenge infection, no such signs were recorded in previously infected or in challenge control animals.

**Body weight**

During the study period, lambs in the control groups continued to gain body weight, whereas the body weight of infected animals started to decline by 7 dpi in all breeds. Body weight in infected groups was significantly decreased when compared with their respective controls within the first three weeks. However, after 35 dpi, when the infected animals started to regain their body weight, the difference at any particular week was not significant.

Data on mean daily weight gains of infected lambs in each breed during the pre-infection (63-0 day) and primary infection period (0-63 days ) is presented in Table 3.

**Table 3. Mean daily weight gain (gm/day) during pre-infection and primary infection period in infected Kage, Baruwal and Lampuchhre lambs**

| Breeds | 63-0 dpi | 0-63 dpi |
|---|---|---|
| Kage | 23.1± 7.6 | -34.0 ±11.2 |
| Baruwal | 22.5± 13.2 | -63.5 ±6.5 |
| Lampuchhre | 18.0± 2.2 | -39.7± 0 |

During the pre-infection period, mean daily weight gains in all three breeds were similar. Following infection, lambs in all three breeds lost weight. At the end of infection period, the mean daily weight loss was the lowest in Kage lambs than the other two breeds, but the difference was not statistically significant. The mean daily weight loss trend changed from 42 dpi as the Kage lambs started to regain weight. The rate of body weight loss remained at the same level throughout the infection period in the Lampuchhre lambs but increased in the Baruwal breed in the later weeks of infection.

**Faecal egg counts**

In all breeds, the prepatent period in primary or challenge infection was 18-19 days. Following primary infection, significant breed differences were recorded in mean egg counts (Figure 1).

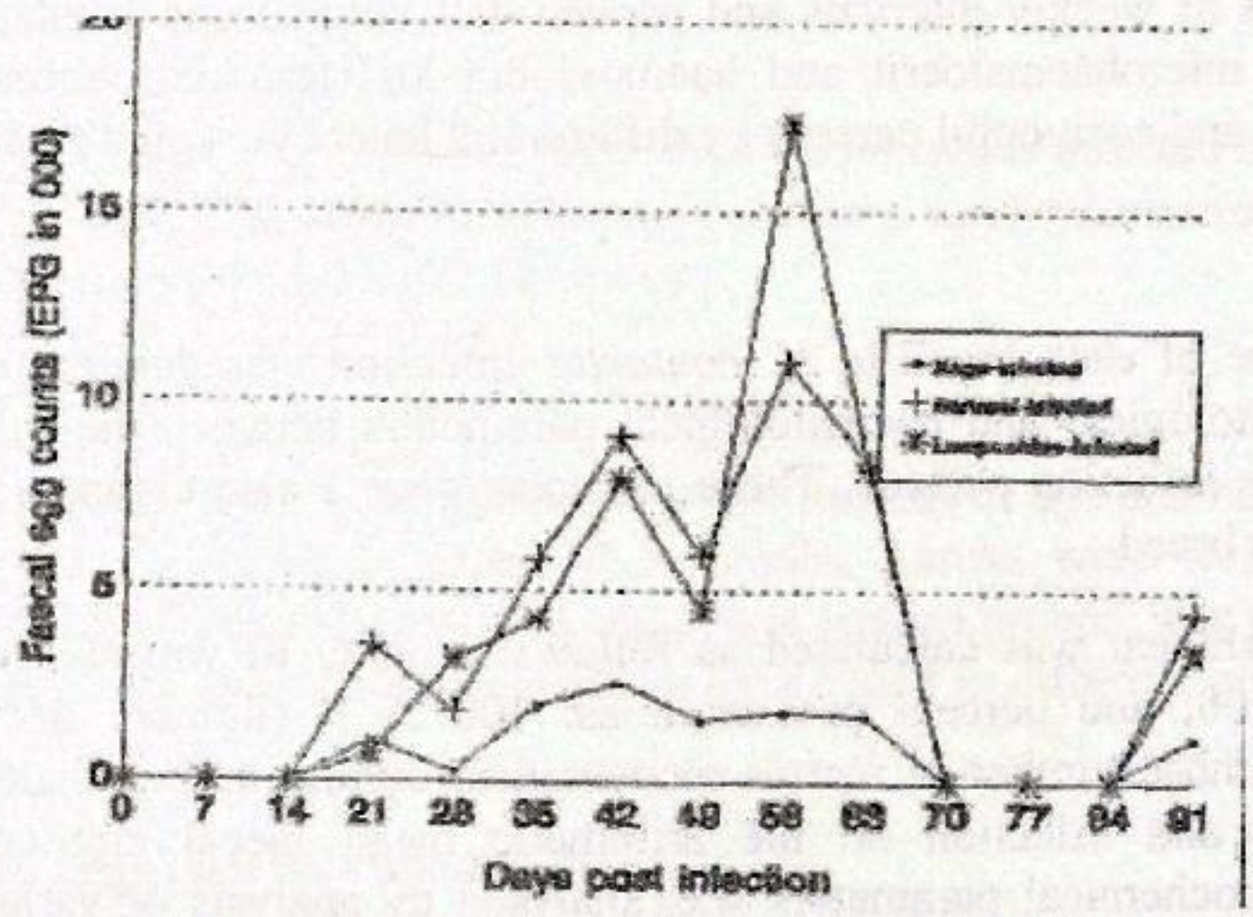


**Fig.1. Mean faecal egg counts in infected Kage, Baruwal and Lampuchhre lambs**

Mean feacal egg counts of the Kage lambs were significantly lower than those of Baruwal or Lampuchhre lambs from 42 dpi and this difference was maintained throughout the primary infection period. No differences were observed between Baruwal and Lampuchhre lambs.

Following challenge infection, the mean count of previously infected Kage lambs at 91 dpi, was lower than those of the other groups (Table 4), although this difference was not significant ($F=2.14$, $P=0.106$). Egg counts of previously infected and challenge lambs were not significantly different in any breed.

**Table 4. Mean faecal egg counts at 91 days post infection (dpi)**

| Breeds | Previously infected | Challenge control |
|---|---|---|
| Kage | 575 ±508 | 1314±584 |
| Baruwal | 4466±1589 | 7266±3997 |
| Lampuchhre | 4450±1350 | 5000±2300 |

## Worm recovery

Mean worm recovery (the establishment rate) at 21 and 91 dpi is presented in Table 5. Kage lambs had a lower worm burden than the other two breeds at day 21 and 91 dpi. These differences were not, however, statistically significant. The percentage of hypobiotic larvae at slaughter was the highest (16%) in previously infected Kage lambs and lowest (1.8%) in challenge control Baruwal lambs, but the differences between breeds or between infected and challenge control lambs within a breed were not significant.

**Table 5. Mean worm recovery in lambs slaughtered at 21 and 91 days post infection (dpi)**

| Breeds | At 21 dpi | Percent establishment | At 91 dpi | | Percent protection |
|---|---|---|---|---|---|
| | | | Previously infected | Challenge control | |
| Kage | 2830±404 | 28.3 | 2517±489 | 3560±860 | 30 |
| Baruwal | 3506±919 | 35 | 3498±196 | 3830±544 | 9 |
| Lampuchhre | 3800±140 | 38 | 3027±1076 | 5935±730 | 49 |

No significant differences were recorded between breeds or between previously infected and challenge control lambs within a breed in mean worm length, the percentage of gravid females or in the fecundity of the female worms at 21 days post challenge infection.

## Haematological values

At 21 days following primary infection, the packed cell volume (PCV) of each infected group was significantly lower ($P<0.05$) than their respective controls and this trend continued until anthelmintic treatment. Between the infected groups, the rate of decline was significantly greater in Baruwal lambs than in the other breeds. The PCVs of infected Kage and Lampuchhre lambs were similar until 56 dpi, when values in Lampuchhre lambs started to decline more rapidly. Changes in packed cell volume between infected groups are presented at Figures 2.

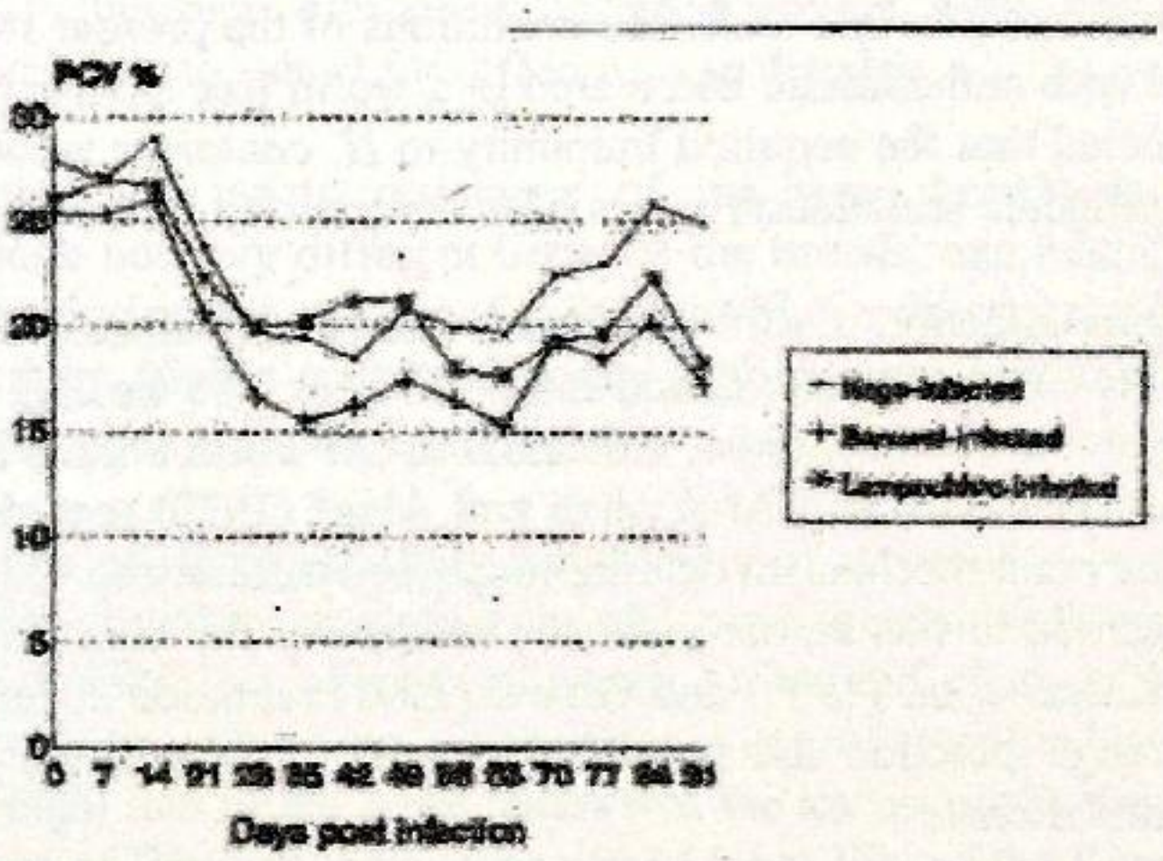


**Fig.2. Mean packed cell volume in infected Kage, Baruwal and Lampuchhre**

The changes in haemoglobin concentration followed a more or less similar pattern to those of the packed cell volumes but the decline became significant one week later. Haemoglobin values started to increase following anthelmintic treatment at 63 dpi but declined again following challenge infection.

A significant ($P<0.05$) increase in eosinophil (most marked in infected Kage lambs) was recorded in infected lambs of all three breeds from 14 dpi (Figure 3).

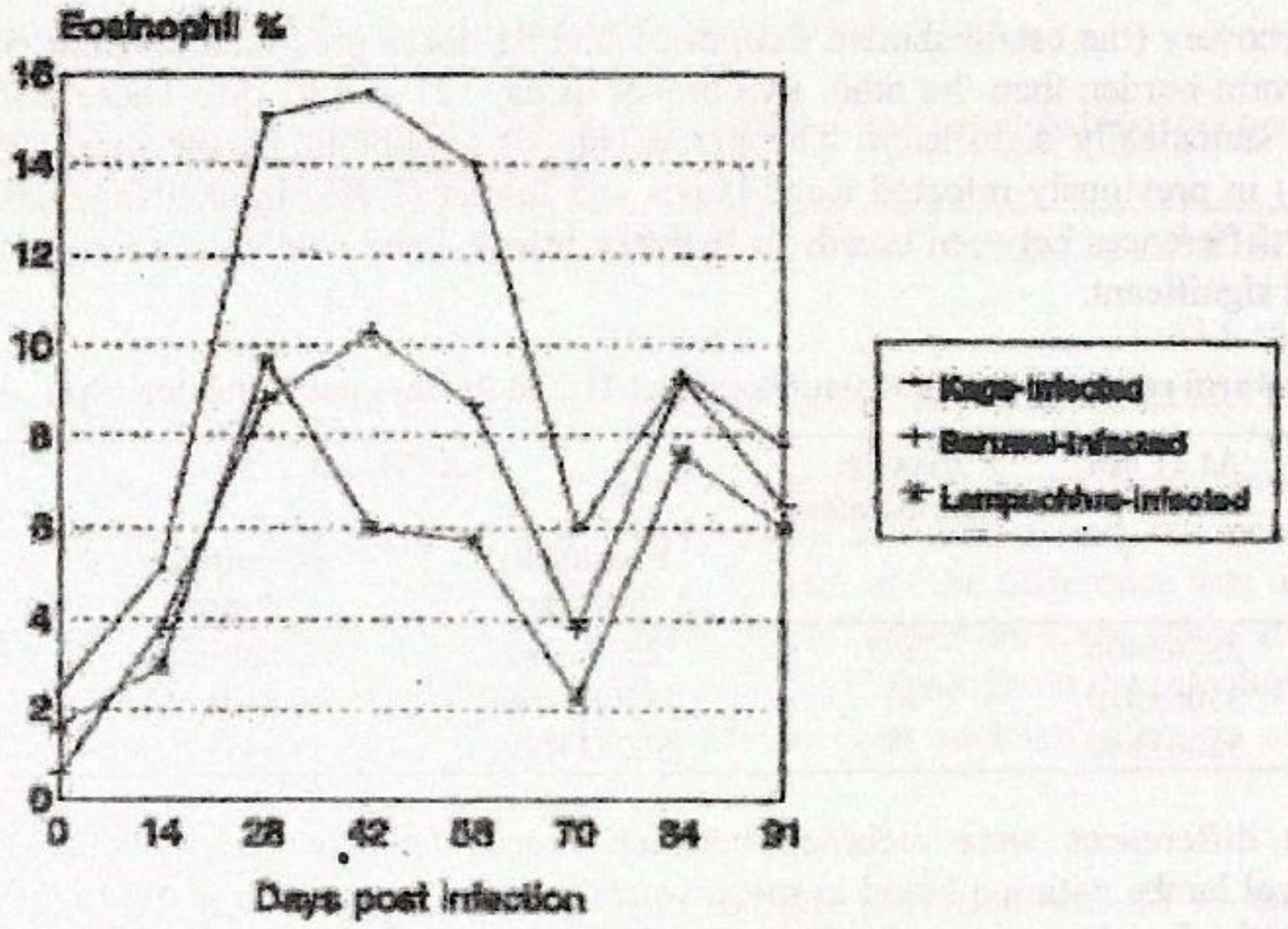


**Fig.3. Mean eosinophil percent in infected Kage, Baruwal and Lampuchhre lambs**

This was maintained until day 63 when the animals were treated with anthelmintic. Two weeks after challenge infection, the eosinophil percentage increased significantly ($P<0.001$) in all infected groups.

## DISCUSSION

Although, in studies of this type, it is desirable to use animals that have never been exposed to nematode infection, it was not possible under the conditions of the present study. Thus, on purchase, the lambs were treated with anthelmintic and reared in a worm free environment for more than nine months. It is thus expected that the acquired immunity to *H. contortus* would have been lost by 84 days in the absence of antigenic stimulation as has been reported by Jackson *et al.* (1988).

Resistance to *H. contortus* infection in different breeds has been evaluated by comparing faecal egg counts (Albers *et al.*, 1984) worm counts (Kassai *et al.*, 1990) or PCV decline (Albers *et al.*, 1984). In all cases measurements are direct or indirect indicators of the worm burden acquired by each breed. While, Preston and Allonby (1978) and Al-Khshali and Altaif (1979) regarded initial establishment (innate resistance ) as the main mechanism determining breed differences. Courtney *et al.* (1985) and Kassai *et al.* (1990) regarded this as a poor indicator because of the high variability within a group. Courtney *et al.* (1985, Kassai *et al.* (1990) and Gruner (1991) recorded differences in worm burdens between breeds at challenge infection and suggested that the full expression of resistance requires a number of antigenic stimulations.

In the present experiment, although the mean number of worms established in the Kage lambs was 10 and 7 percent lower than in the Lampuchhre and Baruwal lambs, respectively. These differences were not statistically significant. However, following challenge infection, the worm burdens of previously

infected Kage lambs were lower than those of the Lampuchhre and Baruwal breeds by 20 and 39 percent, respectively. But again these differences were not statistically significant probably due to high variability within the group and small number of animals in each group. Even so, these results suggest that the Kage lambs had a higher level of resistance than the other breeds both at primary and secondary infection. This inference has to be tentative, of course, and needs to be confirmed with larger numbers of animals.

Significant differences were recorded in the faecal egg counts of the three breeds during primary infection or after challenge infection. Mean faecal egg counts of Kage lambs were lower than those of the other two breeds. This difference was obvious from 28 dpi and statistically significant from 42 dpi onward. AT 56 dpi, when the mean egg counts of the Lampuchhre and Baruwal lambs were 17000 and 11000 epg, respectively, the Kage lambs had a mean count of 1880 epg. A similar trend was recorded following challenge as well. Faecal egg counts have been regarded as an indicator of resistance against *H. contortus* infection (Albers *et al.*, 1984; Gray *et al.*, 1992) and the present findings strongly indicate that the Kage lambs exhibited higher resistance than the other two breeds included in this study. In contrast, there was no difference between the Baruwal and Lampuchhre breeds for this parameter. The low egg counts of the lambs during the later weeks of primary infection suggest that this breed was able to mount a more effective immune response against the infection. This might have resulted in the expulsion of a proportion of the worm burden, as faecal egg counts have been shown to correlate strongly to worm burdens in *H. contortus* infection in sheep (Roberts and Swan, 1981). It is also possible that the differences in faecal egg counts might have resulted due to immune effects on parasite fecundity as has been suggested by (Zajac *et al.*, 1990). Kage lambs have also the greatest eosinophil response following infection as was also recorded by Stear and Murray (1994) in *H. contortus* resistant Red Messai sheep.

Differences between the breeds were recorded in the rate of decline of mean haematocrit and haemoglobin values following infection. The non-significant but rapid PCV decline in the Baruwal lambs during the primary infection period, and rapid decline in haematocrit and haemoglobin values in Lampuchhre lambs after 56 dpi indicate that these animals were unable to cope with the increased blood loss probably due to declining iron reserves during the later period of infection (Dargie and Allonby, 1975).

The trend in PCV decline was inversely related to the faecal egg count trend in the infected groups and was therefore related to the level of resistance shown by different breeds. This finding would support the observation that haematocrit values could provide an useful indicator for resistance in infected sheep (Albers *et al.*, 1984, 1987). Following challenge infection, the differences in haematological parameters between previously infected groups were not very marked but the observation period was probably too short for differences to develop.

Thus, it was evident that the innate resistance of the three breeds as expressed by initial establishment, was although not very different between the breeds, one breed, the Kage, acquired a higher level of resistance during the course of infection. This was expressed by lower faecal egg counts, lower worm burdens, higher eosinophilia and higher haematocrit values in Kage animals, although not all differences were statistically significant.

During the pre-infection period, the mean daily weight gain in all breeds was similar, indicating that the inherent potential for growth was similar in all three breeds. Following primary infection, however, animals of all breeds lost weight. However, this trend changed by 42 dpi, as clinical recovery in Kage breed was associated with a considerable improvement in body condition. Hence by 63 dpi, the mean body weight loss of the Kage lambs was the lowest of the three breeds. At this time, the mean daily weight loss of Baruwal lambs was nearly twice that of the Kage lambs. These results would suggest that resistance to *H. contortus* infection primarily determined the body weight gain of the animals.

The Lampuchhre breed has been evolved in the sub-tropical Terai region of Nepal and has probably experienced greater exposure to *H. contortus* infection than the hill breeds. Even so, the level of resistance in this breed shown in this study was not greater than the Baruwal hill breed. This supports the findings of Al-Khshali and Altaif (1979) who recorded higher susceptibility in the Awassi breed than in the Merino indicating that resistance to *H. contortus* is not necessarily related to the historical level of exposure of a breed.

The findings of this study indicate that the Kage breed exhibited the higher resistance to *H. contortus* infection than the Baruwal and Lampuchhre animals. This attribute was reflected by parasitological, haematological and body weight responses of the Kage lambs. The Lampuchhre and Baruwal breeds did not develop significant resistance and because of their higher susceptibility to *H. contortus* infection, these breeds would not be suitable to be raised in *H. contortus* endemic areas.

## ACKNOWLEDGEMENTS

The author is thankful to the staff members of Veterinary Investigation Laboratory of Agricultural Research Station, Lumle for their technical assistance and to the Department for International Development of UK Government for the financial help provided for this study.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# FOOD SECURITY AND POVERTY ALLEVIATION THROUGH LARGE RUMINANT SITUATION AND SCOPE

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## INTRODUCTION

Sufficient food and nutrition is necessary to increase the physical and mental capacity of the people. An adequate quantity of balanced and nutritious food helps to build up the efficiency of the people and is a primary indicator of quality of life, human welfare and development (Sansoucy *et al.*, 1995). Reports of the Food and Agriculture Organization (FAO) shows that the diet of the inhabitants of the developing countries is hardly sufficient in terms of dietary calories and mainly from vegetable origin and in short in animal proteins (Hazarika, 1990).

The demand for food is increasing due to the tremendous growth of population. Production process and available resources are not being utilized at optimum level. A large mass of population has suffered from poverty and under-nutrition and this situation is increasing over the years. In this context, there will be a need for more intensification of existing production system to meet the demand for food (Devendra, 1993).

Nepal is heavily trapped in food problem and this situation is becoming more serious in the succeeding years. About 51 percent of the total population is in under consumption level and 47 percent are meeting just. This problem is more serious in the mountain, where more that 63 percent are living on below the requirement level followed by hill (54.67 percent) and Teṛai (44.86 percent), respectively. Similarly this problem is serious in Far-western Development Region followed by Western, Central, Eastern and Mid-western Regions respectively. The problem is acute in rural areas than urban so far but the extent of the problem is uneven in urban than rural areas (Table 1).

**Table 1. Food consumption by different characteristics**

| Region | Particular | | | |
|---|---|---|---|---|
| | Less than adequate | Just adequate | More than adequate | Total |
| Ecological belt | | | | |
| Mountain | 63.16 | 33.55 | 3.29 | 100.0 |
| Hill | 54.67 | 43.11 | 2.22 | 100.0 |
| Terai | 44.86 | 33.96 | 1.18 | 100.0 |
| Development region | | | | |
| Eastern | 49.13 | 49.70 | 1.16 | 100.0 |
| Central | 49.83 | 47.42 | 2.75 | 100.0 |
| Western | 54.82 | 44.32 | 0.86 | 100.0 |
| Mid-western | 46.86 | 51.29 | 1.85 | 100.0 |
| Far-Western | 55.84 | 41.96 | 2.19 | 100.0 |
| Urban/Rural | | | | |
| Urban | 36.27 | 61.82 | 1.92 | 100.0 |
| Rural | 52.01 | 46.17 | 1.82 | 100.0 |
| Nepal | 50.86 | 47.31 | 1.83 | 100.0 |

Source: CBS, Nepal Living Standards Survey Report, 1996, Main Findings, Volume II, Central Bureau of Statistics / National Planning Commission Secretariat/HMG/Nepal

## LAND BASE CHARACTERISTICS OF THE LIVESTOCK RAISER IN NEPAL

Land holding size of the country is divided in small parcel. About 70 percent of the total population is relying on less than one hectare of land (Table 2). Which indicate the necessity of other economic activities for livelihood, specially, to meet the demand for food. But the knowledge and mobility status of the farmers is not adjustable to other productive activities, which are different in Nepal.

**Table 2. Size of land holding in Nepal**

| Size of holding | Number ('000) | Holdings percent | Cumulative percent |
|---|---|---|---|
| Under 0.1 ha | 173.0 | 6.4 | 6.4 |
| 0.1-0.2 ha | 263.8 | 9.8 | 16.2 |
| 0.2-0.5 ha | 729.3 | 27.0 | 43.1 |
| 0.5-1.0 ha | 711.7 | 26.3 | 69.4 |
| 1.0-2.0 ha | 529.5 | 19.6 | 89.0 |
| 2.0-3.0 ha | 168.4 | 6.2 | 95.3 |
| 3.0-4.0 ha | 59.6 | 2.2 | 97.5 |
| 4.0-5.0 ha | 28.6 | 1.1 | 98.5 |
| 5.0-10.0 ha | 32.0 | 1.2 | 99.7 |
| 10.0 ha and over | 8.2 | 0.3 | 100.0 |

Source: CBS/NPC National Sample Census of Agriculture, 1991/92, Analysis of Results, HMG/Central Bureau of Statistics, 1995.

Land less families in the country is increasing over the years. The growth of land less families in all ecological regions is consistent. The data of the different agricultural census clearly indicate that the problem is serious in Terai region followed by hill and mountain, respectively. Land less families in Terai has increased by more than five times and the cause may be the heavy pressure of population both by the natural growth and migration from hill and mountain in search of job for livelihood (Table 3). Similarly the immigration of the Indian citizen due to porous border has compounded this problem.

**Table 3. Number and area of holdings by ecological belts**

| Number of holdings ('000) | Ecological belts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1981/82 | | | | 1991/92 | | | |
| | Mountain | Hill | Terai | Nepal | Mountain | Hill | Terai | Nepal |
| Holding with land | 197.1 | 1041.9 | 946.8 | 2185.7 | 259.9 | 1351.3 | 1092.8 | 2703.9 |
| Holding with no land | 0.5 | 3.3 | 4.4 | 8.2 | 0.8 | 6.4 | 24.9 | 32.1 |
| Total holdings | 197.6 | 1045.2 | 951.2 | 2194.0 | 260.7 | 1357.7 | 1117.6 | 2736.1 |

Source: National Sample Census of Agriculture, Nepal, 1991/92, Analysis of Results, HMG/National Planning

## CATTLE AND BUFFALOES FOR FOOD SECURITY

Cattle and buffaloes constitute significant place in food security in the Nepalese economy. These two species provide directly meat and milk for consumption. Milk and meat production in the fiscal year 1996/97 is 1012 and 175 thousand metric tones, respectively and indirectly helps to raise the agricultural production by providing manure and draft power. Cattle and buffaloes convert the unused agricultural by products, which otherwise may be wastage, and crop residues into the edible items. Draft power and manure are significant inputs for agricultural production throughout the country, where mechanization in agriculture is less and difficult at present and near future too, and supply of chemical fertilizer is sharply inadequate throughout the country in all season.

Livestock sector constitutes significant place in the Nepalese economy. It constitutes about 41 percent in agricultural gross domestic production (AGDP) and 17 percent in gross domestic

production (GDP), excluding the other role such as the supply of manure and draft power. The share of livestock is increasing over the years and shows the bright prospect in the economy in the years to come.

**Table 4. Livestock and agriculture contribution on gross domestic production (Rs. million)**

| Fiscal Year | GDP | AGDP | LGDP | FGDP | AGDP% | LGDP% | LAGDP% | FAGDP | F/L% AGDP |
|---|---|---|---|---|---|---|---|---|---|
| 1984/85 | 44441 | 22761 | 7388 | 95 | 51.22 | 16.62 | 32.46 | 0.42 | 32.88 |
| 1985/86 | 53215 | 27136 | 8972 | 202 | 50.99 | 16.86 | 33.06 | 0.75 | 33.81 |
| 1986/87 | 61140 | 30623 | 10304 | 259 | 40.09 | 16.85 | 33.65 | 0.85 | 34.99 |
| 1987/88 | 73170 | 36755 | 12937 | 351 | 50.23 | 17.68 | 35.20 | 0.96 | 36.16 |
| 1988/89 | 85830 | 42572 | 15492 | 417 | 49.60 | 18.05 | 36.39 | 0.98 | 37.37 |
| 1989/90 | 99702 | 50470 | 19208 | 530 | 50.62 | 19.27 | 38.50 | 1.05 | 39.11 |
| 1990/91 | 116128 | 56368 | 21315 | 632 | 47.68 | 19.36 | 38.50 | 1.14 | 30.64 |
| 1991/92 | 144931 | 65155 | 25269 | 848 | 44.96 | 17.44 | 38.78 | 1.30 | 40.09 |
| 1992/93 | 165262 | 70090 | 27383 | 840 | 42.41 | 16.57 | 39.07 | 1.20 | 40.27 |
| 1993/94 | 190959 | 81621 | 32484 | 1001 | 42.74 | 17.01 | 39.80 | 1.23 | 41.03 |
| 1994/95 | 210532 | 87072 | 35762 | 1209 | 41.35 | 17.00 | 41.07 | 1.39 | 42.46 |

Source: Agricultural Statistics Division/ Ministry of Agriculture Central Bureau of Statistics /National Planning Commission, His Majesty Government of Nepal/Ministry of Finance," Economic Survey, 1995/96. Compiled by Upendra Mishra and Nanda Prasad Shrestha, " National Research Strategy to Promote sustainable Production of Livestock and Fisheries for Food Security" Proceeding of First National workshop of Livestock and fisheries Research in Nepal, NARC, National Animal Science Research Institute.

## SCOPE OF CATTLE AND BUFFALOES FOR FOOD SECURITY

Cattle and buffaloes are widely distributed economic resources in Nepal and provide the base for food supply throughout the country with better nutritional standard. This is more viable in all ecological regions as it has been distributed. Most of the cattle and buffaloes are concentrated in the hill region followed by Terai and mountain, respectively. The concentration of the cattle and buffalo in hill and Terai region is caused by the demand for agricultural power and progressively commercialization of the livestock sector allowing the opportunities for profitable situation.

**Table 5. Cattle and buffalo distribution by ecological belts in Nepal (in number)**

| Livestock species | Mountain | Hill | Terai | Total |
|---|---|---|---|---|
| Cattle | 825827 (11.8) | 3429753 (48.8) | 2769195 (39.4) | 7024775 |
| Buffalo | 304537 (9.1) | 1918722 (57.1) | 1139176 (33.8) | 3362435 |

Source : HMG/Ministry of Agriculture, Statistical Information on Nepalese Agriculture, 1996/97, HMG/Ministry of Agriculture

Similarly, these two species are widely accepted and most of the households keep for food production. They provide directly meat, milk food and indirectly manure and power more food production for the people.

**Table 6. Percent households with livestock by development region**

| Livestock Species | Development regions | | | | | |
|---|---|---|---|---|---|---|
| | Eastern | Central | Western | Mid-Weastern | Far-Western | Total |
| Cattle | 80.6 | 68.6 | 68.9 | 84.6 | 88.5 | 75.6 |
| Chauri | 0.6 | 0.1 | 0.3 | 0.5 | 0.1 | 0.3 |
| Buffaloes | 38.1 | 41.3 | 63.8 | 47.8 | 55.2 | 47.8 |

CBS : Nepal Living Standard Survey, 1996

Cattle and buffaloes are important for food security and nutrition for households as they provide milk and meat for consumption and save substantial amount of cash, earned from other sectors of the economy. The cattle and buffaloes provide the basis for food security in several ways.

1. Many poor small holders would have direct access to more food of livestock origin as they raise at their home.
2. Cattle and buffaloes help to produce more food through supplying manure for maintaining soil fertility.
3. Livestock farming helps to preserve the foreign currency, reducing the importation of livestock origin food items.
4. Livestock is a reliable source of agricultural power for crop.
5. Livestock is divisible asset and can be sold during crisis, which can be used to purchase food to escape from starvation, malnutrition and other productive inputs for agricultural production.

## MILK PRODUCTION

Milk is an important aspect of the cattle and buffalo production. The production level depends on the genetic structure, feeding techniques and management system of the given species. Various studies have indicated that the productivity of improved cattle and buffaloes are higher than that of the local in many cases throughout the country. The share of milking cattle and buffaloes is about 11 and 25 percent in the country. Comparatively low percentage of the milking cattle is mainly due to the existence of unproductive cattle and poor management system throughout the country. The region wise situation shows the variation in these percentages (Table 7).

**Table 7. Number of milking cattle and buffaloes by ecological regions in Nepal, 1996/97**

| Regions | Total cattle | Milking cattle | Total buffaloes | Milking buffaloes |
|---|---|---|---|---|
| Mountain | 825827 | 102078 (12.4%) | 304537 | 82586 (23.8%) |
| Hill | 3429753 | 440493 (12.8%) | 1918722 | 542606 (28.3%) |
| Terai | 2769195 | 273699 (9.9%) | 1139176 | 242228 (21.3%) |
| Total | 7024775 | 816270 (11.6%) | 3362435 | 857420(25.5%) |

Source : Statistical Information on Nepalese Agriculture, 1996/97, HMG/Ministry of Agriculture.

The main source of milk is the cattle and buffaloes and level of milk production depends upon the efficiency of the milk production parameters of these two species. The region and species wise milk production situation, clearly indicate the significant place of buffaloes in milk production. Buffaloes constitute about two third shares of milk and rest by the cattle. Similarly, about 57 percent out of total milk are produced in the hill region in overall situation and this is consistent in case of cattle and buffaloes followed by the Terai and mountain regions, respectively. The region wise milk production data clearly indicate that cattle constitute higher share in the Terai and mountain than buffalo (Table 8).

**Table 8. Distribution of milk production (kg) by ecological belts, 1996/97**

| Ecological region | Milk production | | |
|---|---|---|---|
| | Cow milk | Buffalo milk | Total milk |
| Mountain | 32657 (10.5%) | 51375 (7.3%) | 84032 (8.3%) |
| Hill | 158869 (51.32%) | 419573 (59.8%) | 578442 (57.2%) |
| Terai | 118657(38.3%) | 231032 (32.9%) | 349689 (34.6%) |
| Total | 310183 (100.0%) | 701980 (100.0%) | 1012163 (100.0%) |

Source: Statistical Information on Nepalese Agriculture, 1996/97, HMG/Ministry of Agriculture, Kathmandu

## MEAT PRODUCTION

Meat is another major production of livestock sector in Nepal. The sources of meat are buffaloes, goats, sheep, poultry and pigs, but buffaloes constitute about two third shares in total meat production (Table 9).

**Table 9. Meat production trend in the different years**

| Fiscal year | Total meat | Buffalo meat |
|---|---|---|
| 1984/85 | 127016 | 86268 (67.9%) |
| 1985/86 | 130002 | 88040 (67.7%) |
| 1986/87 | 132080 | 89384 (67.7%) |
| 1987/88 | 137818 | 91954(66.7%) |
| 1988/89 | 141226 | 93928(66.5%) |
| 1989/90 | 145381 | 94478(65.0%) |
| 1990/91 | 147347 | 95312(64.7%) |
| 1991/92 | 148695 | 96013(65.6%) |
| 1992/93 | 149893 | 96574(64.4%) |
| 1993/94 | 154343 | 100383(65.0%) |
| 1994/95 | 158747 | 104070(65.5%) |
| 1995/96 | 161520 | 104830(64.9%) |
| 1996/97 | 174268 | 113482(65.1%) |

Source : HMG/MOA, Statistical Information on Nepalese Agriculture, 1996/97, HMG/Ministry of Agriculture

The meat production data of various years (Table 10) clearly indicate that hill region has significant place in total meat production and this figure is consistent for all livestock and poultry species except duck, which is higher in Terai.

**Table 10. Meat production and distribution in Nepal by ecological regions and species**

| Sources of meat | Ecological regions | | | |
|---|---|---|---|---|
| | Mountain | Hill | Terai | Total |
| Buffalo Meat | 9642 (8.5%) | 64639(57.0%) | 39201((34.5%) | 113482 |
| Mutton | 1155(39.8%) | 1305(45.0%) | 440(15.2%) | 2900 |
| Goat Meat | 2733(7.9%) | 14399(41.9%) | 17418(50.4%) | 34550 |
| Pig Meat | 1115(9.0%) | 7151(57.8%) | 4108(33.2%) | 12374 |
| Chicken | 711(6.6%) | 6458(60.5%) | 3502(32.8%) | 10671 |
| Duck Meat | 6(2.1%) | 55(18.9%) | 230(79.0%) | 291 |
| Total | 15362(8.8%) | 94007(54.0%) | 34899(37.2%) | 174268 |

Source : HMG/MOA, Statistical Information on Nepalese Agriculture, 1996/97, HMG/Ministry of Agriculture

## POWER

The domestication of animal for drought purpose is estimated to have started over 5000 B.C. years. Animal supply drought power for land development, tillage, seeding, operations, inter-cultural operations, lift irrigation, harvesting, threshing and transport.

Nepalese farmers are heavily dependent on animal power for crop cultivation and other agricultural activities. Therefore, the draught animals are invariably treated with great care. The variation of the size of draught animals tends to be related to the size of land holding. The small holders tend to keep small animals. Only male cattle, buffaloes and yaks are used in agricultural operations and only male members of the family operate them (Joshi, 1992). The use of female cattle and buffaloes for work is contrary to social practices at present (Oli, 1984, 1985).

Around 50% farmers of Nepal live in the hill region and small piece of land is basis for their livelihood. Farm mechanization process in the hill region is limited due to inaccessibility and limited extension of infrastructure. A pair of draught animal and a simple wooden plough is the usual and prevalence means of land preparation. In narrow terraces, where a pair of oxen is impossible to drive, hand hoes are used. Substantial mechanization in the hill and mountain regions, is not feasible because of dominance of small size, sloped conditions and limited access to the field. This problem is compounded by the continuous fragmentation of land.

Animal power is significant for Nepalese economy and it has high economic value, especially in case of hill region where 58% of cultivated land and 62% of rural population are found in the hill and mountain areas. Only a limited area is accessible by road and the majority comprises small, fragmented and steeply terraced land where modern agricultural equipment could not be used efficiently.

Cattle and buffaloes oxen are the main source of draught power for agriculture in Nepal. Bullocks are used to plough throughout the country except Kathmandu valley and buffalo oxen in the Terai region. The supply of draught power depends upon the number and working hours and day per year. Cattle oxen are distributed throughout the country. Draught power is the prime reason why cattle are maintained in the Eastern hills and wherever possible a farmer keeps a pair of ploughing oxen (Hopkins, 1983).

In Nepal, there are about 2794487 cattle oxen and about 48.59 percent of them are concentrated in the Terai region followed by hill (42.53%) and mountain (8.8%), respectively (Table 11). The main reason for such distribution is the result of uneven distribution of the availability of arable land. About 98.8 percent buffalo oxen are in the Terai region and it indicates that buffalo oxen are valuable only in the Terai region. About 1.2 percent buffalo oxen are in the mountain and hill but are not utilized for the draft purpose.

**Table 11. Number of cattle and buffalo oxen population in Nepal, 1994/95**

| Development region | Ecological region | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mountain | | Hill | | Terai | | Total | |
| | Cattle | Buffalo | Cattle | Buffalo | Cattle | Buffalo | Cattle | Buffalo |
| Eastern | 67668 | 72 | 269226 | 1457 | 379212 | 58776 | 716106 | 60305 |
| Central | 72791 | 10 | 115463 | 126 | 427371 | 9133 | 615585 | 9269 |
| Western | 1493 | 0 | 374639 | 122 | 268194 | 17476 | 644326 | 17598 |
| Mid-Western | 44619 | 0 | 291193 | 713 | 179025 | 73455 | 514837 | 74168 |
| Far-Western | 61492 | 19 | 137953 | 7 | 104188 | 51210 | 303633 | 51236 |
| Total | 248063 | 101 | 1188474 | 2425 | 1357950 | 210050 | 2794487 | 212576 |
| | (8.8%) | (0.05%) | (42.53%) | (1.15%) | (48.59%) | (98.81%) | (100.0%) | (100.0%) |

Source : Statistical Information on Nepalese Agriculture, 1994/95.

Animal constitutes significant place in the supply of agricultural power in Nepal and this is consistent for all ecological region and different crops. Cattle oxen constitute higher place than buffaloes in all regions. Due to less mechanization in the agriculture, tractor and other machines constitutes less than one percent contribution in this regard (Table 12).

**Table 12. Percent farmers reporting use of animals for ploughing**

| Ecological/Development region | Rice | | | Maize | | |
|---|---|---|---|---|---|---|
| | Bullock | Buffalo | Tractor | Bullock | Buffalo | Tractor |
| High mountain | 100 | 0 | 0 | 92.2 | 0 | 0 |
| Mid mountain, FWDR | 99.6 | 0.4 | 0 | 100 | 0 | 0 |
| Mid mountain, MWDR | 100 | 0 | 0 | 100 | 0 | 0 |
| Mid mountain, WDR | 100 | 0 | 0 | 100 | 0 | 0 |
| Mid mountain, CDR | 99.7 | 0 | 0 | 100 | 0 | 0 |
| Kathmandu, hill slope | 0 | 0 | 0 | 77 | 0 | 0 |
| Kathmandu, valley | 0 | 0 | 0 | 43 | 0 | 0 |
| Upper Terai | 91.3 | 7.8 | 0.9 | 94.5 | 4.5 | 0.9 |
| Main Terai, FWDR | 94.5 | 2.5 | 0 | 97.2 | 2.8 | 0 |
| Main Terai, MWDR | 88.3 | 11.7 | 0 | 87.6 | 12.4 | 0 |
| Main Terai, WDR | 96.8 | 2.2 | 0.5 | | | |
| Main Terai, CDR | 98.8 | 1.2 | 0 | 97.6 | 2.4 | 0 |
| Main Terai, EDR | 96.6 | 3.1 | 0 | 90.8 | 9.2 | 0 |

Source : Land Resource Mapping Project, 1986, Cited in Livestock Master Plan Vol.3, P. 390
EDR = Eastern Development Region, CDR = Central, WDR = Western, MWDR = Mid-Western, FWDR = Far-Westernn

As cattle and buffaloes are main source of agricultural power, the demand for bullock and buffalo oxen is positively associate with the landholding size i.e., higher the land the farmers have, higher would be the demand for draught animals and this relationship is consistent in all ecological regions (Table 13).

**Table 13. Percent availability of animal power by farm size in different region**

| Region/Number of animals | Farm size | | | |
|---|---|---|---|---|
| | I | II | III | All |
| **Terai** | | | | |
| Farmers owing none | 56.3 | 11.65 | - | 30.2 |
| One draught animal | 10.4 | 43.35 | 28.0 | 35.5 |
| Two draught animals | 25.3 | 25.02 | 65.0 | 28.1 |
| Three draught animal | 8.0 | 19.98 | 7.0 | 6.2 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** |
| **Hill** | | | | |
| Farmers owing none | 84.10 | 27.743 | - | 44.53 |
| One draught animal | 10.64 | 45.15 | 29.0 | 23.47 |
| Two draught animals | 5.26 | 20.28 | 64.0 | 28.43 |
| Three draught animal | - | 7.14 | 7.0 | 3.57 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** |
| **Mountain** | | | | |
| Farmers owing none | 72.2 | 20.0 | 5.95 | 53.6 |
| One draught animal | 16.6 | 50.0 | 51.35 | 28.6 |
| Two draught animals | 5.6 | 10.0 | 33.20 | 7.1 |
| Three draught animal | 5.6 | 20.0 | 7.50 | 10.7 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** |

Source : Livestock Production in the Terai Hills and Mountain

Note: I = 0.2 hectare of land holding, II = 2.4 hectare of land holding, III = 4+ hectare of land holding

Oxen are ploughed in the form of pairs. In this sense, work burden per pair is significant for economic valuation of draught power availability. Calculation of work burden assuming zero contribution of male buffalo in the hill and mountain region clearly indicates that in the hill and Terai region, oxen have to do a lot work. In mountain region, per pair oxen have to prepare less than 1.7 percent hectare land for cultivation, where as in the Terai region 2.24 hectare is common. Similarly, in the hill region each pair has to plough about 2.36 hectare (Calculated from the data of Statistical Information on Nepalese Agriculture).

Farm management study of 1983-85 has estimated the animal labour per hectare land in different ecological region for different crops. Paddy cultivation in hill region requires 55 animal days per hectare followed by the Terai (54 days) and mountain (20 days) (Table 14). Maize, wheat, millet cultivation in the Terai region requires highest animal labour days than other region. The study has indicated that animal power is necessary for all crops and this is the significant determinant for crop intensity. It can be concluded that the demand for animal labour increases with the crop intensity and animal power is necessary for agricultural development.

Animal draught power places significant position for agricultural activity in Nepal. Assuming that a pair of draught animals can generate an estimated 0.4 kilowatt (kw) of power under acceptable level of animal husbandry system, about 0.8 million KW of power is generated by the estimated two million draught animals. This might vary depending on the type of cultivation, nature of soil etc. However, if 0.4 KW is desirable for one hectare of land, an estimate 1.37 million (KW) of power is required to cultivate Nepalese cropped area (2,330,000), where approximately 50 percent of the land is under double crop. Such estimate of power requirement certainly increases when nature of soil, gradients of hills, up hill ploughing and cropping system are considered (Oli, 1984).

**Table 14. Animal labour requirement for various crops production in Nepal (animal labour days per hectare)**

| Crop | Ecological region | | |
|---|---|---|---|
| | Mountain | Hill | Terai |
| Paddy | 20 | 55 | 54 |
| Maize | 19 | 32 | 40 |
| Wheat | 21 | 34 | 44 |
| Millet | 29 | 7 | 42 |
| Buck Wheat | 24 | 83 | - |
| Naked Barley | 10 | - | - |
| Barley | 15 | 31 | - |
| Potato | 17 | 45 | 33 |
| Lentils | - | - | 31 |
| Pigeon Pea | - | - | 6 |
| Gram | - | - | 11 |
| Grass Pea | - | - | 17 |
| Mustard | - | 36 | 16 |
| Linseed | - | 5 | - |
| Sugarcane | - | - | 39 |
| Jute | - | - | 54 |

Source : Farm Management Study, 1983-85

## CATTLE AND BUFFALO AS SOURCE OF MANURE

The traditional hill farming has been entirely dependent on locally available manure for maintaining soil fertility. Farmers keep livestock specially cattle and buffalo for manure. Livestock, especially cattle and buffaloes provide significant amount of dung for compost converting their forest resource, crop residues and other wastage into manure. Soil fertility is sustained by the importation of nutrients from the forest (Suwal *et al.,* 1991). It is estimated that a farmer with a half hectare of Khet land for rice wheat maize systems would need at least six cattle, with the associated fodder to meet the total nitrogen needs with the traditional FYM preparation (Suwal *et al.,* 1991).

Nutrient recycling is an essential part of any strategy for sustainable agriculture. Integration of livestock and crop allows for efficient recycling through use of crop residues and by-products, and animal feeds and animal manure as crop fertilizer. Cattle dung contains about 8 kg of nitrogen, 4 kg of phosphate and 16 kg potash per ton of dry matter to the soil helping to maintain its structure as well as its water retention and drainage capacities ( Sansoucy *et al.,* 1995).

Most of the farmers in the hill region use compost for maintaining soil fertility and the amount used varies accordingly the crops and their rotations. An average of 39 ton/ha compost, the highest rate, is applied in potato and maize production system. Usually farmers do not apply compost on Khet for rice crop. The main reason for not using the compost on Khet land is the long distance from the farms. However, practice for *in situ* manuring in Khet during crop intervals is common (Khadka and Chand, 1987).

Most of the farmers in the hill region are illiterate and unable to use the chemical fertilizer in proper ways. They have not got sufficient information about the use of chemical fertilizer. Moreover, compost is superior to chemical fertilizer in case of Nepal. Application of large amount of compost is good for soil. The soil becomes loose, allows excess water to drain and at the same time, retains moisture, in dry season, it becomes easier to plough, there are less clods, and soil aeration is improved. Even poor soil can be improved over time by application of compost. Applying compost can decrease some of the negative qualities of chemical fertilizer (Tamang, 1991).

Cattle and buffalo help to make the land fertile in various ways. These two species transfer the forest resources to farmland. Farmer can use the animal for manuring either collecting dung or mixing with

other wastage or *in situ* form. In the former case, dung is collected and piled near the shed mixing with leaf letter and wastage straw and stover. But *in situ* manuring process is different than this.

## CATTLE AND BUFFALO: AS SOURCE OF EMPLOYMENT AND INCOME GENERATION

Livestock sector provides employment for rural people through out the year and help to reduce the disguised unemployment and off-farm passiveness. The potentiality of livestock for employment generation can be justified on various grounds. Livestock raising can be operated in rural areas with a little capital resource and locally available raw materials. First, livestock provides milk and meat for direct cash earning. Also, they provide raw materials for livestock based industries such as leather and tanning, milk processing, carpet weaving, meat processing and other activities in rural areas. Development of commercial livestock sector provides impetus for feed industry and agricultural by-product trade such as hay, straw, maize stover, etc. These activities provide substantial amount of employment to rural people in Nepal.

Livestock enterprises constitute a major source of income for the average households in Nepal. A multipurpose household budget survey published in 1988 showed that in the total household income, livestock sources contributed 21.2% in mountain, 19.7% in the hill region, and 9.7 percent in the Terai region (Nepal Rastra Bank). In a household survey in mid-hill village of western Nepal, Shrestha et al (1991), reported that only 12.9 percent of annual cash income came from agricultural activities, of which livestock enterprises contributed 8.6%. The major livestock products for cash generation is ghee followed by live animals (Joshi, 1992).

Livestock sector contributes significant place in income earning on the national scale. The livestock sector earned a total of 1.6 million rupees during 1987/88, which accounted for 64% of total agricultural exports. The major commodities for export are ghee, live animals, and hides and skins. These represent about 50% of the total export of livestock commodities.

## CONSLUSION

Cattle and buffaloes, constitutes significant place in food security in the Nepalese economy. These two species provide directly meat and milk for consumption and indirectly help to raise the agricultural production by providing manure and draft power. Cattle and buffaloes convert the unused agricultural by-products and crop residues into the edible items. Draft power and manure are significant inputs for agricultural production throughout the country, where mechanization in agriculture is less and difficult at present and near future too, and supply of chemical fertilizer is sharply inadequate throughout the country.

Cattle and buffaloes constitute significant place in the household wealth portfolio and serve as the capital assets providing regular output in various forms. These two species and their production are divisible and can be sold during emergency at required amount to meet the demand. Cattle and buffaloes are living banks for many raisers and plays critical role in the agricultural development, specially strengthening the food base for people.

Cattle and buffaloes have significant place and better prospects in the Nepalese economy at present, and likely to be remained in the foreseeable future. Most of the rural households keep cattle in different numbers and loosely affected by ethnicity than other species of livestock. Due to the rugged topography of the country and availability of cattle and buffaloes, they are the special means for draft power for Nepalese agriculture throughout the country. Cattle and buffaloes are viable and there is much scope to increase the productivity in Nepal. Improved cattle and buffaloes can provide higher

level of milk. Stall feedings of cattle and buffaloes can produce more manure, and helps to maintain the soil fertility for higher level of production, which is necessary for food security.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# MEAT PRODUCTION PERFORMANCE OF DIFFERENT COLOR TYPES OF GOAT

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## ABSTRACT

A study was conducted to investigate the meat production performance of different color types of goat (Ghorlie, Dhobini, Kali, Seti and Singari). A total of 42 local male goats aged between 22 and 24 months old were slaughtered by the local method. The mean slaughter weight of the goats was 21.5±3.32 kg. Data on meat production performance were analyzed using the least square analysis. The live weight of different color goats during slaughter was non-significant. The dressed carcass weight was significantly lower ($P<0.05$) in Seti (9.83±0.70 kg) and Singari (9.88±0.97 kg), compared to Ghorlie (11.5±0.43 kg). However, this was not significant with Dhobini (10.5±75 kg) and Kali (10.4±0.34 kg). The total meat production, including all edible offal was significantly lower ($P<0.05$) in Seti (13.5±1.05 kg) as compared to Ghorlie (16.0 ± 0.70). The carcass dressing percentage and the dressing percentage, including all edible offal or by-products was significantly lower in Seti goats as compared to Ghorlie and Dhobini. However, the reasons for low dressing percentage in Seti are not known. The results of this study showed the validity of the farmers' perception that white goats have lower meat production potential, and that Ghorlie, Dhobini and Kali were better meat producers.

## INTRODUCTION

Goat (*Capra hircus*) is an important meat producing domestic animal in Nepal. It occupies second place is supplying meat (20%) after buffalo (65%) (MOA, 1998). It is reared by all classes of farmers and provides an immediate source of cash to them. Goat meat is accepted in almost all communities, and it is the most expensive meat in Nepal (Aryal *et al.*, 1995; Kharel and Pradhan, 1988). An economic slaughter age between 1.5 and 2.0 years has been reported by Aryal *et al.* (1995) for Nepalese hill goats.

In the USA, the majority of consumers regard of lamb, mutton, or goat meat as having relatively low palatability (Griffin *et al.*, 1982), primarily because of their species-specific characteristic flavors (Sink and Caporaso, 1977). However, Hale (1990) concluded that goat meat could be made more acceptable and less variable in taste appeal by using more consistent management practices and by marketing them always at less than six months of age.

Oli and Gatenby (1990) reported that there are five color types of goat recognized in the eastern hills. These are known as Khairi (brown, sometimes with white or black markings on the spine, belly, face and ears), Kali (black), Singari (black with white markings on legs, belly, neck, face and ears), Seti (white) and Dhobini (white with black marking on spine, belly, legs, face and ears). The proportions of these five color types are estimated to be Khairi 40%, Kali 39%, Singari 10%, Seti 7%, Dhobini 3% and others 1%. Neopane (1997) reported six color types, including Ghorlie, which is similar to Khairi.

## MATERIALS AND METHODS

A total of 42 male fattening goats aged between 22 and 24 months were grouped into five different color types as per the characters described in Table 1. The goats were slaughtered by the local method as described by Aryal *et al.* (1995). Skinning of goats was not done during slaughter. Data on live weight, carcass, and offal were recorded. Dressing percentage was calculated basing on their live weights during slaughter. Data were analyzed for least square analysis using Statistical Analysis System (SAS) computer package and results were compared between the color types for different parameters.

**Table 1. Characteristics of different color type goats**

| Color | Characters |
|---|---|
| Ghorlie | Light to dark brown to red, sometimes with white markings on face, ears, spine, legs and underside the body. |
| Dhobini | White with black markings on face, ears, spine, belly, tail and lower legs. |
| Kali (black) | Black, no white markings. |
| Seti (white) | Complete white |
| Singari | Black with white marking on face, ears, lower legs and underline the body. |

## RESULTS AND DISCUSSION

### Live weight

The live weight of goats during slaughter was 21.5±3.32 kg. The live weights for Ghorlie, Dhobini, Kali, Seti and Singari were 23.5±0.87 kg, 21.2±1.31 kg, 21.5±0.85 kg, 21.4±1.46 kg, 20.0±1.71 kg, respectively and these were non-significant to each other (P>0.05). Similar live weights have been reported by several authors (Aryal *et al.*, 1995 - 22.3±3.68 kg for two years old fattening hill goats; Kulkarni *et al.*, 1992 - 17.7±0.84 kg at 1.5 years of age in Gaddi goats; Ibara, 1988 - 18.97 kg live weight in the Philippine goats).

### Meat production

The mean carcass production from Ghorlie, Dhobini, Kali, Seti and Singari was 11.5±0.43 kg, 10.5±0.75 kg, 10.5±0.34 kg, 9.83±0.70 kg and 9.88±0.97 kg, respectively (Table 2). The carcass production was significantly lower (P<0.05) in Seti and Singari as compared to Ghorlie, Dhobini and Kali. Color had significant effect on meat production of goats. Seti color had the lowest meat production, an indication that Ghorlie, Dhobini and kali have more compact body conformation with more meat production as compared to Seti and Singari.

Aryal *et al.* (1995) reported 10.2±1.58 kg meat productions from similar age group fattening goats. Several authors (*Aryal et al.*, 1994; Aryal and Neopane, 1996; Ibara, 1988, 1989) also reported similar results.

The meat production, including all edible offal (guts, liver, lungs, heart, spleen and fat) were 16.0±070 kg, 14.7±1.08 kg, 14.6±0.55 kg, 13.5±1.05 kg and 13.7±1.40 kg for Ghorlie, Dhobini, Kali, Seti and Singari color, respectively and this was significantly lower in Seti (P<0.05).

### Dressing percentage

The mean dressing percentage of meat for Ghorlie, Dhobini, Kali, Seti and Singari was 49.1±0.37 %, 49.5±1.41%, 48.4±0.69%, 46.1±1.29% and 48.6±1.69, respectively. The dressing percentage of meat was significantly lower in Seti color only (P<0.05). A dressing percentage of 45.6±1.18% was reported by Aryal *et al.* (1995) for two years old fattening goats and of 43% for intact male hill goats

(Aryal and Neopane, 1996). Dressing percentages of 44.7±0.45% and 50.8±0.99% were reported by Rao *et al.* (1984, 1985) for Black Bengal goats. It has been reported that carcass characteristics of goats are affected by breed, sex, live weight etc (McGregor, 1985, 1992; Rao *et al.*, 1988; Warmington and Kirton, 1990).

The dressing percentage of meat, including all edible offal was 68.1±0.84%, 69.1±1.57%, 68.0±0.74%, 63.3±1.94% and 67.2±2.62% for Ghorlie, Dhobini, Kali, Seti and Singari, respectively and this was significantly lower in Seti ($P<0.05$). Aryal *et al.* (1995) reported 62.76±5.09%, 62.2±2.01%, 62.46±2.37% and 68.43±4.14% dressing percentage for 1.0, 1.5, 2.0 and 2.5 year old fattening goats, respectively. A similar dressing percentage (62%) was also obtained from intact male hill goats (Aryal and Neopane, 1996).

**Table 2. Meat production and dressing percentage of meat from different color types goat**

| Parameters | Color types | | | | | Significance |
|---|---|---|---|---|---|---|
| | Ghorlie | Dhobini | Kali | Seti | Singari | |
| Live weight (kg) | 23.5 (±0.87) | 21.2 (±1.31) | 21.5 (±0.85) | 21.4 (±1.46) | 20.0 (±1.71) | NS |
| Meat production (kg) (excluding edible offal) | 11.5a (±0.43) | 10.5ab (±0.75) | 10.4ab (±0.34) | 9.83b (±0.70) | 9.88b (±0.97) | * |
| Dressing % | 49.1a (±0.37) | 49.5a (±1.41) | 48.4ab (±0.69) | 46.1b (±1.29) | 48.6ab (±1.69) | * |
| Total edible offal (kg) | 3.56 (±0.25) | 3.30 (±0.19) | 3.30 (±0.19) | 2.87 (±0.35) | 2.95 (±0.47) | NS |
| Total meat including edible offal (kg) | 16.0a (±0.70) | 14.7ab (±1.08) | 14.6ab (±0.55) | 13.5b (±1.05) | 13.7ab (±1.40) | * |
| Dressing percentage with edible offal | 68.1a (±0.84) | 69.1a (±1.57) | 68.0a (±0.74) | 63.3b (±1.94) | 67.2ab (±2.62) | * |

ab = Row means bearing the different letters are significantly different. Figures in parentheses are standard error.
* = Significant at $P<0.05$, NS = Non-significant

In Nepal, almost all body parts of goats except hoof, hair and horns are eaten. Goat carcasses are lean compared with other species of farm or ranch livestock (Smith *et al.*, 1982; Snowder *et al.*, 1982; Hale, 1990; Smith, 1992). A higher dressing percentage of meat was obtained when all edible offal was included in the meat. The carcass realization value depends on the meat eating habit of the country of community. Devendra and Burns (1970) reported that in many parts of the world, developing countries are to a greater or lesser extent dependent upon the goat as a meat supplier and make use of every part regardless of its quality. The situation is the same for Nepal, especially in the rural areas.

**By-products**

The by-product yield of different color type goats is presented in Table 3. The color type of goat has a significant effect on gut and fat weight. Seti had significantly low gut weight ($P<0.05$). However, the abdominal fat weight was significantly lower in Kali (0.302±0.062 kg) and the highest in Dhobini (0.800±0.295 kg) ($P<0.05$). McGregor (1992) reported that slow growth rates are associated with high rates of fat deposition, and excessive use of grain can lead to over-fat carcasses. Neopane (1997) reported that color type had a significant effect on birth weight and weaning weight of goats, and Seti and Singari were found to have the lowest weights. Aryal *et al.* (1995) and Aryal and Neopane (1996) reported similar results.

Table 3. By-product yield (edible offal) of different color type goats

| Parameters | Color types | | | | | Significance |
|---|---|---|---|---|---|---|
| | Glorlie | Dhobini | Kali | Seti | Singari | |
| Guts and intestines (kg) | 1.807a (±0.182) | 1.460ab (±0.125) | 1.847a (±0.079) | 1.336b (±0.128) | 1.574ab (±0.237) | * |
| Lungs, heart, spleen and kidney (kg) | 0.600 (±0.021) | 0.540 (±0.040) | 0.582 (±0.040) | 0.543 (±0.037) | 0.500 (±0.055) | NS |
| Liver (kg) | 0.579 (±0.028) | 0.500 (±0.032) | 0.564 (±0.039) | 0.543 (±0.030) | 0.540 (±0.040) | NS |
| Fat (kg) | 0.577ab (±0.091) | 0.800a (±0.295) | 0.302b (±0.062) | 0.446ab (±0.230) | 0.335ab (±0.193) | * |
| Total | 3.56 (±0.25) | 3.30 (±0.30) | 3.30 (±0.19) | 2.87 (±0.35) | 2.95 (±0.47) | NS |

ab = Row means bearing the different letters are significantly different. Figures in parentheses are standard error.
* = Significant at P<0.05, NS = Non-significant

## CONCLUSION

The results of this study confirmed that Seti (white color goats) produces less meat compared to that of Ghorlie. These findings have been found true with the farmers' perception. However, the reason for low meat production from white goats is not known. It indicates that there is an area for improvements by selection and breeding, with relation to color, for higher meat production from goats. But the social aspect of different color goats (requirement of different color of goats for different social work purposes) need to investigated and considered. It is still not known that whether the different color type goats are different breeds. Therefore, it is suggested to carry out an in-depth study to develop a suitable goat breed, by focusing on higher prolificacy (twin birth), multi-season kidding, higher growth rate, higher carcass yield and grade.

## ACKNOWLEDGEMENTS

I am grateful to Dr. L. Sherchan, Livestock Officer of the Department of Livestock Services, for his help in analyzing the data.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# NUTRIENT CONTENT IN THE FODDER TREES AND SHRUBS FOUND IN VARIOUS PARTS OF NEPAL

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## ABSTRACT

Nutrient content of various fodder trees and shrubs found in different parts of Nepal were determined during the past few years. A total of 84 fodder trees and shrubs were analyzed for their proximate, 58 for detergent and 43 for mineral contents. Variations within and among different species were observed. Dry matter content was highest in Bhimal (*Grewia oppositifolia*) and lowest in Nimaro (*Ficus roxburghii*) and Chuletro (*Brassaiopsis hainla*) with values of 42 and 21%, respectively. Crude protein (CP) content was generally high in most species indicating their suitability as good forage for supplementation of crop residues. Variation in CP content was quite high, with the highest of 31.17% in Kalo Siris (*Albizzia odoratissima*) and the lowest of 4.45% in Pata. Total ash (TA) content also varied greatly, with values as low as 2.06% in Phykar to 23.3% in Khadko. Organic matter content varied inversely to that of TA. Among the detergent fibres, acid detergent fibre varied from 19.5% in Barro (*Terminalia bellirica*) to 67.27% in Bholdung. Neutral detergent fibre was the highest in Bans and the lowest in Saj (*Terminalia alata*) with values of 74.93 and 25.21%, respectively. Acid detergent lignin content was generally high in all species with the highest of 32.91% in Bhote Archal but was as low as 1.27% in Pharse. Hemicellulose (HCEL) was generally low and individual samples were even negative. The highest HCEL was found in Bans (*Bamboosa* sp; 31.18%) and the lowest in Kamle (*Pilea wightii*, 0.31%). Cellulose content was generally low and was below 30% in most of the species. Calcium content was relatively high in all species, the highest being 5.77% in Chuletro and the lowest in Bans (0.31%). Phosphorus content varied from 0.14 to 0.78%. In conclusion, fodder trees and shrubs were found to be statisfactory in their nutrient content, with very good levels of CP and calcium.

## INTRODUCTION

Various types of fodder trees have been grown in Nepal from time immemorial. Species and types of fodder trees grown in various parts of the country differ according to the climate, altitude and ecozone. The practice of traditionally cultivating fodder trees by the farmers in their homestead, Baris, Kanlas, bunds etc. is very much common in the mid hills and to some extent in the high hills but not in Terai. Cultivation of fodder trees by the farmers in Terai started only after the migration of hill people down to the plains and is not yet a common practice. Their importance as a source of fodder is very high because our farmers know them and are growing them for centuries; harvesting is done mostly during the time when other feed resources are finished; crop yield is not affected much since marginal land, Kharbaris, Kanlas etc. are used for their cultivation. Their importance also lies in the conservation of environment through increased greenery, protection of soil from various types of erosion, supply of fuel wood after the green matter is fed to the animals and so forth. Therefore, they should be given high priority for reducing the fodder scarcity during long dry periods. This will be more practical, easily adaptable, simple, economical and sustainable.

These fodder trees are used particularly for feeding lactating ruminants e.g. buffaloes, cattle and goats, although other categories of ruminants are also not excluded. These are mostly used as fodder

during winter and early summer months when all other green forages, pastures and other feed resources get exhausted and a scarcity of feed and forage arises. As a result, not only the production of meat and milk from buffalo, goat and cattle declines but also the body conditions deteriorate. The decline in the production and body conditions would have been much severe if the practice of cultivation of fodder trees had not been there.

Weise (1984) estimated that total production from fodder trees accounts for about 15% (includes those cultivated by the farmers and those in the forest) of the total digestible nutrient requirement of the country. More than 170 species (Shrestha and Tiwari, 1992) of trees contribute to this amount of fodder, of which more than 40 species are traditionally cultivated by the farmers. Variations within species are also quite common.

Farmers have different opinions with regards to the nutritional value, preference, and feeding practices e.g. most farmers regard Badahar (*Artocarpus lakoocha*) as the most valuable one whereas farmers of Kaski, Parbat value Raj Khanyoo (*Ficus semicordata*) parallel to Badahar. Similarly, Tame Bans (*Dendrocalamus strictus*) is not commonly fed in most parts of the country but is extensively used and is the major fodder base for the farmers of Parbat and Baglung districts.

Nutritional analysis of these fodder trees is very important in order to identify the best ones in terms of nutrient content, adaptability, digestibility, bio-mass yield and dry matter production. Animal Nutrition Division has been studying various aspects of feeding fodder trees to the ruminants. This paper presents the last 5 years data on nutritional status of various fodder trees and shrubs available in different parts of Nepal.

## MATERIALS AND METHODS

### Data collection

This is the compilation of the work carried out in Animal Nutrition Division on the nutritional analysis of various fodder trees over the last 5 years.

### Sample collection

Although the data has been collected over the past few years, procedure for sample collection was same. Samples of fodder trees were collected from various parts of the country during different years. A standard 100 g sample was collected from all parts of the trees, bottom and upper part, inner and outer side and young and mature leaves. This was air dried in field and brought to the Division for detail chemical analysis. Altogether 84 fodder trees and shrub species were analyzed for their nutrient content.

### Chemical analysis

Laboratory analysis for different nutrients viz. crude protein (CP), dry matter (DM), organic matter (OM) and total ash (TA) were determined as per the methods described by AOAC (1980); detergent fibres viz. acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL) as per the method described by Goering and Van Soest (1967); cellulose and hemicellulose by subtraction, calcium by titration and phosphorus by spectrophotometry.

## RESULTS AND DISCUSSION

### Proximate Components

Table 1, 2 and 3 show the proximate components of various fodder trees and shrubs available in Nepal.

## Dry matter

Dry matter (DM) content of the tree fodder samples varied from 21 to 42%. Within species variation was also observed in all fodder trees, which is not surprising. This may be due to the difference in altitude, soil condition, aspect, stage of maturity and time of sample collection. DM content was the highest in Bhimal (42%) followed by Kalo Kavro (40%) whereas it was the lowest in Chuletro, Nimaro and Timilo (21%). Generally, DM content was around 30% and increased as the time of harvesting and maturing prolonged. It might have also seen affected by the leaf to twig ratio in the samples collected, which generally are inversely proportional. Since total biomass production from individual species was not studied, it is not possible to determine which particular species would give relatively more DM at a particular time.

## Crude protein

Crude protein (CP) content is the most important criterion for judging its nutritive value, although ADF, lignin and tannin content affect its availability to the animal. Most fodder trees and browse plants were high in CP content with values more than 10% and as high as 33%. However, a few fodder trees and shrubs were quite low in CP values e.g. Pata (4.45%), Kaiyo (6.66%) , Kyamuno (6.86%). Fodder trees like Kutmiro, Gindheri, Badahar were high in CP. They also produced high bio-mass yield. These are the same fodder trees, which are generally preferred by the farmers indicating their suitability for promotion at farmers level. However, they were also relatively high in ADF and lignin content. But fodder trees like Kimbu, Gedilo Chiple, Painyoo were high in CP and low in ADF and lignin content with relatively low bio-mass yield.

## Total ash and organic matter

Total ash (TA) content of the fodder trees and shrubs was generally high and organic matter (OM) content low. This may give some negative impression that less OM is available for digestion in the rumen when these fodder trees and shrubs are fed as the basal forage to various species of ruminants. But TA may also be available for body function if it is high in digestibility (which was not determined in this study) and have special significance under detrain physiological conditions. Specific mineral contents have to be determined for this purpose. They are high in certain minerals which are required for the ruminants e.g. calcium during early stage of lactation. Fodder trees of *Ficus* sp. contained high levels of TA than many other species.

**Table 1. Dry matter, organic matter, crude protein and total ash content of various fodder trees and shrubs found in Nepal**

| Name of the fodder trees/shrubs | | Dry matter | Organic matter | Crude protein | Total ash |
|---|---|---|---|---|---|
| Nepali | Botanical | | | | |
| Angeri | *Lyonia ovalifolia* | - | 91.19 | 9.50 | 8.81 |
| Amilee | *Tamarindus indica* | - | 94.50 | 19.17 | 5.50 |
| Amdung | - | - | 94.70 | 11.41 | 5.30 |
| Ipil Ipil | *Leucaena leucocephala* | 33.00 | 91.62 | 22.18 | 8.38 |
| Uttis | *Alnus nepalensis* | - | 95.97 | 14.25 | 4.03 |
| Umaro | - | - | 83.82 | 14.71 | 16.18 |
| Ausati | - | - | 93.66 | 16.60 | 3.34 |
| Katus | *Castanopsis indica* | 36.71 | 9610 | 15.57 | 3.90 |
| Karam | *Holoptelea integrifolia* | - | 90.70 | 13.79 | 9.30 |
| Karmsing | - | - | 91.62 | 15.32 | 8.38 |
| Kaiyo, Chillo | - | - | 94.93 | 6.66 | 5.07 |
| Kauso | - | - | 80.27 | 19.80 | 19.73 |
| Kavro Sheto | *Ficus lacor* | 37.00 | 87.69 | 14.19 | 12.31 |
| Kavro, Kalo | *Ficus infestoria* | 40.00 | 93.15 | 11.99 | 6.85 |
| Kamle | *Pilea wightii* | - | 82.44 | 10.79 | 17.56 |
| Kimbu | *Morus alba* | 31.00 | 87.07 | 18.66 | 12.93 |
| Kuto | - | - | 82.04 | 20.54 | 17.96 |
| Kutmiro | *Litsea polyantha* | 30.20 | 92.92 | 16.51 | 7.08 |
| Koiralo | *Bauhinia variegata* | 28.00 | 93.79 | 14.94 | 6.21 |
| Kyamuno | *Eugenia operculata* | - | 94.43 | 6.86 | 5.57 |
| Khadko | - | - | 76.71 | 15.21 | 23.29 |

| | | | | | |
|---|---|---|---|---|---|
| Khanayoo | *Ficus cunia* | - | 86.73 | 13.50 | 13.27 |
| Raj Khanyoo | *Ficus semicordata* | - | 87.60 | 10.80 | 12.40 |
| Khayar | *Acacia catechu* | - | 95.00 | 27.59 | 5.00 |
| Khari | *Celtis australis* | - | 85.31 | 19.41 | 14.69 |
| Khasru | *Quercus semicarpifolia* | - | 95.58 | 12.59 | 4.42 |
| Gaut | - | | 96.81 | 22.07 | 3.19 |
| Gayo | *Bridelia retusa* | 30.29 | 95.20 | 14.53 | 4.98 |
| Gindheri, Kalo | *Premna bengalensis* | - | 93.00 | 21.56 | 7.01 |
| Gindheri | *Premna latifolia* | 23.00 | 87.52 | 21.01 | 12.48 |
| Gedilo (Bedulo) | *Ficus clavata* | 31.00 | 85.92 | 16.30 | 14.08 |
| Gogan | *Saurauia nepaulensis* | - | 90.38 | 12.23 | 9.63 |
| Chasingba | - | - | 94.18 | 13.09 | 5.82 |
| Chiple (kaulo) | *Machilus gamblei* | 35.00 | 89.41 | 21.84 | 10.59 |
| Chuletro | *Brassaiopsis hainla* | 21.00 | 87.26 | 12.73 | 12.74 |
| Chyuri | *Bassia butyracea* | 36.65 | 85.32 | 13.50 | 14.68 |
| Jangal Jilebi | - | - | 97.96 | 15.80 | 2.04 |
| Jhingane | *Eurya cerasifolia* | - | 93.55 | 11.11 | 6.45 |
| Tanki | *Bauhinia purpurea* | 30.00 | 92.87 | 18.06 | 7.13 |
| Thotne (Khasreto | *Ficus hispida* | 31.00 | 83.03 | 15.73 | 16.97 |
| Dumri | *Ficus glomerata* | - | 84.15 | 12.55 | 15.85 |
| Timilo | *Ficus auriculata* | 21.00 | 84.10 | 13.14 | 15.90 |
| Tuisharo | - | - | 85.39 | 10.62 | 14.61 |
| Dabdabe | *Garuga pinnata* | 30.00 | 90.35 | 15.91 | 9.65 |
| Damar | - | - | 94.98 | 18.09 | 5.02 |
| Dudhilo | *Ficus nemoralis* | 30.00 | 90.46 | 11.53 | 9.54 |
| Narchur | - | - | 93.94 | 16.53 | 6.06 |
| Nigalo | *Arundinaria intermedia* | - | 92.66 | 13.08 | 7.34 |
| Nimaro | *Ficus roxburghii* | 21.00 | 85.29 | 10.88 | 14.71 |
| Pakhuri | *Ficus glaberrima* | 29.00 | 90.52 | 16.44 | 9.48 |
| Pata | - | - | 91.74 | 4.45 | 8.26 |
| Pipal | *Ficus religiosa* | - | 85.43 | 12.91 | 14.57 |
| Painyoo | *Prunus cerasoides* | 30.00 | 92.79 | 15.67 | 7.21 |
| Phaledo | *Erythrina arborescence* | 30.00 | 90.94 | 29.64 | 9.06 |
| Pharse | - | - | 92.96 | 13.50 | 7.04 |
| Phyakar | - | - | 97.94 | 10.22 | 2.06 |
| Bakaino | *Melia azedarach* | 29.00 | 89.15 | 21.64 | 10.85 |
| Badahar | *Artocarpus lakoocha* | 27.00 | 85.65 | 15.01 | 14.35 |
| Barro | *Terminalia bellirica* | - | 93.97 | 14.71 | 6.03 |
| Baldyangro | - | 35.00 | 94.18 | 25.97 | 5.82 |
| Bakhre | - | - | 88.01 | 15.06 | 11.99 |
| Bans | *Bamboosa sp.* | - | 87.61 | 12.04 | 12.39 |
| Bans, Rame | *Dendrocalamus strictus* | - | 87.61 | 9.09 | 12.39 |
| Bains | *Salix babylonica* | - | 91.33 | 15.30 | 8.67 |
| Bhatmase | *Flemingia congesta* | - | 95.20 | 26.50 | 4.80 |
| Bhimal | *Grewia oppositifolia* | 42.00 | 89.98 | 18.44 | 10.02 |
| Bheldo | - | - | 77.03 | 9.77 | 22.97 |
| Bhote archal | - | 23.43 | 91.53 | 15.54 | 8.57 |
| Bholdung | - | - | 95.67 | 9.39 | 4.33 |
| Rajbriksha | *Cassia fistula* | - | 92.92 | 29.03 | 7.48 |
| Lahare pipal | *Populous ciliata* | - | 91.31 | 14.11 | 8.69 |
| Bijaya sal | *Pterocarpus marsupium* | - | 93.78 | 18.48 | 6.22 |
| Shwami | *Ficus benjamina* | 31.17 | 89.26 | 13.40 | 10.74 |
| Saj | *Terminalia alata* | - | 93.73 | 7.81 | 6.27 |
| Sajh | *Terminalia tomentosa* | - | 93.15 | 14.60 | 6.85 |
| Singa | - | - | 95.12 | 11.08 | 4.88 |
| Sindure | *Mallotus philipiensis* | - | 92.90 | 15.80 | 7.10 |
| Simal | *Bombax malabaricum* | - | 93.30 | 15.38 | 7.70 |
| Sirish | *Albizzia odoratissima* | - | 94.04 | 26.31 | 5.96 |
| Sirish, Kalo | *Albizzia lebbeck* | - | 93.76 | 31.17 | 6.24 |
| Srirish, Seto | *Dalbergia sissoo* | - | 94.83 | 28.24 | 5.17 |
| Sissoo | *Grewia tiliaefolia* | 35.00 | 89.70 | 21.35 | 10.30 |
| Syalphusro | *Terminalia chebula* | - | 92.00 | 15.88 | 8.00 |
| Harro | - | - | 94.40 | 12.94 | 5.60 |

**Detergent fiber components**

Most of the fodder trees and shrubs were found to contain relatively low levels of cellulose which is the main source of volatile fatty acids used as energy by the ruminants. Although hemicellulose

content in many of them was mediocre, some of them were very low and some individual samples of these fodders were even negative which is not common. Relatively low levels of cellulose has also been reported by Subba (1998) in various fodder trees and shrubs found in the eastern part of Nepal. Some of them were very high in NDF content e.g. Bans (74.93%), Bholdung (74.71%), Nigalo (71.81%).

**Table 2. Detergent fibre components in various fodder trees and shrubs available in different parts of Nepal**

| Name of the fodder trees/shrubs | | NDF | ADF | ADL | HCEL | CELL |
|---|---|---|---|---|---|---|
| Nepali | Botanical | | | | | |
| Ipil Ipil | *Leucaena leucocephala* | 53.03 | 37.86 | 20.31 | 20.60 | 17.55 |
| Umaro | - | 68.66 | 41.21 | 7.31 | 27.44 | 33.90 |
| Ausati | - | 61.49 | 55.21 | 28.03 | 6.28 | 27.18 |
| Karam | *Holoptelea integrifolia* | 35.13 | 31.04 | 10.07 | 4.09 | 20.97 |
| Kavro Sheto | *Ficus lacor* | 60.43 | 53.73 | 26.74 | 6.69 | 27.00 |
| Kavro, Kalo | *Ficus infestoria* | 65.59 | 53.23 | 18.89 | 12.36 | 34.34 |
| Kamle | *Pilea wightii* | 47.35 | 47.05 | 21.89 | 0.31 | 25.16 |
| Kimbu | *Morus alba* | 47.13 | 30.45 | 8.43 | 16.67 | 22.03 |
| Kuto | - | 44.37 | 42.79 | 19.11 | 1.58 | 23.68 |
| Kutmiro | *Litsea polyantha* | 62.68 | 53.69 | 31.85 | 8.99 | 21.84 |
| Koiralo | *Bauhinia variegata* | 52.67 | 45.18 | 21.73 | 7.49 | 26.38 |
| Khadko | - | 37.96 | 26.63 | 10.56 | 11.33 | 16.07 |
| Khanayoo | *Ficus cunia* | 51.00 | 43.62 | 19.98 | 7.38 | 23.34 |
| Raj Khanyoo | *Ficus semicordata* | 31.32 | 26.20 | 11.25 | 10.41 | 14.28 |
| Khari | *Celtis australis* | 45.38 | 32.42 | 13.79 | 12.97 | 18.63 |
| Gayo | *Bridelia retusa* | 57.78 | 48.97 | 20.78 | 8.81 | 28.19 |
| Gindheri, Kalo | *Premna bengalensis* | 60.47 | 46.82 | 23.15 | 13.65 | 23.67 |
| Gindheri | *Premna latifolia* | 54.93 | 44.60 | 20.18 | 10.37 | 24.42 |
| Gedilo (Bedulo) | *Ficus clavata* | 44.46 | 37.31 | 7.99 | 7.15 | 29.32 |
| Gogan | *Saurauia nepaulensis* | 57.58 | 51.05 | 26.48 | 6.53 | 24.57 |
| Chiple (Kaulo) | *Machilus gamblei* | 42.62 | 31.94 | 13.25 | 10.68 | 18.69 |
| Chuletro | *Brassaiopsis hainla* | 48.28 | 44.91 | 21.86 | 3.37 | 23.05 |
| Chyuri | *Bassia butyracea* | 47.08 | 43.64 | 17.10 | 3.44 | 26.54 |
| Jhingane | *Eurya cerasifolia* | 44.95 | 33.81 | 12.12 | 11.14 | 21.70 |
| Tanki | *Bauhinia purpurea* | 58.64 | 47.31 | 19.85 | 11.33 | 27.34 |
| Thotne (Khasreto) | *Ficus hispida* | 49.71 | 41.24 | 18.36 | 8.47 | 22.89 |
| Dumri | *Ficus glomerata* | 56.36 | 51.57 | 30.91 | 4.79 | 20.66 |
| Timilo | *Ficus auriculata* | 52.49 | 45.67 | 21.58 | 6.83 | 24.09 |
| Tuisharo | - | 45.03 | 46.69 | 19.20 | 1.66 | 27.49 |
| Dabdabe | *Garuga pinnata* | 39.90 | 31.97 | 12.46 | 7.93 | 19.51 |
| Dudhilo | *Ficus nemoralis* | 46.57 | 44.22 | 18.93 | 2.35 | 25.30 |
| Nigalo | *Arundinaria intermedia* | 71.81 | 37.30 | 8.85 | 34.51 | 28.46 |
| Nimaro | *Ficus roxburghii* | 42.14 | 34.65 | 12.72 | 7.49 | 21.93 |
| Pakhuri | *Ficus glaberrima* | 45.70 | 37.90 | 19.90 | 7.80 | 18.00 |
| Pipal | *Ficus religiosa* | 45.65 | 37.64 | 13.75 | 8.01 | 23.90 |
| Painyoo | *Prunus cerasoides* | 39.21 | 27.07 | 12.01 | 12.14 | 15.06 |
| Phaledo | *Erythrina arborescence* | 41.30 | 33.27 | 11.78 | 8.02 | 21.49 |
| Pharse | - | 49.69 | 22.62 | 1.27 | 27.07 | 21.35 |
| Bakaino | *Melia azedarach* | 45.80 | 32.77 | 13.01 | 6.52 | 13.66 |
| Badahar | *Artocarpus lakoocha* | 51.62 | 42.40 | 17.23 | 9.09 | 25.17 |
| Barro | *Terminalia bellirica* | 27.39 | 19.49 | 6.04 | 7.80 | 13.45 |
| Bakhre | - | 43.65 | 31.85 | 11.51 | 11.80 | 20.34 |
| Bans | *Bamboosa sp.* | 74.93 | 43.75 | 10.97 | 31.18 | 32.78 |
| Bans, Tame | *Dendrocalamus strictus* | 61.11 | 35.89 | 12.28 | 25.22 | 23.62 |
| Bains | *Salix babylonica* | 52.84 | 43.36 | 20.75 | 9.49 | 22.61 |
| Bhimal | *Grewia oppositifolia* | 46.44 | 33.48 | 10.70 | 12.96 | 22.77 |
| Bhote Archal | - | 59.28 | 56.10 | 32.91 | 3.18 | 23.19 |
| Bholdung | - | 74.71 | 6727 | 34.96 | 7.44 | 32.31 |
| Lahare pipal | *Populous ciliata* | 44.71 | 30.74 | 12.90 | 13.97 | 17.84 |
| Shwami | *Ficus benjamina* | 53.45 | 47.28 | 17.33 | 6.17 | 29.95 |
| Saj | *Terminalia alata* | 25.21 | 21.61 | 8.82 | 3.60 | 12.79 |
| Sajh | *Terminalia tomentosa* | 53.67 | 52.67 | 34.77 | 1.00 | 17.90 |
| Singa | - | 60.91 | 45.64 | 17.41 | 15.26 | 28.24 |
| Sindure | *Mallotus philippensis* | 62.55 | 48.91 | 19.50 | 13.64 | 29.41 |
| Simal | *Bombax malabaricum* | 56.22 | 44.37 | 20.66 | 11.85 | 23.71 |
| Sissoo | *Dalbergia sissoo* | 60.73 | 53.69 | 25.36 | 7.04 | 28.33 |
| Syalphusro | *Grewia tiliaefolia* | 55.90 | 43.61 | 21.00 | 12.28 | 22.62 |
| Harro | *Terminalia chebula* | 38.22 | 30.52 | 10.07 | 7.71 | 20.44 |

**Table 3. Calcium and phosphorus content in various fodder trees and available in different pats of Nepal**

| Name of the fodder trees/shrubs | | Minerals | |
|---|---|---|---|
| Nepali | Botanical | Calcium | Phosphorus |
| Amdung | - | - | 0.23 |
| Ipil Ipil | *Leucaena leucocephala* | 2.63 | 0.22 |
| Umaro | - | 4.15 | 0.27 |
| Katus | *Castanopsis indica* | - | 0.22 |
| Kainyo, Chillo | - | - | 0.23 |
| Kavro, Seto | *Ficus infestoria* | 2.73 | 0.40 |
| Kamle | *Pilea wightii* | 5.33 | 0.42 |
| Kimbu | *Morus alba* | 4.04 | 0.40 |
| Kuto | - | 2.27 | 0.34 |
| Kutmiro | *Litsea polyantha* | 1.21 | 0.38 |
| Koiralo | *Bauhinia variegata* | 1.83 | 0.16 |
| Khadko | - | 4.81 | 0.14 |
| Khanayoo | *Ficus cunia* | 2.24 | 0.20 |
| Khari | *Celtis australis* | 3.72 | 0.25 |
| Gindheri, seto | *Premna bengalensis* | 1.67 | 0.24 |
| Gedilo (Bedulo) | *Ficus clavata* | 2.02 | 0.30 |
| Gogan | *Saurauia nepaulensis* | 1.93 | 0.28 |
| Chasongba | - | - | 0.23 |
| Chuletro | *Brassaiopsis hainla* | 5.72 | 0.34 |
| Chyuri | *Bassia butyracea* | 3.46 | 0.18 |
| Jhingane | *Eurya cerasifolia* | 0.92 | 0.22 |
| Tanki | *Bauhinia purpurea* | 1.55 | 0.25 |
| Thotne (Khasreto | *Ficus hispida* | 2.49 | 0.24 |
| Timilo | *Ficus auriculata* | 3.01 | 0.21 |
| Tuisharo | - | 4.26 | 0.18 |
| Dudhilo | *Ficus nemoralis* | 2.40 | 0.20 |
| Nigalo | *Arundinaria intermedia* | 0.56 | 0.17 |
| Painyoo | *Prunus cerasoides* | 1.27 | 0.29 |
| Phaledo | *Erythrina arborescence* | 1.22 | 0.78 |
| Pharse | - | 1.91 | 0.15 |
| Bakaino | *Melia azedarach* | 2.00 | 0.34 |
| Badahar | *Artocarpus lakoocha* | 1.38 | 0.27 |
| Bakhre | - | - | 0.24 |
| Bans | *Bamboosa sp.* | 0.36 | 0.19 |
| Bans, Tame | *Dendrocalamus strictus* | 0.77 | 0.22 |
| Bains | *Salix babylonica* | 3.10 | 0.34 |
| Bhimal | *Grewia oppositifolia* | 2.08 | 0.13 |
| Bheldo | - | - | 0.23 |
| Bhote Archal | - | - | 0.23 |
| Bholdung | - | 0.77 | 0.20 |
| Lahare pipal | *Populous ciliata* | 4.44 | 0.22 |
| Singa | - | 1.46 | 0.24 |
| Syalphusro | *Grewia tiliaefolia* | 1.09 | 0.41 |

## CONSLUSION

Most of the fodder trees and shrubs were nutritionally good, with CP values higher than 10% and as high as 33%. They were also high in lignin, an antinutrient compound, which may reduce the availability of protein to the animals. Calcium content of the fodder trees were quite high, up to 5.72%. High CP with high calcium content could be very useful as a green forage for high yielding lactating animals during early stage of lactation in minimizing the milk fever. Total ash content of these green forages were relatively high which is an indication of less OM being available to the animals. With regards to detergent fibers, both cellulose and hemicellulose were a bit low. Detail

analysis of these fodders and shrubs both *in vivo* and *in vitro* as well as estimation of bio-mass yield is necessary in future.


## ACKNOWLEDGEMENTS

Authors are thankful to the technicians of Animal Nutrition Division for laboratory analysis, data entry and storage in the computer.


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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# POSTERIOR PARALYTIC SYNDROME IN GOATS IN BANKE DISTRICT OF MID-WESTERN REGION OF NEPAL

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## ABSTRACT

The cause of the posterior paralytic syndrome in goats of mid-western region of Nepal is not due to poisoning, traumatic injury to the lumbar region, Helminths parasitism and nutritional deficiency of calcium, phosphorus, vitamin D or vitamin A. The disease is suspected to be caused by parasitism of the spinal cord.

## INTRODUCTION

Since 1986/87, posterior paralytic syndrome in goats, locally known as Kumri (literally meaning weak back) was noticed in the goat rearing pockets of Banke district of mid-western region of Nepal. Three years later, it was also reported in Bardiya, Kailali and Surkhet districts of the same region. Till date, it can be said that the disease is localized in the mid-western region. Initially, when the disease outbreak occurred during the festival time (Dashain and Tihar), the outmost selling period, the farmers got setback due to the high morbidity rate. It created such a havoc that the farmers in Banke district exchanged the goat with rice as a barter system in equal weight basis. When there was an outbreak the morbidity rate was is in between 15-20% and the mortality rate was 2.5%. About 5-10% of the goats showed the symptom of posterior limbs weakness and partial paralysis after the recovery from the disease (Karki, 2053 BS). Actual mortality and morbidity rate was not known as the farmers tend to sell the goats at cheap price to the local butchers before the diseased goats die. The disease is mostly seen during peak winter months (September-January) after the monsoon when there is breeding of mosquitoes and their activities and number increased tremendously.

The clinical signs and symptoms of posterior paralytic syndrome in goats are suggestive of the possibilities of involvement of one of the following factors:

a. Poisoning
b. Traumatic injury to the lumber region
c. Helminths parasites
d. Nutritional deficiency of calcium, phosphorus, vitamin D or vitamin A.
e. Parasites of the spinal cord

Before commencing of the research, the above 5 factors were considered for the etiology

## MATERIALS AND METHODS

As the epidemiological and etiologic factors of the posterior paralytic syndrome in goats were not ascertained, focus were put forth in finding the same. Therefore, basic research criteria such as field survey, faecal sample examination, blood smear examination, post-mortem study of diseased animals, histopathological study of the viscera and the spinal cord and the cerebrospinal fluid (C.S.F.) of healthy and diseased goats were taken for analysis. Symptomatic treatment and its response was also studied.

## RESULTS AND DISCUSSION

### Clinical signs and symptoms

On physical examination of the diseased goats, the physiological parameters i.e. body temperature, respiratory rate, heart rate and even rumination seemed to be normal. However, the diseased goats showed the following signs:

- Complete paralysis of the hind legs, no pinching reflex in the toes and tail hence the animal dragged the posterior portion for locomotion.
- Partial paralysis of the hind legs with tremblings gait.
- Paralysis of one side of the body hence laid down only on one side and unable to move. Extension of the head and hind legs in the opposite direction like in the case of Tetanus.
- Ate normally until it could move and when the disease advanced the condition worsened to paralysis, then became unable to eat. However, ate normally while mouth feeding.
- In untreated cases, the goats died within 10 days after showing clinical signs and in recovered cases, the goats exhibited partial paralysis.
- The morbidity rate was15-20% in a flock and the mortality rate was 2-5%.

### Poisoning

On physical examination of diseased goats, the signs and symptoms exhibited did not match to the poisoning case. The post-mortem findings of the goats also did not indicate any signs of poisoning of any kind.

### Traumatic injury to the lumbar region

There was no signs of any injury, cuts or burns in the external body as well as in the internal organs. The syndrome was thus not due to traumatic injury to the lumbar region.

### Nutritional deficiency

The goats in the flock were watered, fed and grazed together. The managemental conditions were same for the flock. However, the morbidity was between 15-20% only, which indicated that the syndrome was not due to nutritional deficiency. Therapeutic doses of calcium, phosphorus, vitamins A and D were administered in some diseased cases without giving Diethylcarbamazine (DEC) or Ivermection, but the recovery was not there. In the case where DEC was given, recovery was satisfactory. Hence, the syndrome was not due to any nutritional factors.

### Post-mortem findings

Four goats suffering from posterior paralytic syndrome were ethunasized for post-mortem examination. Post mortem revealed that in two cases it was hydropericardium and pale liver and other visceral organs were found normal. However, the sciatic nerve was enlarged. The spinal cord was quite normal. No filarial parasites were observed in the peritonial cavity. However, in two cases cestode and nematode parasites were seen.

## Collection of cerebrospinal fluid

Cerebrospinal fluid (CSF) samples were collected from three clinically healthy and three suffering from posterior paralytic syndrome goats by cisternal punture method.

CSF from posterior paralytic syndrome goats was similar to that of the normal ones in terms of colour and turbidity where as the pH value is increased in diseased goats (Table 1).

**Table 1. Cerebrospinal fluid differentiation from healthy and diseased goats**

| Parameter | Healthy | Diseased |
|---|---|---|
| Colour | Colourless | Colourless |
| Turbidity | Absent | Absent |
| pH | 7.75 | 8.17 |

## Parasitological investigation

With the total faecal samples of 139 and 63 in the year 1996/97 and 1997/98, respectively from the goats with posterior paralytic syndrome, only 92 and 26 cases, respectively were positive for Helminths and protozoan parasites. From this, it could be concluded that the disease was not due to helminthiasis as goats free from internal parasites were also suffering from the posterior paralytic syndrome ( Table 2).

**Table 2. Faecal samples examination of goats showing posterior paralytic syndrome**

| | 1996/97 | 1997/98 |
|---|---|---|
| Total faecal samples | 139 | 63 |
| Positive for parasites | 92 | 26 |
| *Strongyle* spp. | 59 | 13 |
| *Trichuris* spp. | 10 | 3 |
| *Coccidia* spp. | 2 | 1 |
| Mixed infestation | 21 | 9 |

## Haematological investigation

Total 121 blood samples in the year 1996/97 and 1997/98 were examined for blood parasites and differential leucocyte count.

No blood protozoan and blood parasites were found in 121 samples taken from the diseased goats. Most of the blood smears were prepared in the noon time. All the parameters except Eosinophilic (slightly) seemed to be normal (Table 3).

**Table 3. Differential leucocyte count from blood smear of goats showing posterior paralytic syndrome**

| Normal value | Parameter | Mean±SE |
|---|---|---|
| 0-3 | Basophil | 0.46±0.10 |
| 1-8 | Eosinophil | 8.78±0.38 |
| 1-5 | Monocyte | 0.93±0.16 |
| 40-75 | Lymphocyte | 57.63±1.30 |
| 10-50 | Neutrophil | 32.20±1.25 |

### Histopathological examination

Histopathological examination of autopsied goats' visceral organs and the spinal cord were conducted. Section of lungs revealed congestion and pheumonia. There was no change in the spinal cord.

### Treatment response

Apart from the supportive therapy, treatment with Diethylcarbamazine (DEC) 10 mg/kg body weight and Ivermection at the rate of 1 ml/15 kg body weight responded very well. Almost a complete recovery was obtained when treated within the 3 days of showing clinical signs. However, at the late stage of the disease, there was only partial recovery with trembling gaits. For preventive measure, it is advised to give 100 mg DEC per goat per month from Srawan to Kartik in the outbreak areas. The result of the preventive measure has drastically reduced the morbidity rate of the disease.

## CONCLUSION

Though the exact cause of the posterior paralytic syndrome in goats at the mid-western region of Nepal is yet to be find out, the factors like poisoning, traumatic injury to the lumbar region, Helminths parasitism and nutritional deficiency of calcium, phosphorus, vitamin D or A have been ruled out from the above results. The cause of parasitism to the spinal cord is still unknown. There was no change in spinal cord on histopathological examination. Hence, more samples should be collected for histopathology in future. The pH of the cerebrospinal fluid in the diseased goats is higher than the clinically healthy goats, which may be due to parasitism (filarial larvae?) of the spinal cord (Bhatia *et al.*, 1972). From the slaughtered buffaloes in the outbreak areas, the adult Setaria worm has been collected from the peritonial cavity, which confirms that the areas have Setaria infestation in bovines. The treatment response of Diethylcarbamazine (10mg/kg body wt) and Ivermection(1 ml /15 kg body wt ) is responding very well, which also suggest that the syndrome to be of filarial worm parasitism. The preventive measure suggested to the farmers has also resulted positively as the morbidity rate has been declined drastically.

## ACKNOWLEDGEMENT

We express our sincere thanks to Dr. A. Pradhan, Chief, Animal Health Research Division of Nepal Agricultural Research Council and U. M. Singh for their active involvement in the study. Mr. B. Kunwar and S. B. KC are sincerely acknowledged for their involvement in collecting data and laboratory works. Mr. G. Shrestha is gratefully acknowledged for computer typing of the manuscript.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# PRELIMINARY STUDY ON DISEASES, WITH SPECIAL REFERENCE TO RESPIRATORY PROBLEMS IN GOATS IN TANAHU DISTRICT OF NEPAL

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## ABSTRACT

A questionnaire survey was conducted in the three selected study sites and Agricultural Research Station (ARS, Goat) at Bandipur for the preliminary study on diseases, with special reference to respiratory problems in goats of Tanahu District. Data on the purposes of goat keeping, problems of goat keeping, disease problems in goats, systems of goat keeping etc. were recorded. The treatment case records of the District Livestock Services Office of Tanahu and ARS, Bandipur were analyzed for identifying the disease problems in goats. Among the various disease problems in goats, internal parasitic and respiratory diseases were accounted to be the first two major diseases of goats. The bacteriological examination of the nasopharyngeal swabs and lungs sample from goats detected were: *Esherichia coli, Streptococcus* spp., *Staphylococcus* spp., *Proteus* spp., *Pasterurella* spp., *Haemolytica* spp. and *Mycoplasma* spp.

## INTRODUCTION

Goats are one of the predominant domestic ruminants mainly reared for meat and manure production in the hills and mountains of western Nepal. Diseases and parasites form one of the main constraints to goat production in many parts of the tropics (Devendra and McLorey, 1982). The success of goat husbandry depends upon the disease free status of the herd, for which knowledge of various disease entities affecting them is of paramount importance.

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. Respiratory diseases in goats of Agricultural Research Station (ARS, Goat) at Bandipur and in the villages of Tanahu district are the major health problems. Data on the causes of the higher number of cases of respiratory disease are insufficient. On post-mortem examination of goats at ARS, Bandipur, in majority of cases, the pneumonic conditions of lungs were observed (Annual Report, 1995).

This paper reports on the preliminary study on the diseases, with special reference to respiratory disease in goats in Tanahu District of western Nepal.

## MATERIALS AND METHODS

With the assistance of the staff of District Livestock Services Office of Tanahu District, three different sites of major goat rearing areas at different altitudes were selected. Altitude-wise the three sites were Ranipokhari (high altitude), Deurali (mid altitude) and Dulegauda (low altitude). Along with the three research sites in the villages, ARS, Bandipur was included as a fourth site for this

study. A questionnaire was designed to know the purposes of goat rearing, season for high incidence of respiratory disease and also conditions of existing management systems. One hundred and eighty farmers, 60 in each study site were interviewed using the designed questionnaire.

The treatment case records from 1996 to 1997 of the District Livestock Services Office and Livestock Services Centres of respective study sites from 1990 to 1997 of ARS, Bandipur were analyzed to know the existing disease problems of goats.

Ninety-four nasopharyngeal swabs were randomly collected from the goats having purulent nasal discharge. Five lung samples from the autopsied goats at ARS, Bandipur were also collected for the laboratory investigation. The nasopharyngeal swabs and lungs samples were subjected to general bacteriological and mycoplasma culture. During the visits, data on the management aspects particularly housing of goats, ventilation and disposal system of manure and urine were also gathered.

## RESULTS AND DISCUSSION

The results of the questionnaire survey and treatment record analysis are presented in Table 1, 2, 3, 4, 5, 6 and 7.

Table 1. Purposes of goat keeping

| Purpose | Survey sites | | | Total | Percentage |
|---|---|---|---|---|---|
| | Ranipokhari | Dulegauda | Deurali | | |
| Cash income | 47 | 36 | 58 | 141 | 30.4 |
| Manure | 55 | 49 | 53 | 157 | 33.9 |
| Meat consumption | 43 | 45 | 52 | 140 | 30.2 |
| Others | 8 | 10 | 7 | 25 | 5.4 |

Total farmers interviewed = 180; Total response = 463

Table 2. Problems of goat keeping

| Purpose | Survey sites | | | Total | Percentage |
|---|---|---|---|---|---|
| | Ranipokhari | Dulegauda | Deurali | | |
| Feed/Pasture | 11 | 11 | 10 | 32 | 6.9 |
| Disease | 56 | 49 | 55 | 160 | 34.7 |
| Lack of medicines | 54 | 31 | 40 | 125 | 27.1 |
| Technical know how about management | 17 | 12 | 24 | 53 | 11.5 |
| Labour shortage | 17 | 18 | 17 | 52 | 11.3 |

Total farmers interviewed = 180; Total response = 461

Table 3. Disease problems in goat at Tanahu district

| Disease | Survey sites | | | Total | Percentage |
|---|---|---|---|---|---|
| | Ranipokhari | Dulegauda | Deurali | | |
| Internal parasites/diarrhea | 55 | 57 | 48 | 160 | 34.7 |
| Respiratory disease/Pneumonia | 44 | 52 | 37 | 133 | 28.8 |
| Gid | 14 | 14 | 6 | 34 | 7.4 |
| Tympany/Impaction | 13 | 16 | 4 | 33 | 7.1 |
| External parasites | 18 | 15 | 21 | 54 | 11.7 |
| Swelling of head | 3 | 6 | 4 | 13 | 2.8 |
| Others | 3 | 7 | 24 | 34 | 7.4 |

Total farmers interviewed = 180; Total response = 461

**Table 4. Treatment case record analysis from 1996 to 1997 of District Livestock Services Office, Tanahu and Ranipokhari, Dulegauda and Deurali Livestock Services Centres, Tanahu**

| Disease | District Livestock Service Office | Ranipokhari | Dulegauda | Dharampani Deurali | Total |
|---|---|---|---|---|---|
| Internal parasites/diarrhea | 108 (40.9) | 112 (67.5) | 119 (66.1) | 60 (65.2) | 399 (56.8) |
| Respiratory disease/Pneumonia | 67 (25.4) | 26 (15.6) | 17 (9.4) | 8 (8.7) | 118 (16.8) |
| Fever (Septicemia) | 21 (7.9) | - | - | - | 21 (3.0) |
| Tympany | 8 (3.0) | 4 (2.4) | 8 (4.4) | 3 (3.3) | 23 (3.3) |
| External parasites | 6 (2.3) | 8 (4.8) | 12 (6.6) | 6 (6.6) | 32 (4.5) |
| Swelling of head | 54 (20.4) | 16 (9.2) | 24 (13.3) | 15 (16.3) | 109 (15.5) |
| Total | 264 | 166 | 180 | 92 | 702 |

Figures in parentheses are the percentage of the total disease cases in each column.

**Table 5. Treatment case record analysis from 1990 to 1997 of Agricultural Research Station (Goat), Bandipur**

| Disease/Pathological condition | Number treated | Percentage |
|---|---|---|
| Internal parasites | 716 | 35.7 |
| Pneumonia | 497 | 24.7 |
| Enteritis | 316 | 15.7 |
| Metritis | 159 | 7.9 |
| Wound | 81 | 4.0 |
| Eye infection | 70 | 3.5 |
| Plant poisoning | 35 | 1.7 |
| Bone fracture | 15 | 0.7 |
| Mastitis | 13 | 0.6 |
| Tympany | 6 | 0.3 |
| Other | 99 | 4.9 |
| Total | 2007 | 100 |

**Table 6. Systems of goat keeping in the study areas**

| System | Survey sites | | | Total | Percentage |
|---|---|---|---|---|---|
| | Ranipokhari | Dulegauda | Deurali | | |
| Stall Feeding | 13 | 4 | 12 | 29 | 16.1 |
| Partial grazing | 47 | 56 | 48 | 151 | 83.9 |

Total farmers interviewed = 180

**Table 7. Duration of removal of dung from the pen**

| System | Survey sites | | | Total | Percentage |
|---|---|---|---|---|---|
| | Ranipokhari | Dulegauda | Deurali | | |
| 1 -3 months | 11 | 10 | 17 | 38 | 21.2 |
| 4-6 months | 20 | 44 | 33 | 97 | 53.8 |
| 6 -12 months | 29 | 6 | 10 | 45 | 25.0 |

Total farmers interviewed = 180

Of the farmers interviewed, 78% responded that respiratory problem occurs mainly during winter season whereas 22% responded that this problem is major during rainy season.

The questionnaire survey results and treatment case record analysis revealed that the two major diseases accounted were internal parasitic and respiratory diseases (Tables 3, 4 and 5). These results clearly indicate that there is urgent need for the development and launching of effective and economic preventive/treatment measures against these two major disease problems.

The internal parasites identified in the goats of Tanahu district were *Strongylus* spp. (69.5%), *Eimeria* spp. (23%), *Trichuris* spp. (4.4%), *Fasciola* spp. (1.7%), *Paramphistomum* spp. (0.7%) and 0.7% *Monezia* spp. (Annual Report, 1995).

**Table 8. Bacterial species isolated from nasopharyngeal swabs and lungs of goats**

| Bacterial species isolate | Number of isolates from nasal swabs | Number of isolates from lungs |
|---|---|---|
| *Esherichia coli* | 34 | - |
| *Streptococcus* spp. | 12 | - |
| *Staphylococcus aureus* | 7 | 2 |
| *Proteus* spp. | 6 | - |
| *Staphylococcus epidermidis* | 5 | - |
| *Pasteurella haemolytica* | 2 | 2 |
| *Mycoplasma* spp | - | 3 |

The results of the bacteriological examination of nasopharyngeal swabs and lungs samples revealed that apart from *Pasteurella haemolytica* and *Mycoplasma* spp. the other bacterial species isolated are not considered to be major causes of respiratory problems in goats. Further attempts should be made to find out the actual pathogens playing role in causing respiratory problems in goats. The existing goat rearing practices in the villages of Tanahu district may contribute to respiratory diseases. The over crowding of goats in the pen during night and long storage of droppings and urine below goat pens in villages may be predisposing factors for the occurrence of respiratory disease. Therefore, awareness to the farmers needs to be created so as to follow the good management practices for rearing goats.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# PRODUCTIVITY, NUTRIENT CONTENT AND UTILIZATION OF MAJOR FODDER TREE LEAVES (BADAHAR, KUTMIRO, DABDABE, NIMARO) BY GOATS UNDER STALL-FED CONDITION

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## ABSTRACT

A trial was conducted to assess the productivity, palatability of major fodder tree and utilization of tree leaves by goats in stall-fed management. Four different fodder trees species such as Badahar (*Artocarpus lakoocha*), Tanki (*Bauhinia purpurea*), Dabdabe (*Garuga pinnata*), Nimaro (*Ficus roxburghii*) were tagged and lopped to get the tree leaves production. Morphological characters such as branch extension, tree height, tree circumference (breast height) were recorded. Leaves were analyzed for proximate composition. Sixteen growing goat hoggets were assigned to four types of tree leaves, used to estimate the utilization of tree leaves, and feed conversion efficiency.

Dry matter production was better in *G. pinnata* (54.9 kg/tree/year) followed by *F. roxburghii* (26.33 kg), *A. lakoocha* (24.89 kg/tree/tree), and *B. purpurea* (10.17 kg/tree/year). But *A. lakoocha* ranked first in feed utilization (87.32%), feed conversion efficiency (15.14± 67%), dry matter digestibility percent (73.0 + 7.4), crude protein digestibility percent (86.2 ± 5.4), and growth performance (70.0 ± 7.74 g/d) compared to other three tree leaves. Feed intake was the lowest in *F. roxburghii* (349.55 ± 13.27) recording heights to *G. pinnata* (455.6 ±13). Lower leaves intake in *F. ruxburghii* may be due to broad leaves.

Dry matter intake, growth performance and feed conversion efficiency of four different tree leaves in goat was significantly different. Looking at the response to the growth performance, *A. lakoocha* leaves were the best followed by *B. purpurea*, *G. pinnata* and *F. roxburghii*. With proper management, goat can be reared with different level of growth performance (30.0 to 70.0 g/d) in the tree leaves diet under stall-feed condition.

## INTRODUCTION

Goat contributes to the subsistence of small farmer and landless rural poor. The opportunity to increase goat meat production is enormous in the context of the more efficient use of production resources and innovative nutritional strategies. Goat production is suffered by acute feed shortage and lack of grazing land due to the activities carried out by community forestry. These two situation demanded to develop a fodder based feeding package and adopt stall-feed management system.

## MATERIALS AND METHODS

### Fodder production and tree measurement

Fodder tree used in the experiment were shown in Table 1.

Table 1. Fodder tree species

| Species | Local name | Species code |
|---|---|---|
| *Artocarpus lakoocha* | Badahar | AL |
| *Bauhinia purpurea* | Tanki | BP |
| *Garuga pinnata* | Dabdabe | GP |
| *Ficus roxburghii* | Nimaro | FR |

Total 10 mature fodder trees in each fodder species were randomly selected, tagged and used to collect the fodder production and plant morphological information. Fodder trees were Badahar (AL), Tanki (BP), Dabdabe (GP) and Nimaro (FR). Trees were lopped once in a year. Total edible twigs and leaves production were recorded. Plant height and branches extension (canopy) was recorded for each trees in all four fodder species. Two separate samples of fresh leaves were taken from the lopped tree for proximate principle analysis.

**Fodder utilization**

Total of 16 growing female hoggets goats of 5-6 months age of similar weight were used to find out the utilization of fodder leaves, effect of leaves on the live weight change, and feed conversion efficiency. The growing female hogget were of almost similar body weight and body condition (3 to 4 score). The experiment lasted for 60 days after one week adjustment period.

**Design and treatments**

The 16 growing female hoggets were randomly and equally divided into 4 groups. RCBD design was used to allocate the animal. Animals were individually penned in a metabolism pen of 1 meter long and 0.45 meter width with 1 meter height of open top up to roof. Following treatments were imposed to see the effect of fodder leaves feeding on the live weight change.

T1 (Diet 1): Badahar (AL) leaves + 100 gram concentrate
T2 (Diet 2): Tanki (BP) leaves and twigs + 100 gram concentrate
T3 (Diet 3): Dabdabe (GP) leaves and twigs + 100 gram concentrate
T4 (Diet 4): Nimaro (FR) leaves and twigs + 100 gram concentrate

**Basal ration and feeding**

Feed formulation was done to meet the following nutrient requirement of growing kids:

DM = 3% of body weight, CP= 3 g/kg wt/day

Animals were fed 3 times a day-9 hours, 14 hours and 19 hours. Small twigs with leaves were offered in wooden box fixed at brisket height. Fresh water was supplied libitum in a clean bucket separately.

**Animal health**

Animals were drenched against internal parasite using Panacur at recommended dose (5 mg/kg body weight) before the trial start (1 day before the adjustment period). Dipping was also done to remove the external parasite. Faecal sample was analyzed (EGP count) to see the parasitic burden in experimental animals.

**Observation**

Daily feed intake and refusal was recorded. Body weight change was recorded at 15 days interval. Fortnightly records were used to calculate the daily weight change in each treatment.

**Statistics**

Harvey computer package was used to analyze the body weight change due to the treatment effect. Least square analysis of variance was used to separate the mean difference. LSD and CV were calculated. Least square means was calculated for fodder production and morphological characters and feed intake. Health records were averaged to its egg count (EPG). Feed conversion efficiency (FCE) was computed using following equation:

$$FCE = \frac{\text{Weight gain}}{\text{Feed consumed}} X\ 1000$$

## RESULTS AND DISCUSSION

**Fodder production and tree measurement**

Among the major used fodder trees, GP (Dababe) recorded the highest dry matter production of 54.0 kg followed by FR (26.33 kg), AL (24.89 kg) and BP (10.17 kg) per tree per year (Table 2).

Regarding the plant characteristics, the plant height was recorded the highest for AL 12.98±2.01 meter with 3.5± 0.96 meter branch extension (canopy) followed by GP (12.42 ± 2.2 m), FR (6.68 ± 0.31 m), and BP (4.36 ± 0.58 m).

FR recorded broad leaves of 37.88 ±89 cm long with 33.87±5.54 width. Leaves of other 3 fodders were smaller in both length and width (Table 2) compared to FR.

**Table 2. Fodder production and tree measurement of 4 different fodder trees**

| Fodders name | Measurements | | | | Production/tree/year | |
|---|---|---|---|---|---|---|
| | Canopy (m) | Height (m) | Leaf (cm) (n=5) | | Green matter (kg) | Dry matter (kg) |
| | (n=5) | (n=5) | Length | Breadth | | |
| *Artocarpus Lakoocha* | 3.5±0.96 | 12.98±2.0 | 31.34±4.5 | 10.57±2.4 | 92.2±68 | 24.89 |
| *Bauhinia Purpurea* | 3.97±4.3 | 4.36±0.5 | 10.92±2.8 | 9.78±2.3 | 33.9±14 | 10.17 |
| *Garuga pinnata* | 9.9±1.59 | 12.42±2.2 | 12.98±2.0 | 3.79±0.6 | 183.0±70 | 54.9 |
| *Ficus roxburghii* | 6.1±1.7 | 6.68±0.3 | 37.88±6.9 | 33.87±5.5 | 125.4±42 | 26.33 |

**Proximate composition, polyphenolics and their utilization**

BP and GP yielded the highest dry matter percentage (30.0). BP also contained the highest crude protein (15.22%) compared to other 3 fodder trees (Table 3). Similarly, polyphenol (lignin) content was the lowest (6.48%) in FR followed by AL (8.31%), and BP and GP (12.22%).

**Body weight gain**

Overall average body weight change of goats was 50.62 ±8.6 gram per day. Daily growth rate to different diets was significantly different ($P<0.05$).

**Table 3. Proximate composition and polyphenolics of fodder trees**

| Fodder trees | Location | Proximate composition (%) | | | | | Fat % | |
|---|---|---|---|---|---|---|---|---|
| | | DM | CP | TA | ADF | NDF | | Lignin |
| *Artocarpus lakoocha* | Tanahun | 27.0 | 12.25 ±1.6 | 16.32 ±4.4 | 32.33 ±4.4 | 38.75 ±4.15 | 7.78 ±2.16 | 8.31 ±1.5 |
| | Dhankuta | 31.2 | 15.8 | 13.1 | 36.7 | 51.62 | - | 8.90 |
| *Bauhinia purpurea* | Tanahun | 30.0 | 15.22 ±1.5 | 9.60 ±0.4 | 39.5 ±6.9 | 44.4 ±7.2 | 9.64 1.88± | 12.22 |
| | Dhankuta | 35.9 | 19.8 | 8.6 | 36.9 | 58.64 | - | 19.85 |
| *Garuga pinnata* | Tanahun | 30.0 | 11.82 ±2.1 | 11.47 ±3.4 | 28.27 ±1.4 | 33.32 ± 1.8 | 10.03 ±1.4 | 12.22 ±3.2 |
| | Dhankuta | 30.0 | 15.36 | 9.65 | 31.97 | 39.9 | - | 12.46 |
| *Ficus roxburghii* | Tanahun | 21.0 | 10.5 ±1.5 | 10.5 ±1.5 | 31.25 ±4.4 | 37.49 4.3± | 4.79 ±4.3 | 6.48 ±1.2 |
| | Dhankuta | 32.4 | 13.3 | 12.2 | 34.65 | 42.4 | | 12.72 |

DM = Dry matter, CP = Crude protein, TA = Total ash, ADF = Acid detergent fibre, NDF = Neutral detergent fibre.

## Dry matter intake

In Table 4, significant (P<0.001) differences are shown in intake of four types of tree leaves on the dry matter basis. The highest DM intake (488.73) was for GP and the lowest (349.55) for FR. Daily DM intake in percent of body weight had significant differences. Mackenzie (1970) reported that goats could consume plant DM up to 5% of body weight. The level of consumption is affected by quality of feed, sex of animal, temperature and other environmental factor (Kibria *et al.,* 1994). Banerjee (1982), on the other hand, indicated DM consumption records up to 11% of body weight, compared to only of 2.5 to 3% in the cases of sheep and cattle. Majumder (1960) reported that goats had high DM intake, indicating their greater efficiency to utilize feed. Lower DM intake in FR may be related to the bigger leaf size, lower CPD%, lower DMD% (Table 4). DMI was not affected by the parasites as EPG was low during the trial period.

**Table 4. Feed intake, nutrient utilization, body weight change and feed conversion efficiency fed with different fodder tree leaves**

| | Treatments (Tree leaves) | | | | Significance | | |
|---|---|---|---|---|---|---|---|
| | D1(AL) | D2 (BP) | D3 (GP) | D4 (FR) | Sign. | LSD (5%) | CV% |
| Fodder tree leaves intake (g/day) | 455.60 ±13.27 | 488.73 ±13.27 | 541.71 ±13.27 | 349.55 ±13.27 | 0.001 *** | 1.80 | 5.78 |
| Total dry matter intake (DMI) (% body weight) | 3.52 ±0.29 | 4.07 ±0.9 | 4.64 ±0.29 | 3.47 0.29 | 0.048 | 1.80 | 14.88 |
| Concentrate intake DMI (g/day) | 98.0 | 98.0 | 980 | 98.0 | NS | - | - |
| Growth performance (g/day) | 70.0a ±7.74 | 52.5b ±7.74 | 50.0b ±7.74 | 30.0c ±7.74 | 0.024 * | 5.70 | 30.57 |
| Feed conversion efficiency (FCE) for meat production | 15.14 ±1.67 | 10.64 ±1.67 | 9.12 ±1.67 | 7.94 ±1.67 | 0.048 * | 10.31 | 31.25 |
| Feed utilization (%) | 87.32 | 71.04 | 77.7 | 76.89 | | | |
| Dry matter digestible (DMD), % | 73.0 ±74 | 51.5 ±12.9 | NA | 60.9 ±3.1 | | | |
| Crude protein digestible (CPD), % | 86.2 ±5.4 | 67.2 ±8.7 | NA | 60.3 ±5.8 | | | |

Mean with the same letters are not significant (P<0.05).

**Feed conversion efficiency and body weight gain**

Feed utilization, growth performance and feed conversion efficiency (FCE) are detailed in Table 4. Significantly higher FCE (15.14±1.67) was found for AL leaves, whereas it was the lowest for FR leaves (7.94±1.67) ($P<0.05$). FR leaves were inferior to FP, BP and AL. Kibria and Mia (1990) indicated that body weight change per day in goat was 50.0 gm, which was in agreement to the present study (50.0±7.74).

## CONCLUSION

Based on the above finding, regarding DM production. *G. pinnata* was better for annual fodder production followed by *F. roxburghii, A. lakoocha* and *B. purpurea*. But looking at the response to the growth performance, *A. lakoocha* leaves were the best, followed by *B. purpurea , G. pinnata* and *F. roxburghii* with proper management. Goat can be reared with different level of growth performance (30 g to 70 g/day) in the tree leaves diet under stall-fed conditions.

## ACKNOWLEDGEMENTS

Authors thank Dr. S. P. Neopane, Chief, Animal Breeding Division of Nepal Agricultural Research Council, for analysing the data.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# SITE AND SEASONAL VARIATION ON THE NUTRIENT CONTENT OF TWENTY IMPORTANT FODDER TREES IN THE WESTERN HILLS OF NEPAL

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## ABSTRACT

The nutrient content of twenty important fodder trees, namely Bains (*Salix* sp.) Banjh (*Quercus incana*), Bedulo (*Ficus clavata*), Dhursul, Dudhilo (*Ficus nemoralis*), Gaya (*Ardelia retusa*), Harro (*Viscum album*), Khari (*Seltis australis*), Kimbu (*Morus alba*), Pakhuri (*Ficus glaberrima*), Thotne (*Ficus hispida*), Kavreo (*Ficus lacor*), Nimaro (*Ficus auriculata*), Chuletro (*Brassaiopsis hainla*), Dabdabe (*Garuga pinnata*), Khanyu (*Ficus semicordata*), Kutmiro (*Litsea polyantha*), of 4 different agro-ecological research (AER) sites were analysed during three different seasons (monsoon, autumn, late winter). The results showed that these species contain the nutrient in the range of 13.4-56.1% dry matter, 2.1-31.14% total ash, 6.1-30.4% crude protein, 5.5-58.7% acid detergent lignin, 0.86-13.0% hemicellulose, 8.6-34.9% cellulose, 0.54-11.0% calcium, and 0.11-0.66% phosphorus on a dry matter basis. The fluctuation on nutrient content was mainly due to difference in sites, seasons and fodder trees species.

## INTRODUCTION

Animals are dependent on fodder trees to supply their nutrient requirement in the hills of Nepal, especially during winter and early summer seasons. Given the importance of fodder trees for livestock feed it is essential to understand their nutrient contents and variability due to the change in sites and season so that deficiencies, and their efficient utilization could be achieved. Except for some work on nutrient status in local trees fodder and forages (Panday 1982; Subba and Tamang, 1992), information on the seasonal variation in the nutrient content of fodder trees is limited in Nepal. Although the farmers have been growing various species of fodder trees since time immemorial, they do not have clear idea regarding the nutrient contents of the fodder trees and which grow more densely or which are more productive, especially during the dry season when there is shortage of feed stuffs. These fodder trees can be used as basal diet, if available in a large quantity and/or as supplementary diet to crop residues, if available in a small quantity.

Nutrient content of these fodder trees varies within and between species from one place to another due to various reasons such as climate, soil structure, and altitude. Determination of seasonal changes in nutrient content will help to identify the most nutritious fodder trees in different agro-ecological regions and also in different seasons and their nutrient availability during different season of year.

This report attempts to present different parameters of nutrition analysis - dry matter (DM), total ash (TA), crude protein (CP), acid detergent lignin (ADL), hemicellulose (HCI), cellulose (Cel), calcium (Ca) and phosphorus (P) contents during different seasons of the year in different agro-ecological sites of the western hills of Nepal.

## MATERIALS AND METHODS

On the basis of farmers preference, twenty different fodder trees viz. Bains (Salix sp.) Banjh (*Quercus incana*), Bedulo (*Ficus clavata*), Dhursul, Dudhilo (*Ficus nemoralis*), Gaya (*Ardelia retusa*), Harro (*Viscum album*), Khari (*Seltis australis*), Kimbu (*Morus alba*), Pakhuri (*Ficus gaoberrima*), Thotne (*Ficus hispida*), Kavreo (*Ficus lacor*), Nimaro (*Ficus auriculata*), Chuletro (*Brassaiopsis hainla*), Dabdabe (*Garuga pinnata*), Khanyu (*Ficus semicordata*), Kutmiro (*Litsea polyantha*) were selected for the above mentioned nutrient analysis.

Sample of leaves, petioles and twigs together were collected from all four agro-ecological research (AER) sites viz Chambas (river basin), Maduwa (low hill), Chhahara (mid hill) and Bhakimle (high hill) during monsoon (August/September), autumn (November/December) and winter (February/March). Sampling was done from the same tree in three different seasons, and the trees were given individual identification number. Three trees were identified from each AER site of each species as per their availability in the respective AER site. Samples from each tree were collected from all parts of the tree lower branches, upper branches and middle branches from top, sunny and shady region of the tree and leaves were also included. All the leaves were mixed thoroughly and respective samples of about 250 grams were collected for drying. Fresh sample weight was recorded on the spot at the time of collection.

All the samples were oven dried at 70°C for 24 hours in an hot air oven. The samples were ground to pass through a 1mm mesh sieve and analysed for proximate principles using conventional laboratory techniques (AOAC, 1980) at Animal Nutrition Division, Khumaltar. Data were analysed using General Linear Regression of Genstat 5 Release 3.2 software.

## RESULTS AND DISCUSSION

Comprehensive results are presented in Tables 1 and 2.

### Seasonal effect on nutrient contents

Among 20 different fodder trees samples, crude protein (CP) content was significantly higher ($P<0.001$) in Khari, Badahar, Nimaro and Dabdabe during monsoon season (Table 3). However, in Bains, Dudhilo and Kimbu high content of CP was noted in winter. Across the three seasons the highest CP content was found in Kimbu and recorded the lowest in Harro. CP content was significantly low ($P<0.001$) in autumn. Ca content was found high in Bains and Kimbu in autumn, however, it was the highest in Khari in winter.

Acid detergent lignin (ADL) content of fodder trees such as Gideri, Chuletro and Kutmiro was significantly high ($P<0.01$) in monsoon and low in winter (Table 3). Banjh, Kimbu and Kutmiro had significantly high ($P<0.001$) Cellulose in winter and low in monsoon. The high percent of cellulose contents were significantly affected by season (Table 3).

Variation on hemicellulose content of fodder trees was seasonally affected ($P<0.05$). Hemicellulose was found high in monsoon and low in winter (Table 4). Dry Matter (DM) content of fodder trees was significantly affected by season ($P<.001$) and was found significantly high in autumn and winter. Fodder trees such as Bains, Dudhilo, Khari, Badahar, Gideri and Nimaro contents high value of DM in autumn. Whereas Banjh, Bedulo, Harro, Pakhuri, Thotne, Bhimal, Kavro, Chuletro, Dabdabe and Khanyu had high DM content in winter (Table 4). Christopher (1994) also reported the high DM content in Badahar, Khanyu and Dudhilo in winter and autumn. They also reported the increased total ash content during winter in Badahar, Dudhilo, Pakhuri and Khanyu is consistent with our results. The effect of season on phosphorus and total ash contents were significantly high ($P<0.001$) in winter and low in monsoon. The effect of season on phosphorus (P) and total ash (TA) content of fodder trees

were significantly high (P<0.001) in winter and low in Monsoon (Table 4). Similarly Subba *et al.* (1994) reported that total ash content was significantly high in Badahar, Tanki and Ghotli in winter.

**Site effect on nutrient contents**

Crude protein content of fodder trees was significantly affected by site (P<0.001). It was noted that CP content was high at mid hill and low at river basin (Table 5). Calcium (Ca) content was not significantly affected by site. The Bhimal showed significantly high (P<0.001) content of Ca at mid hill and Badahar at river basin (Table 5). At low hill, acid detergent lignin content was not significant (P<0.05) (Table 5). DM content was highly affected by site (P<0.001) and was high at high hill followed by river basin and low hill (Table 6). Significantly high value of phosphorus was recorded at high hill. Among 20 fodder trees phosphorus content noted higher (<0.001) in Bhimal, Nimaro, Chuletro and Khanyu at high hill and in Dabdabe and Kutmiro at mid hill. Effect of site on total ash content was significantly higher (P<0.001) at river basin and found significant in Badahar and Khanyu (Table 6).

**Effect of site x season**

Interactions between site x season were significant only in case of DM and total ash contents. Significant effect of site and season interaction on high DM and total ash content was noted at river basin in winter.

Following is a summary chart on variation in nutrient contents of various fodder trees as influenced by site, season and their interaction

| Nutrient | Site | Season | Site X Season |
|---|---|---|---|
| Crude protein | ↑ Mid hill<br>↑ High hill<br>↓ River basin | ↑ Monsoon (Khari, Badahar, Dabdabe)<br>↓ Autumn | |
| Acid detergent lignin | Low hill | | |
| Cellulose | - | ↑ Autumn (Gidari)<br>↓ Winter (Khanyo, Chuletro, Thotne, Khari) | |
| Hemicellulose | - | ↑ Monsoon<br>↓ Winter | |
| Dry matter | ↑ Mid hill<br>↑ High hill<br>↓ River basin | ↑ Autumn (Bains, Dudhilo, Khari, Badahar, Gidari, Nimaro)<br>↑ Winter (Khanyo,Dabdabe, Chuletro, Kavro, Bhimal, thotne, Pakhri, Harro, Bedulo, Banjh) | ↑ High hill X Autumn<br>↑ River basin X Winter |
| Phosphorus | ↑ High hill (Bhimal, Nimaro, Chuletor & Khanyo)<br>↑ Mid hill (Dabdabe, Khumiro) | ↑ Winter (Gidari, Thotne, Kimbu, Dudhilo, Banjh, Bains)<br>↓ Monsoon (Kutmiro, Khanyo, Dabdabe, Chuletro, Nimaro, Kavro, Bedulo) | |
| Total ash | ↑ River basin ( Badahar, Khanyo) | ↑ Winter | ↑ River basin X Winter |

**Table 1. Crude protein (CP), calcium (CA), acid detergent lignin (ADL) and cellulose (CEL) contents of fodder trees at various sites of western hills of Nepal**

| Fodder / Site | Site x Season | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monsoon | | | | Autumn | | | | Winter | | | | Mean | | | |
| | CP | CA | ADL | CEL | CP | CA | ADL | CEL | CP | CA | ADL | CEL | CP | CA | ADL | CEL |
| **Bhakimli** | | | | | | | | | | | | | | | | |
| Bains | 12.41 | 1.96 | 23.8 | 20.23 | 8.53 | 3.17 | 24.47 | 17.37 | 18.55 | 1.42 | 27.95 | 16.77 | 13.16 | 2.18 | 25.41 | 18.12 |
| Banjh | 12.01 | 0.67 | 29.89 | 22.76 | 10.4 | 0.87 | 39.48 | 28.20 | 9.20 | 0.94 | 28.42 | 31.33 | 10.54 | 0.83 | 32.60 | 27.43 |
| Dhursul | 12.36 | 1.17 | 18.91 | 24.1 | 11.89 | 2.42 | 19.10 | 31.01 | 12.30 | 2.39 | 17.33 | 30.93 | 12.18 | 1.99 | 18.45 | 28.68 |
| Dudhilo | 10.48 | 2.06 | 9.32 | 19.73 | 9.87 | 2.82 | 23.92 | 21.66 | 13.27 | 2.72 | 24.15 | 20.12 | 11.21 | 2.53 | 19.13 | 20.50 |
| Kimbu | 18.99 | 2.95 | 12.57 | 17.17 | 14.46 | 3.88 | 7.02 | 19.60 | 23.49 | 1.75 | 12.37 | 26.08 | 18.96 | 2.86 | 10.65 | 20.95 |
| Bhimal | 15.71 | 2.35 | 14.14 | 27.12 | 15.76 | 1.24 | 17.2 | 24.7 | 14.74 | 1.34 | 48.51 | 21.73 | 15.4 | 1.64 | 26.62 | 24.52 |
| Nimaro | 9.76 | 2.07 | 12.9 | 23.2 | 10.44 | 2.5 | 12.26 | 22.56 | 8.98 | 2.83 | 14.36 | 23.56 | 9.73 | 2.47 | 13.17 | 23.11 |
| Chuletro | 13.93 | 1.89 | 24.66 | 19.31 | 13.46 | 2.32 | 19.88 | 18.2 | 10.64 | 3.86 | 21.87 | 10.73 | 12.68 | 2.69 | 22.14 | 16.08 |
| Khanyu | 13.76 | 2.94 | 14.64 | 26.83 | 11.46 | 3.48 | 18.63 | 18.04 | 11.36 | | 16.55 | 18.62 | 12.19 | 3.21 | 16.61 | 21.16 |
| Mean | 13.27 | 2.01 | 17.87 | 22.27 | 11.81 | 2.52 | 20.218 | 22.37 | 12.38 | 2.16 | 23.501 | 22.21 | 12.90 | 2.27 | 20.53 | 22.28 |
| **Chhahara** | | | | | | | | | | | | | | | | |
| Khari | 17.62 | 2.94 | 30.51 | 21.92 | 14.63 | 4.90 | 20.49 | 22.88 | 12.05 | 6.31 | 22.83 | 16.24 | 14.77 | 4.72 | 24.61 | 20.35 |
| Bhimal | 14.82 | 1.89 | 11.96 | 22.16 | 18.22 | 1.81 | 18.76 | 21.86 | 16.83 | 1.66 | 20.71 | 18.98 | 16.62 | 1.79 | 17.14 | 21.00 |
| Dabdabe | 17.72 | 1.84 | 17.73 | 25.36 | 14.05 | 1.92 | 12.91 | 18.48 | 10.86 | 1.73 | 14.06 | 20.41 | 14.21 | 1.83 | 14.9 | 21.42 |
| Kutmiro | 14.42 | 0.74 | 38.03 | 20.39 | 15.92 | 0.97 | 21.17 | 22.26 | 13.89 | 1.26 | 15.38 | 24.45 | 14.74 | 0.99 | 24.86 | 22.37 |
| Mean | 16.15 | 4.85 | 24.56 | 22.46 | 15.71 | 2.40 | 18.33 | 21.37 | 13.41 | 2.74 | 18.25 | 20.02 | 15.09 | 2.33 | 20.38 | 21.28 |
| **Chambas** | | | | | | | | | | | | | | | | |
| Gayo | 12.18 | 1.04 | 14.81 | 24.17 | 11.03 | 2.02 | 19.09 | 25.27 | | | | | 11.61 | 1.53 | 16.95 | 24.72 |
| Harro | 8.77 | 1.34 | 5.69 | 18.19 | 8.53 | 2.43 | 9.93 | 19.27 | 7.04 | 2.97 | 7.51 | 18.30 | 8.11 | 2.25 | 7.71 | 18.59 |
| Thotne | 13.18 | 2.41 | 8.25 | 26.58 | 11.88 | 1.44 | 15.35 | 22.58 | 10.96 | 1.73 | 18.64 | 18.74 | 12.01 | 1.86 | 14.08 | 22.63 |
| Badahar | 13.38 | 1.52 | 15.83 | 25.5 | 12.66 | 8.52 | 16.36 | 22.68 | 10.49 | 1.12 | 15.6 | 22.43 | 12.18 | 3.72 | 15.93 | 23.54 |
| Gideri | 22.38 | 1.68 | 31.88 | 25.35 | 19.44 | 7.58 | 25.54 | 27.15 | 15.4 | 1.78 | 19.04 | 20.07 | 19.14 | 3.68 | 25.49 | 24.19 |
| Kavro | 10.51 | 2.15 | 25.35 | 27.89 | 10.57 | 2.93 | 21.05 | 26.56 | 7.66 | 2.34 | 19.3 | 25.31 | 9.58 | 2.47 | 21.9 | 26.59 |
| Dabadabe | 14.41 | 1.28 | 14.23 | 16.33 | 11.98 | 2.04 | 10.68 | 18.04 | 11.68 | 2.59 | 10.53 | 18.08 | 12.6 | 1.97 | 11.81 | 17.48 |
| Khanyu | 10.98 | 3.5 | 17.57 | 25.29 | 9.66 | 3.46 | 20.63 | 21.83 | 10.18 | 2.9 | 15.26 | 19.09 | 10.27 | 3.29 | 17.82 | 22.07 |
| Kutmiro | 15.58 | 1.2 | 32.52 | 24.77 | 13.46 | 1.32 | 23.42 | 21.13 | | | | | 14.52 | 1.26 | 27.97 | 22.95 |
| Mean | 13.46 | 1.79 | 18.46 | 23.79 | 12.16 | 3.53 | 18.01 | 22.72 | 10.49 | 2.20 | 15.13 | 20.29 | 12.22 | 2.45 | 17.74 | 22.53 |
| **Maduwa** | | | | | | | | | | | | | | | | |
| Pakhuri | 10.57 | 2.67 | 28.43 | 20.57 | 10.04 | 2.68 | 23.51 | 23.16 | 9.26 | 1.10 | 21.60 | 22.33 | 9.96 | 2.15 | 24.51 | 22.02 |
| Badahar | 17.32 | 1.24 | 30.48 | 26.61 | 14.51 | 1.63 | 20.65 | 21.28 | 11.78 | 1.74 | 23.18 | 18.05 | 14.54 | 1.54 | 24.77 | 21.98 |
| Gideri | 20.32 | 1.35 | 40.99 | 22.25 | 20.88 | 1.62 | 28.94 | 31.46 | 17.94 | 1.46 | 24.4 | 23.93 | 19.71 | 1.48 | 31.44 | 25.88 |
| Kavro | 12.75 | 2.51 | 34.67 | 27.15 | 12.65 | 2.02 | 25.49 | 26.45 | 13.51 | 2.19 | 26.84 | 24.01 | 12.97 | 2.24 | 29.00 | 25.87 |
| Nimaro | 15.95 | 3.14 | 38.01 | 25.61 | 11.8 | 3.25 | 16.2 | 23.93 | 9.07 | 3.41 | 24.14 | 19.55 | 12.27 | 2.37 | 26.12 | 23.03 |
| Chuletro | 12.46 | 1.76. | 42.82 | 17.05 | 12.25 | 1.41 | 21.25 | 18.84 | 11.13 | 2.19 | 21.47 | 12.66 | 11.95 | 1.79 | 28.51 | 16.18 |
| Dabadabe | 17.58 | 0.87 | 18.85 | 16.04 | 12.14 | 1.58 | 13.67 | 21.81 | 11.25 | 1.83 | 10.89 | 15.6 | 13.66 | 1.43 | 14.47 | 17.82 |
| Khanyu | 11.2 | 2.4 | 36.15 | 25.22 | 11.44 | 2.64 | 16.37 | 26.54 | 10.18 | 2.34 | 31.86 | 13.65 | 10.94 | 2.46 | 28.13 | 21.8 |
| Kutmiro | 12.36 | 0.87 | 50.33 | 12.57 | 19.66 | 1.3 | 28.05 | 19.05 | 15.71 | 1.94 | 20.96 | 23.44 | 15.91 | 1.37 | 33.11 | 18.35 |
| **Mean** | **13.27** | 1.92 | 33.27 | 21.54 | **11.81** | 2.08 | 21.38 | 23.76 | **12.38** | 2.09 | .22.64 | 19.72 | **12.90** | 2.03 | 25.76 | 21.68 |
| **G. Mean** | **14.03** | 1.89 | 23.54 | 22.51 | **12.87** | 2.63 | 19.48 | 22.56 | **12.16** | 2.30 | 19.88 | 20.56 | **13.28** | 2.27 | 21.10 | 21.94 |

**For CP:** CV = 16.7%, LSD (site x season) = 0.8 P<0.001, LSD (site x season x Fodder) = 3.6 P<0.05; **For CA:** CV = 37.5%, LSD (site x season) = 0.3 P<0.05, LSD (site x season x Fodder) = 1.34 P<0.05; **For ADL:** CV = 37.8%, LSD (site x season) = 2.98P<0.001, LSD (site x season x Fodder) = 13.31 P<0.05; **For CEL:** CV = 14.7%, LSD (site x season) = 1.19 P<0.05, LSD (site x season x Fodder) = 5.33P<0.05

Table 2. Hemicellulose (HEM), dry matter (DM), phosphorus (P) and total ash (TA) contents of fodder trees at various sites of western hills of Nepal

| Fodder / Site | Site x Season | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monsoon | | | | Autumn | | | | Winter | | | | Mean | | | |
| | HEM | DM | P | TA | HEM | DM | P | TA | HEM | DM | P | TA | HEM | DM | P | TA |
| Bhakdmli | | | | | | | | | | | | | | | | |
| Bains | 7.32 | 39.33 | 0.23 | 7.89 | 5.73 | 42.71 | 0.19 | 9.30 | 3.71 | 32.42 | 0.47 | 7.70 | 5.59 | 38.15 | 0.30 | 8.30 |
| Banjh | 7.81 | 44.55 | 0.15 | 2.81 | 8.25 | 51.3 | 0.15 | 2.66 | 5.92 | 54.29 | 0.21 | 3.39 | 7.33 | 50.05 | 0.17 | 2.95 |
| Dhursul | 8.57 | 36.81 | 0.26 | 6.30 | 7.69 | 37.08 | 0.30 | 6.57 | 5.52 | 36.90 | 0.35 | 8.04 | 8.26 | 36.93 | 0.30 | 6.67 |
| Dudhilo | 6.21 | 28.44 | 0.29 | 10.65 | 1.79 | 36.45 | 0.39 | 10.35 | 2.52 | 29.33 | 0.51 | 11.65 | 3.51 | 31.61 | 0.40 | 10.88 |
| Kimbu | 6.12 | 30.24 | 0.39 | 11.62 | 4.31 | 26.91 | 0.35 | 13.84 | 5.67 | 22.44 | 0.62 | 8.82 | 5.37 | 26.53 | 0.47 | 11.43 |
| Bhimal | 6.74 | 33.42 | 0.42 | 10.72 | 3.12 | 41.23 | 0.28 | 10.59 | 4.08 | 45.01 | 0.29 | 11.57 | 4.65 | 39.89 | 0.35 | 10.96 |
| Nimaro | 5.67 | 22.41 | 0.32 | 11.94 | 4.7 | 27.51 | 0.36 | 14.48 | 3.66 | 24.29 | 0.27 | 16.51 | 4.68 | 24.74 | 0.29 | 14.31 |
| Chulemo | 5.3 | 22.97 | 0.30 | 9.13 | 3.92 | 29.9 | 0.16 | 9.51 | 2.42 | 32.55 | 0.42 | 12.53 | 3.88 | 28.47 | 0.36 | 10.39 |
| Khanyu | 4.62 | 30.65 | 0.21 | 13.49 | 6.43 | 37.49 | 0.29 | 17.65 | 3.7 | 39.19 | 0.18 | 22.71 | 4.92 | 35.78 | 0.18 | 17.95 |
| **Mean** | **6.48** | **32.09** | **0.29** | **9.39** | **5.10** | **36.73** | **0.29** | **10.55** | **4.47** | **35.22** | **0.37** | **11.44** | **5.35** | **34.68** | **0.31** | **10.46** |
| Chhahara | | | | | | | | | | | | | | | | |
| Khari | 5.94 | 29.98 | 0.31 | 15.82 | 5.08 | 38.18 | 0.23 | 20.47 | 5.04 | 27.85 | 0.27 | 24.51 | 5.35 | 32.00 | 0.29 | 20.27 |
| Bhimal | 6.68 | 28.25 | 0.29 | 11.67 | 6.67 | 38.75 | 0.27 | 10.07 | 4.22 | 44.53 | 0.24 | 10.75 | 5.86 | 37.18 | 0.25 | 10.83 |
| Dabdabe | 5.9 | 21.16 | 0.37 | 11.13 | 5.33 | 31.11 | 0.35 | 10.47 | 3.75 | 32.51 | 0.19 | 9.14 | 4.99 | 28.26 | 0.28 | 10.25 |
| Kutumiro | 4.5 | 21.1 | 0.42 | 6.95 | 3.34 | 28.05 | 0.285 | 6.7 | 5.43 | 26.55 | 0.31 | 8.66 | 4.42 | 25.23 | 0.36 | 7.44 |
| Mean | 5.76 | 25.12 | 0.348 | 11.39 | 5.105 | 34.02 | 0.32 | 11.93 | 4.61 | 32.86 | 0.25 | 13.27 | 5.16 | 30.67 | 0.295 | 12.20 |
| Chambas | | | | | | | | | | | | | | | | |
| Gayo | 5.6 | 27.88 | 0.19 | 7.11 | 5.17 | 37.85 | 0.19 | 6.33 | | | | | 5.39 | 32.87 | 0.26 | 6.72 |
| Haro | 3.77 | 27.1 | 0.17 | 6.83 | 4.28 | 37.84 | 0.21 | 8.77 | 5.52 | 38.14 | 0.19 | 10.24 | 4.52 | 33.36 | 0.26 | 8.61 |
| Thotne | 7.01 | 22.38 | 0.20 | 18.69 | 5.36 | 27.27 | 0.22 | 23.73 | 5.54 | 32.02 | 0.28 | 28.15 | 5.97 | 27.22 | 0.18 | 23.52 |
| Badahar | 5.22 | 30.69 | 0.19 | 14.34 | 7.19 | 35.34 | 0.21 | 17.57 | 6.52 | 32.36 | 0.19 | 19.87 | 6.31 | 32.8 | 0.23 | 17.26 |
| Gideri | 4.87 | 23.47 | 0.23 | 11.24 | 6.25 | 29.11 | 0.26 | 13.26 | 8.55 | 22.2 | 0.33 | 12.92 | 6.56 | 24.93 | 0.2 | 12.47 |
| Kavro | 74.37 | 28.81 | 0.20 | 13.77 | 5.06 | 36.07 | 0.19 | 18.1 | 5.36 | 33.05 | 0.1 | 13.17 | 4.93 | 32.64 | 0.16 | 15.01 |
| Dabadabe | 4.85 | 25.06 | 0.27 | 8.97 | 4.78 | 34.71 | 0.24 | 13.19 | 3.09 | 35.46 | 0.19 | 17.99 | 4.24 | 31.74 | 0.23 | 1.3.38 |
| Khanyu | 5.42 | 27.65 | 0.17 | 19.31 | 4.68 | 35.72 | 0.14 | 22.51 | 5.66 | 36.61 | 0.16 | 23.42 | 5.25 | 33.33 | 0.16 | 21.75 |
| Kutmiro | 3.69 | 29.15 | 0.3 | 7.21 | 5.3 | 32.19 | 0.27 | 7.22 | | | | | 4.5 | 30.67 | 0.29 | 7.22 |
| Mean | 4.98 | 26.91 | 0.21 | 11.94 | 5.34 | 33.68 | 0.227 | 14.52 | 5.75 | 32.83 | 0.206 | 17.97 | 5.30 | 31.06 | 0.220 | 13.99 |
| Maduwa | | | | | | | | | | | | | | | | |
| Bedulo | 6.73 | 22.89 | 0.28 | 18.24 | 5.73 | 31.16 | 0.23 | 18.15 | 5.80 | 38.54 | 0.24 | 21.05 | 6.09 | 30.86 | 0.25 | 19.15 |
| Paldhuri | 4.02 | 26.89 | 0.20 | 12.01 | 5.03 | 30.41 | 0.24 | 10.36 | 6.92 | 36.29 | 0.20 | 11.79 | 5.32 | 31.20 | 0.21 | 11.39 |
| Badahar | 3.63 | 19.99 | 0.31 | 12.33 | 5.56 | 33.13 | 0.25 | 9.68 | 3.17 | 32.05 | 0.23 | 15.9 | 4.12 | 28.39 | 0.26 | 12.64 |
| Gideri | 5.93 | 18.63 | 0.36 | 10.51 | 4.83 | 31.1 | 0.4 | 10.6 | 4.95 | 23.72 | 0.53 | 11.99 | 5.24 | 24.48 | 0.43 | 11.03 |
| Kavro | 4.48 | 26.53 | 0.23 | 12.45 | 3.75 | 32.75 | 0.23 | 11.94 | 2.1 | 37.53 | 0.21 | 14.01 | 3.44 | 32.27 | 0.22 | 12.8 |
| Nimaro | 4.51 | 19.18 | 0.32 | 17.38 | 3.45 | 28.37 | 0.19 | 17.84 | 1.65 | 13.72 | 0.21 | 16.32 | 3.2 | 20.42 | 0.24 | 17.18 |
| Chuletro | 3.55 | 17.14 | 0.3 | 12.31 | 6.49 | 21.89 | 0.23 | 8.21 | 4.2 | 31.26 | 0.17 | 9.11 | 4.75 | 23.43 | 0.23 | 9.88 |
| Dabadabe | 4.19 | 20.52 | 0.33 | 8.29 | 3.69 | 28.45 | 0.18 | 10.38 | 3.66 | 36.24 | 0.18 | 13.85 | 3.85 | 28.4 | 0.23 | 10.84 |
| Khanyu | 7.22 | 26.18 | 0.2 | 11.93 | 4.81 | 31.24 | 0.13 | 13.68 | 4.29 | 39 | 0.13 | 16.3 | 5.44 | 32.14 | 0.15 | 13.97 |
| Kutmiro | 5.43 | 23.84 | 0.31 | 6.12 | 4.45 | 31.89 | 0.26 | 6.38 | 3.87 | 31.16 | 0.33 | 8.63 | 4.58 | 28.96 | 0.3 | 7.04 |
| Mean | 4.97 | 22.18 | 0.284 | 12.16 | 4.78 | 30.04 | 0.234 | 11.72 | 4.06 | 31.95 | 0.243 | 13.90 | 4.60 | 28.06 | 0.252 | 12.59 |
| G.Mean | 5.55 | 26.58 | 0.283 | 11.22 | 5.08 | 33.62 | 0.258 | 12.18 | 4.72 | 33.22 | 0.268 | 14.14 | 5.10 | 31.12 | 0.270 | 12.31 |

For HEM, DM & P: CV = 16.7%, LSD (site x season) = 0.8 P<0.001, LSD (site x season x Fodder) = 3.6 P<0.05; For TA: CV = 16.5%, LSD (site x season) = 0.74 P<0.01, LSD (site x season x Fodder) = 3.6 P<0.05

**Table 3. Crude protein (CP), calcium (CA), acid detergent lignin (ADL) and cellulose (CEL) contents of fodder trees in different seasons**

| Fodder | Season | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monsoon | | | | Autumn | | | | Winter | | | | Mean | | | |
| | CP | CA | ADL | CEL | CP | CA | ADL | CEL | CP | CA | ADL | CEL | CP | CA | ADL | CEL |
| Bains | 12.41 | 1.96 | 23.8 | 20.23 | 8.52 | *3.17 | 24.47 | 17.37 | *18.55 | 1.42 | 27.95 | 16.77 | 13.16 | 2.18 | 25.41 | 8.32 |
| Banjh | 12 | 0.67 | 29.89 | 22.76 | 10.4 | 0.87 | 39.48 | 28.2 | 9.2 | 0.94 | 28.42 | *31.33 | 10.53 | 0.83 | 32.6 | 2.95 |
| Bedulo | 12.95 | 2.39 | 11.96 | 22.36 | 12.8 | 2.62 | 19.62 | 25.08 | 13.14 | 2.72 | 21.08 | 24.01 | 12.96 | 2.58 | 17.55 | 19.14 |
| Dhursul | 12.35 | 1.17 | 18.91 | 24.1 | 11.88 | 2.42 | 19.1 | 31.01 | 12.29 | 2.39 | 17.33 | 30.93 | 12.17 | 1.99 | 18.45 | 6.95 |
| Dudhilo | 10.47 | 20.6 | 9.32 | 19.73 | 9.87 | 2.82 | 23.92 | 21.66 | *13.27 | 2.72 | 24.15 | 20.12 | 11.2 | 2.53 | 19.13 | 10.68 |
| Gayo | 12.17 | 104 | 14.81 | 24.17 | 11.02 | 0.02 | 19.09 | 25.27 | | | | | 11.6 | 1.53 | 16.95 | 6.71 |
| Harro | 8.77 | 1.34 | 5.69 | 18.19 | 8.52 | 2.43 | 9.93 | 19.27 | 7.04 | 2.97 | 7.51 | 18.3 | 8.11 | 2.25 | 7.71 | 9.61 |
| Khari | *17.61 | 2.94 | 30.51 | 21.92 | 14.63 | 4.9 | 20.49 | 22.88 | 12.05 | *6.31 | 22.83 | 16.24 | 14.76 | 4.72 | 24.61 | 20.26 |
| Kimbu | 18.98 | 2.95 | 12.57 | 17.17 | 14.46 | *3.88 | 7.02 | 19.6 | *23.48 | 1.75 | 12.37 | *26.08 | 18.97 | 2.86 | 10.65 | 11.42 |
| Pakhuri | 10.56 | 2.67 | 28.43 | 20.57 | 10 | 2.68 | 23.51 | 23.16 | 9.26 | 1.1 | 21.6 | 22.33 | 9.94 | 2.15 | 24.51 | 11.38 |
| Thotne | 13.17 | 2.41 | 8.25 | *26.58 | 11.88 | 1.44 | 15.35 | 22.58 | 10.96 | 1.73 | 18.64 | 18.74 | 12 | 1.86 | 14.08 | 23.52 |
| Badahar | *15.55 | 1.36 | 23.92 | 26.11 | 13.68 | 1.2 | 18.73 | 21.91 | 11.2 | 1.04 | 19.79 | 20.01 | 13.48 | 3.2 | 20.81 | 14.7 |
| Bhimal | 15.44 | 2.21 | 13.69 | 25.66 | 16.48 | 1.16 | 17.66 | 23.86 | 15.21 | 1.23 | *42.23 | 21.11 | 15.71 | 1.53 | 24.53 | 10.94 |
| Gideri | 21.24 | 1.5 | *36.91 | 23.64 | 20.32 | 1.05 | 27.42 | *29.53 | 16.8 | 1.02 | 22 | 22.2 | 19.45 | 4.86 | 28.78 | 11.67 |
| Kavro | 11.74 | 2.35 | 30.49 | 27.49 | 11.17 | 2.43 | 23.5 | 26.49 | 12.2 | 2.22 | 25.16 | 24.3 | 11.88 | 2.33 | 26.38 | 13.65 |
| Nimro | 12.96 | 2.62 | 25.91 | 24.45 | 11.14 | 2.89 | 14.3 | 23.27 | 9.01 | 3.08 | 18.56 | 21.83 | 11.04 | 2.86 | 19.59 | 15.8 |
| Chuletro | 12.16 | 1.82 | *34.07 | 18.14 | 12.83 | 1.85 | 20.59 | 18.53 | 10.93 | 2.85 | 21.63 | 11.9 | 12.31 | 2.17 | 25.43 | 10.02 |
| Dabadabe | *16.33 | 1.19 | 16.95 | 17.79 | 12.41 | 1.81 | 12.43 | 19.83 | 11.36 | 2.17 | 11.44 | 17.88 | 13.37 | 1.72 | 13.61 | 11.74 |
| Khanyu | 12 | 2.91 | 23.36 | *25.78 | 10.92 | 3.17 | 18.4 | 22.26 | 10.58 | 3.17 | 21.75 | 16.95 | 11.17 | 3.08 | 21.17 | 17.62 |
| Kutmiro | 13.9 | 0.97 | *41.59 | 18.45 | 16.71 | 1.25 | 25.13 | 20.38 | 15.2 | 1.75 | 19.4 | *23.72 | 15.27 | 1.32 | 28.71 | 7.34 |
| Mean | 13.39 | 1.93 | 22.05 | 22.26 | 12.51 | 2.17 | 20 | 23.11 | 12.72 | 2.02 | 21.3 | 21.30 | 12.95 | 2.43 | 21 | 12.19 |
| Significant | ** | | | | ** | | | | | | | | | | | |

For CP: LSD (season) = 0.4 P<0.01, LSD (season x fodder) = 1.8 P<0.001; For CA: LSD (season) = 0.4 P<0.001, LSD (season x fodder) = 0.67 P<0.01; For ADL: LSD (season) = 1.8 P<0.01, LSD (season x fodder) = 6.64 P<0.001; For CEL: LSD (season) = 0.4 P<0.01, LSD (season x fodder) = 1.8 P<0.001

**Table 4. Hemicellulose (HEM), dry matter (DM), phosphorus (P) and total ash (TA) contents of fodder trees in different seasons**

| Fodder | Season | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monsoon | | | | Autumn | | | | Winter | | | | Mean | | | |
| | HEM | DM | P | TA | HEM | DM | P | TA | HEM | DM | P | TA | HEM | CA | ADL | TA |
| Bains | 7.32 | 39.33 | 0.23 | 7.98 | 5.73 | 42.71 | 0.19 | 9.29 | 3.71 | 32.42 | 0.47 | 7.7 | 5.59 | 38.15 | 0.3 | 8.32 |
| Banjh | 7.81 | 44.55 | 0.15 | 2.81 | 8.25 | 51.3 | 0.15 | 2.65 | 5.92 | 54.29 | 0.21 | 3.39 | 7.33 | 50.05 | 0.17 | 2.95 |
| Bedulo | 6.73 | 22.89 | 0.28 | 18.23 | 5.73 | 31.16 | 0.23 | 18.15 | 5.8 | 38.54 | 0.24 | 21.04 | 6.09 | 30.86 | 0.25 | 19.14 |
| Dhursul | 8.57 | 36.81 | 0.26 | 6.23 | 7.69 | 37.08 | 0.3 | 6.57 | 8.51 | 36.9 | 0.35 | 8.04 | 8.26 | 36.93 | 0.3 | 6.95 |
| Dudhilo | 6.2 | 28.44 | 0.29 | 10.65 | 1.78 | 36.45 | 0.39 | 10.35 | 2.51 | 29.93 | 0.51 | 11.65 | 3.5 | 31.61 | 0.4 | 10.68 |
| Gayo | 5.6 | 27.88 | 0.19 | 7.1 | 5.16 | 37.85 | 0.32 | 6.32 | | | | | 5.38 | 32.87 | 0.26 | 6.71 |
| Harro | 3.77 | 27.1 | 0.17 | 6.83 | 4.28 | 34.84 | 0.19 | 8.76 | 5.51 | 38.14 | 0.19 | 10.23 | 4.52 | 33.36 | 0.18 | 9.61 |
| Khari | 5.93 | 29.98 | 0.31 | 15.82 | 5.07 | 38.18 | 0.29 | 20.46 | 5.03 | 27.85 | 0.27 | 24.5 | 5.34 | 32 | 0.29 | 20.26 |
| Kimbu | 6.12 | 30.24 | 0.39 | 11.62 | 4.3 | 26.91 | 0.39 | 13.83 | 5.67 | 22.44 | 0.62 | 8.82 | 5.36 | 26.53 | 0.47 | 11.42 |
| Pakhuri | 4.01 | 26.89 | 0.2 | 12 | 5.03 | 30.41 | 0.24 | 10.35 | 6.91 | 36.29 | 0.2 | 11.78 | 5.32 | 31.2 | 0.21 | 11.38 |
| Thotne | 7.01 | 22.38 | 0.2 | 18.68 | 5.36 | 27.27 | 0.22 | 23.73 | 5.54 | 32.02 | 0.28 | 28.14 | 5.97 | 27.22 | 0.23 | 23.52 |
| Badahar | 4.34 | 24.78 | 0.26 | 13.22 | 6.28 | 34.12 | 0.23 | 13.21 | 4.67 | 32.19 | 0.21 | 17.67 | 5.1 | 30.36 | 0.23 | 14.70 |
| Bhimal | 6.71 | 31.9 | 0.39 | 11 | 4.17 | 40.5 | 0.31 | 10.43 | 4.1 | 44.9 | 0.28 | 11.38 | 4.99 | 39.1 | 0.33 | 10.94 |
| Gideri | 5.45 | 20.8 | 0.21 | 10.83 | 5.46 | 30.16 | 0.34 | 11.78 | 6.56 | 23.04 | 0.44 | 12.4 | 5.82 | 24.67 | 0.33 | 11.67 |
| Kavro | 4.43 | 27.55 | 0.32 | 13.04 | 4.33 | 34.24 | 0.21 | 14.7 | 2.82 | 36.53 | 0.18 | 13.82 | 3.86 | 32.77 | 0.24 | 13.65 |
| Nimro | 5.07 | 20.74 | 0.3 | 14.76 | 4.05 | 27.95 | 0.24 | 16.22 | 2.79 | 19.75 | 0.24 | 16.42 | 3.97 | 22.81 | 0.26 | 15.80 |
| Chuletro | 4.39 | 19.95 | 0.3 | 10.77 | 5.24 | 25.75 | 0.29 | 8.83 | 3.5 | 31.77 | 0.27 | 10.45 | 4.38 | 25.82 | 0.29 | 10.02 |
| Dabadabe | 4.73 | 22.31 | 0.32 | 9.04 | 4.38 | 31.23 | 0.22 | 11.43 | 3.4 | 35.02 | 0.18 | 14.74 | 4.17 | 29.52 | 0.24 | 11.74 |
| Khanyu | 5.8 | 28.13 | 0.19 | 14.64 | 5.31 | 34.69 | 0.14 | 17.64 | 4.49 | 38.35 | 0.16 | 20.58 | 5.2 | 33.72 | 0.16 | 17.62 |
| Kutmiro | 4.62 | 25.31 | 0.33 | 6.66 | 4.56 | 31.32 | 0.28 | 6.74 | 4.3 | 29.87 | 0.33 | 8.63 | 4.49 | 28.83 | 0.31 | 7.34 |
| **Mean** | **5.70** | 27.90 | 0.26 | 11.10 | **5.11** | 34.21 | 0.26 | 12.07 | **4.83** | 33.7 | 0.30 | 13.76 | **5.23** | 31.92 | 0.27 | 12.19 |

For HEM: LSD (season) = 0.34 P<0.01, LSD (season x fodder) = P<0.05; For DM: LSD (season) = 0.72 P<0.01, LSD (season x fodder) = 3.18 P<0.001; For P: LSD (season) = P<0.01, LSD (season x fodder) = P<0.001; For TA: LSD (season) = 0.36 P<0.001, LSD (season x fodder) = 1.65 P<0.001

**Table 5. Crude protein (CP), calcium (CA), acid detergent lignin (ADL) and cellulose (CEL) contents of fodder trees at different sites**

| Fodder | Site | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bhakimle | | | | Chhahara | | | | Chambas | | | | Maduwa | | | |
| | CP | CA | ADL | CEL | CP | CA | ADL | CEL | CP | CA | ADL | CEL | CP | CA | ADL | CEL |
| Bains | 12.75 | 2.24 | 25.21 | 18.24 | | | | | | | | | | 2.56 | | |
| Banjh | 10.64 | 0.82 | 32.9 | 27.12 | | | | | | | | | | | | |
| Bedulo | | | | | | | | | | | | 5.38 | 12.95 | | 17.27 | 23.79 |
| Dhursul | 12.17 | 1.96 | 18.53 | | | | | | | | | 4.44 | | | | |
| Dudhilo | 11.05 | 2.52 | 18.71 | | | | | | | | | | | | | |
| Gayo | | | | | | | | | 11.6 | 1.53 | 24.72 | | | | | |
| Harro | | | | | | | | | 8.19 | 2.19 | 18.61 | | | | | |
| Khari | | | | | 4.43 | 24.95 | 21.07 | 5.41 | | | | | | | | |
| Kimbu | 19.14 | 2.83 | 10.95 | 20.67 | | | | | | | | | | | | |
| Pakhuri | | | | | | | | | | | | | 10.01 | 5 | 24.75 | 21.99 |
| Thotne | | | | | | | | | 12.19 | 1.03 | 23.33 | 6.05 | | | | |
| Badahar | | | | | | | | | 12.47 | *6.35 | 23.74 | 6.26 | 15.03 | 4.98 | 25.07 | 22.68 |
| Bhimal | 15.45 | 1.08 | 25.02 | *24.74 | *6.44 | 16.5 | 21.36 | 6.14 | | | | | | | | |
| Gideri | | | | | | | | | 19.8 | 4. | 24.91 | 6.2 | 20.02 | 5.15 | 32.72 | 26.2 |
| Kavro | | | | | | | | | 10.18 | 2.52 | 26.99 | 4.79 | 12.92 | 2.25 | 29.19 | 26.02 |
| Nimro | 9.78 | 2.44 | 13.08 | 23.07 | | | | | | | | | 12.84 | 3.24 | 26.51 | 23.65 |
| Chuletro | 13.03 | *2.48 | 22.19 | 17.03 | | | | | | | | | 12 | 1.75 | 29.1 | 16.45 |
| Dabadabe | | | | | 1.85 | 15.06 | *21.61 | 5.21 | 12.76 | 1.86 | 17.37 | 4.44 | 14.43 | 1.3 | 15.62 | 18.51 |
| Khanyu | 12.26 | *3.51 | 16.6 | 21.38 | | | | | 10.28 | 3.32 | 22.3 | 5.22 | 10.99 | 2.47 | 27.88 | 22.43 |
| Kutmiro | | | | | 0.97 | 25.62 | 22.2 | 4.34 | 14.52 | 1.26 | 22.96 | 4.48 | 15.91 | 1.32 | 34.09 | 17.94 |
| **Mean** | 13.15 | 1.98 | 20.35 | 22.36 | 2.42 | 20.53 | 21.56 | 5.28 | 12.44 | 2.21 | 22.77 | 5.25 | 13.71 | 2.98 | 26.22 | 21.97 |
| **Significance** | *** | | | | | | | | *** | | | | | | *** | |

**For CP:** LSD (season) = 0.4 P<0.01, LSD (season x fodder) = P<0.5; **For CA:** LSD (season) = 0.17 P<0.05, LSD (season x fodder) = 0.77 P<0.5; **For ADL:** LSD (season) = 1.71 P<0.001, LSD (season x fodder) = P<0.05; **For CEL:** LSD (season) = 0.39 P<0.05, LSD (season x fodder) = 1.54 P<0.5

**Table 6. Hemicellulose (HEM), dry matter (DM), phosphorus (P) and total ash (L) contents of fodder trees at different sites**

| Fodder | Site | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bhakimle | | | | Chhahara | | | | Chambas | | | | Maduwa | | | |
| | HEM | DM | P | TA | HEM | DM | P- | TA | HEM | DM | P | TA | HEM | DM | P | TA |
| Bains | 5.73 | 38.59 | 0.28 | 8.37 | | | | | | | | | | | | |
| Banjh | 7.43 | 49.71 | 0.17 | 2.92 | | | | | | | | | | | | |
| Bedulo | | | | | | | | | | | | | 6.11 | 30.26 | 0.25 | |
| Dhursul | 8.24 | | | 6.88 | | | | | | | | | | | | |
| Dudhilo | 3.58 | | | 10.82 | | | | | | | | | | | | |
| Gayo | | | | | | | | | | 32.84 | 0.26 | 6.71 | | | | |
| Harro | | | | | | | | | | 32.98 | 0.18 | 6.48 | | | | |
| Khari | | | | | | 32.72 | 0.29 | 19.5 | | | | | | | | |
| Kimbu | 5.47 | 26.84 | 0.46 | 11.35 | | | | | | | | | | | | |
| Pakhuri | | | | | | | | | | | | | 5.19 | 30.8 | 0.21 | 11.35 |
| Thotne | | | | | | | | | | 26.36 | 0.23 | 22.69 | | | | |
| Badahar | | | | | | | | | | 32.86 | 0.2 | 16.79 | 4.28 | 27.72 | 0.27 | 12.06 |
| Bhimal | 4.69 | | 0.36 | 10.91 | | | 0.26 | 10.84 | | | | | | | | |
| Gideri | | | | | | | | | | 25.4 | 0.26 | 12.38 | 5.29 | 24.56 | 0.41 | 10.86 |
| Kavro | | | | | | | | | | 32.5 | 0.18 | 15.58 | 3.54 | 31.85 | 0.22 | 12.7 |
| Nimro | 4.75 | 24.76 | 0.29 | 14.13 | | | | | | | | | 3.48 | 21.59 | 0.25 | 17.33 |
| Chuletro | 4.14 | 27.74 | 0.35 | 10.01 | | | | | | | | | 4.78 | 22.82 | 0.24 | 9.94 |
| Dabadabe | | | | | | | 0.29 | 10.44 | | 1.39 | 0.24 | 12.55 | 3.9 | 25.9 | 0.25 | 9.87 |
| Khanyu | 5 | 35.5 | 0.18 | 17.57 | | | | | | | 0.16 | 21.61 | 5.53 | 31.6 | 0.15 | 13.78 |
| Kutmiro | | | | | | | 0.37 | 7.34 | | 1.31 | 0.28 | 7.21 | 4.64 | 28.78 | 0.3 | 6.91 |
| **Mean** | 5.45 | 34.59 | 0.31 | 10.33 | | | 0.30 | 12.03 | | 1.37 | 0.22 | 13.78 | 4.67 | 27.59 | 0.26 | 12.38 |

**For HEM:** LSD (season) = 0.4 P<0.01, LSD (season x fodder) = P<0.5; **For DM:** LSD (season) = 0.83 P<0.001, LSD (season x fodder) = P<0.5; **For P:** LSD (season) = P<0.001, LSD (season x fodder) = 0.052 P<0.001; **For TA:** LSD (season) = 0.43 P<0.001, LSD (season x fodder) = 1.90 P<0.001

## ACKNOWLEGEMENTS

The author wishes to thank the staff of Animal Nutrition Division, Khumaltar for their help in chemical analysis of samples. Thanks are due to Mr. M. R. Dhakal and Mr. R. R. Bhandari who were involved in the collection of samples. Mr. B. K. Dhital is gratefully acknowledged for assisting in statistical analysis. Thanks are also due to the farmers of Bhakimli, Chhahara, Chambas and Maduwa who kindly allowed us to extract sample from their fodder trees routinely throughout the study period.

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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# STUDIES ON THE PERFORMANCE OF F1 CROSS (HAMPSHIRE X LOCAL) OVER LOCAL PIG

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## ABSTRACT

This study was conducted at Banigama and Dhangadhi Village Development Committees of Morang and Siraha districts, respectively. There were two treatments with ten replications. Treatment one was crossbred of pig (Hampshire x local) and treatment two was local. Litter size, daily weight gain from birth to weaning and age at the first maturity of the crossbred were found significantly different from the local one ($P<0.05$). Litter weight at birth, weaning weight, litter size at weaning, weight, mortality percentage, age at first farrowing and farrowing interval were not significantly different.

## INTRODUCTION

Pig is a high value domestic animal for meat purpose. About 45 percent of farmers raise pig in the hills. Similarly, 10-15 percent of Tharu, Dom, Rajbansi, Satar and Matwali migratory ethinic groups from hills raise pig in the Terai region. Pig also play a vital role in the farming system providing both cash income to the farmers and manure for crop production. Income from pigs play a significant role in contributing to home consumption as well as providing additional income, serving as an insurance against possibility of crop failure on small farm holdings.

## MATERIALS AND METHODS

Four farmers raising pigs from Morang and Siraha districts were selected. They were provided one weaned Hampshire male piglet to cross with local female to obtain F1 for the present study. Two of them died to snake biting and chronic rheumatics and one was killed (because of having only one abnormal testicle). Hence, the observation from above three males could not be recorded. Remainder one male provided good services to about 200 local females. Of them, twenty females, ten with local and ten with crossbred, were studied. They were provided local feed and management. Data were recorded regularly and analyzed according to Statistical Methods for Agricultural Science, Reza.

## RESULTS AND DISCUSSION

### Birth weight

The birth weight of piglets are given in Table 1. The mean birth weights of local and crossbred were 0.94 kg and 1.02 kg, respectively and were not significantly different. Similar birth weight (1.04 kg) was reported for Pakhribas crossbred (Aryal *et al.*, 1992).

**Table 1. Birth weight**

| Breed | Number | Mean± sd (kg) | Range |
|---|---|---|---|
| Local | 10 | 0.94±0.05 | 0.99-0.99 |
| Crossbred | 10 | 1.02±0.09 | 0.91-1.2 |
| Both | 20 | 0.98±0.07 | 0.88-1.09 |

## Litter size at birth

The average litter size at birth was 6.6 of local and 8.4 of crossbred (Table 2). The difference was highly significant. Overall mean litter size was 7.5 and ranged from 5.5 to 9.5. Gatenby *et al.* (1990) reported that litter size for local, imported (European type) and crossbred in Thailand ranged from 5.0 to 8.7.

**Table 2. Litter size at birth**

| Breed | Number | Mean± sd (nos.) | Range |
|---|---|---|---|
| Local | 10 | 6.6±0.8 | 5-8 |
| Crossbred | 10 | 8.4±1.42 | 6-11 |
| Both | 20 | 7.5±1.11 | 5.5-9.5 |

## Litter weight at birth

The mean litter weights at birth were 6.23 kg and 6.81 kg for local and crossbred, respectively (Table 3). The average litter weight of both local and crossbred was 6.52 kg. Bhat (1980) reported that the litter weights of local and crossbred at birth were 7.2 kg and 7.8 kg, respectively. The higher weight might be due to better feeding and management practices.

**Table 3. Litter weight at birth**

| Breed | Number | Mean± sd (kg) | Range |
|---|---|---|---|
| Local | 10 | 6.23±0.85 | 4.95-7.76 |
| Crossbred | 10 | 6.81±0.65 | 5.8-7.8 |
| Both | 20 | 6.52±0.75 | 5.37-7.78 |

## Weaning weight

The mean weaning weights in 45 days of local and crossbred piglets were 6.74 kg and 7.07 kg, respectively (Table 4). The average weaning weight for both varied from 6.15 kg to 7.40 kg. A higher weaning weight of 9.43 kg was reported by Aryal *et al.* (1992) for Pakhribas pigs when they were weaned at 60 days of age.

**Table 4. Weaning weight**

| Breed | Number | Mean± sd (kg) | Range |
|---|---|---|---|
| Local | 10 | 6.74±0.31 | 5.8-6.7 |
| Crossbred | 10 | 7.07±0.40 | 6.5-7.7 |
| Both | 20 | 7.40±0.35 | 6.15-7.4 |

## Litter size at weaning

The litter sizes at weaning of local and crossbred piglets were recorded 5.4 and 7.2, respectively. However, average of both local and crossbred was 6.3 and the range varied from 4.5 to 7.5. Bhat (1980) reported that litter sizes at weaning of local and crossbred were 3.2 and 5 in Sikkim, and 4.1 and 5 in West Bengal, respectively. These results suggest that the litter size at weaning is quite good at first farrowing in our conditions.

**Table 5. Litter size at weaning**

| Breed | Number | Mean± sd (nos.) | Range |
|---|---|---|---|
| Local | 10 | 5.4±0.78 | 4-6 |
| Crossbred | 10 | 7.2±1.37 | 5-9 |
| Both | 20 | 6.3±1.07 | 4.5-7.5 |

## Mortality percentage

The mean mortality percentages from birth to weaning of local and crossbred were 19.73 and 15.71, respectively (Table 6). Gatenby and Chemjong (1990) reported that 21.5 and 14.6 percent mortality in local and Pakhribas crossbred pigs, respectively in the hills of eastern Nepal. The overall average mortality was 17.7 percent. The mortality percentage was not significantly different.

**Table 6. Mortality percentage**

| Breed | Number | Mean± sd | Range |
|---|---|---|---|
| Local | 10 | 19.73±6.49 | 14.88-28.57 |
| Crossbred | 10 | 15.71±5.58 | 10.05-28.57 |
| Both | 20 | 17.72±6.03 | 12.44-28.57 |

## Daily weight gain from birth to weaning

The daily weight gains found from birth to weaning were recorded 140 gm and 157 gm in local and crossbred, respectively (Table 7). However, Gopal Krishnan and Lal (1996) reported that the growth rates of Desi and Crossbred piglets were 0.073 gm and 0.108 gm/day, respectively.

**Table 7. Daily weight gain from birth to weaning**

| Breed | Number | Mean± sd (gm) | Range |
|---|---|---|---|
| Local | 10 | 140.78±7.14 | 128.88-148.88 |
| Crossbred | 10 | 157.07±9.05 | 144.44-171.11 |
| Both | 20 | 148.92±8.09 | 136.66-159.99 |

## Weight from weaning to one year

The mean weights of local and crossbred piglets from weaning to one year age were found 58 kg and 75 kg, respectively (Table 8). The overall average for both were found 67 kg and the range was 59 to 73 kg. Gopal Krishnan and Lal (1996) reported the weight of 40 kg and 73 kg for Desi and crossbred pigs, respectively in 48 weeks. These results suggest that feeding and management system is good in our farmers' conditions.

**Table 8. Weight from weaning to one year**

| Breed | Number | Mean± sd (kg) | Range |
|---|---|---|---|
| Local | 10 | 58.3±3.95 | 49.0-64.0 |
| Crossbred | 10 | 75.7±4.33 | 69.0-82.0 |
| Both | 20 | 67.0±4.14 | 59.0-73.0 |

## Daily weight gain from weaning to one year

The mean daily weight gains from weaning to one year age of local and crossbred were 142 gm and 169 gm, respectively (Table 9). Gopal Krishnan and Lal (1996) reported that the mean body weight gain of Desi piglet was 117 gm and of crossbred was 205 gm.

**Table 9. Daily weight gain from weaning to one year**

| Breed | Number | Mean± sd (gm) | Range |
|---|---|---|---|
| Local | 10 | 142.19±9.63 | 119.51-151.21 |
| Crossbred | 10 | 169.39±9.05 | 165.85-200.00 |
| Both | 20 | 155.79±9.34 | 142.68-175.61 |

## Age of first mating

The average ages of first mating of lcoal and crossbred were found 324 days and 310 days, respectively (Table 10). Gatenby *et al.* (1990) noted the ages of first mating of local and crossbred were 8.7 and 9 months, respectively. Bhat (1990) reported that the first mating of Desi pig was 429 days, which is rather high. It could be due to poor management practices.

**Table 10. Age of first mating**

| Breed | Number | Mean± sd (days) | Range |
|---|---|---|---|
| Local | 10 | 324.6±23.14 | 298-387 |
| Crossbred | 10 | 310.2±8.24 | 296-327 |
| Both | 20 | 317.45±15.69 | 297-357 |

## Gestation period

The gestation periods of local and crossbred were 114.5 and 114.6 days, respectively. Gopal Krishnan and Lal (1996) reported that the gestation period of local pig was 114 days and of crossbred was 112 days.

**Table 11. Gestation period**

| Breed | Number | Mean± sd (days) | Range |
|---|---|---|---|
| Local | 10 | 114.5±0.66 | 114.0-115.0 |
| Crossbred | 10 | 114.6±0.66 | 114.0-116.0 |
| Both | 20 | 114.5±0.66 | 114.0-114.51 |

## Age at first farrowing

The age at first farrowing of local and crossbred were 429 and 425 days, respectively (Table 12). However, Gatenby *et al.* (1990) reported that the age at first farrowing of local and crossbred were 321 and 360 days, respectively. This might be due to different management practices.

Table 12. Age of first farrowing

| Breed | Number | Mean± sd (days) | Range |
|---|---|---|---|
| Local | 10 | 429.2±13.84 | 400-448 |
| Crossbred | 10 | 425.7±9.04 | 410-441 |
| Both | 20 | 427.45±11.44 | 405-444.5 |

## Farrowing interval

Table 13 shows that the farrowing interval of local and crossbred were 204 and 198 days, respectively. The average of both local and crossbred were 201 days and the range was 188 to 212 days. Gatenby *et al.* (1990) reported that the farrowing interval was 222 days in both local and crossbred which is slightly higher than the present results. It might be due to climatic variations.

Table 13. Farrowing interval

| Breed | Number | Mean± sd (days) | Range |
|---|---|---|---|
| Local | 10 | 204.47±0.01 | 191-217 |
| Crossbred | 10 | 198.2±7.79 | 185-207 |
| Both | 20 | 201.33±3.9 | 188-212 |


## ACKNOWLEDGEMENTS

We thank the field staff Mr. H. N. Yadav for their active involvement in the data recording for the study. Thanks are also due to Mrs. S. Rai, Mr. M. D. Jha and U. N. Yadav who were involved in the data collection from time to time. A lot of thanks to Mr. K.P. Pokhrel who help in typing to bring the paper in this form. Special thanks go to Mr. R. B. Bhujel who coordinate staff in outreach sites. Heartily thanks want to give Dr. N. P. Shrestha, Regional Director, Tarahara, for encouraging us to write this paper.


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Advances in Agricultural Research in Nepal
Edited by H.K. Manandhar, C.L. Shrestha, R.K. Shrestha and S.M. Pradhan
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# INCIDENCE OF COCCIDIOSIS IN CHICKEN

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## ABSTRACT

Occurrence of coccidiosis was monitored in three commercial broiler poultry farms in Lalitpur for one year. Clinical symptoms were droopiness, soiled vent, diarrhoea, sometimes blood tinged, chocolate colour or bloody droppings. Post-mortem lesions were intestine ballooning, pin point haemorrhage, haemorrhagic enteritis, caecal distention and bloody ingesta and some times cheesy materials. There were altogether 123 cases of coccidiosis, of which 51 (41.5%) were caecal coccidiosis, 45 (36.6%) intestinal coccidiosis and 27 (21.9%) mixed coccidiosis. Seventy-two cases (58.6%) occurred in 0-4 week age group, 49 (39.8%) in 4-8 week age group and 2 (1.60%) in >8 week age group of chickens. In the same way incidence of coccidiosis recorded at the Central Veterinary Laboratory was analysed. Total cases of coccidiosis were 133, of which 71 (53.4%) were intestinal and 62 (46.6%) caecal coccidiosis. Mortality and morbidity were 5.53% and 6.29%, respectively. The highest incidence of coccidiosis was 61 (45.8%) recorded in 4-8 week age group followed by 52 (39.1%) in 0-4 week age group.

## INTRODUCTION

Coccidiosis is one of the important diseases of chicken and occurs in almost all flocks raised in deep litter system. The disease is caused by *Eimeria* species protozoan affecting the small intestine and caecum. Based on the organ affected, the disease is classified as intestinal coccidiosis, affecting the small intestine and caecal coccidiosis, affecting the large intestine (caeca). At least nine species of coccidia are known to occur in poultry of which *E. tenella*, *E. necatrix* and *E. acervulina* are highly disastrous to chicken. Each species has its own site of predilection in the intestine of chicken. *E. tenella* attacks the double caeca, while *E. necatrix* affects the major portion of the small intestine. Similarly, *E. acervulina* attacks the duodenal portion of intestine. The intestinal coccidiosis occurs in chicks aged between 5 and 20 weeks. It occurs in both acute and chronic forms. In the acute form the chicken dies without showing any clinical signs while in the chronic form the chicken shows anorexia, becomes inactive for some days and ultimately dies.

Coccidiosis causes high mortality in chicks and growers up to the age of 2-3 months. It is considered to be a disease of poor management. It exists all over the world wherever chicken is maintained. Chicken of all ages, turkeys, geese, ducks and pigeons get affected from this disease. The coccidia are host specific. Despite the immunity developed by chicken against one particular species like *E. tenella* the chicken is still vulnerable to other species of *Eimeria*. The infection takes place by the ingestion of sporulated oocysts of coccidia from contaminated feeds, water and litter (Seetha Rama Rao, 1989). A single viable sporulated oocyst (coccidial egg) swallowed by a bird is capable of massive and very rapid multiplication so that within 5 days it can cause complete destruction of more than a million of the cells lining the digestive tract (Sekar and Eajendran, 1997).

Even the birds recovered from coccidiosis may carry and possibly discharge oocysts for months. These oocysts can survive in soil or litter for about a year or more. The oocysts to become infective require an ideal condition of air, temperature and moisture under which they sporulate in about 2 days. When chicken ingests these sporulated oocysts, they go into intestines where they multiply and destroy the mucosa and are expelled in about a week time. The magnitude of destruction of mucosa is related to the number of sporulated oocysts present (Dhingra, 1993).

Out of 1031 poultry carcasses received for post-mortem (PM) examination at the Central Veterinary Laboratory, Tripureswor, 189 (18.3%) cases were found positive for coccidiosis (Annual Report of Central Veterinary Laboratory, 1997).

Most of the poultry farms in Nepal are maintained in deep litter system, which is the key factor for the occurrence of this disease. Inspite of incorporation of various types of anti-coccidiostats in the feed the disease still occurs in various forms.

## MATERIALS AND METHODS

Three commercial broiler poultry farms in Lalitpur were monitored for one year. Different batches of birds maintained in the same farms were used for the study. Clinical symptoms of sick birds due to coccidiosis were recorded. Epidemiological information with regard to the coccidiosis outbreak was collected. PM examination of the dead birds was carried out and total number of coccidiosis cases was compiled.

Dead birds were routinely brought to the Central Veterinary Laboratory for PM examination. Records of coccidiosis cases during PM examination were analysed. The birds included both broilers and layers. Overall morbidity and mortality rates were calculated and total cases were compiled.

## RESULTS AND DISCUSSION

### Clinical symptoms

Dehydration, pale mucous membrane, soiled vent, droopiness, huddling together, reduced feed and water consumption, decreased weight gain, diarrhoea some times with blood tinged, chocolate color or bloody droppings were seen.

### Post mortem findings

***Intestinal.*** Ballooning of intestine and pin point haemorrhage were seen in serosa before opening the intestine. While opening mucous, flakes of faecal matter and in some cases blood mass were seen.

***Caecal.*** Distended and filled with bloody mass containing oocysts were found. In chronic cases, caeca filled with cheesy core matter was seen.

### Laboratory findings

Examination of faecal contents and intestinal mucosal scrapings collected during PM examination revealed the presence of coccidial oocysts.

### Record analyses

Out of 123 clinical cases in the monitored farms, 45 (36.6%) were intestinal coccidiosis, 51 (41.4%) caecal coccidiosis and 27 (21.9%) mixed infection (Table 1). Total case fatality rate due to coccidiosis was 2.1%.

**Table 1. Coccidiosis cases in the monitored farms, Lalitpur, Nepal**

| Month | Flock size | Total clinical case of coccidiosis | Case fatality rate (%) | Intestinal coccidiosis | Caecal coccidiosis | Mixed coccidiosis |
|---|---|---|---|---|---|---|
| January | 353 | 19 | 5.38 | 6 | 13 | - |
| February | 403 | 9 | 2.23 | 2 | 7 | - |
| March | 200 | 13 | 6.50 | 13 | - | - |
| April | 363 | 9 | 2.48 | - | 9 | - |
| May | 375 | 14 | 3.73 | 14 | - | - |
| June | 200 | 5 | 2.50 | - | - | 5 |
| July | 580 | 21 | 3.62 | 4 | 2 | 15 |
| August | - | - | - | - | - | - |
| September | 300 | 4 | 1.33 | - | 4 | - |
| October | 550 | 11 | 2.00 | - | 11 | - |
| November | 355 | 8 | 2.25 | - | 1 | 7 |
| December | 900 | 10 | 1.11 | 6 | 4 | - |
| **Total** | **5335** | **123** | | **45** | **51** | **27** |
| **Percent** | | | **2.1** | **36.6** | **41.4** | **21.9** |

Table 2 shows the age-wise incidence of coccidiosis in the monitored farms. There were 72 (58.6%) cases occurred in 0-4 week age group, 49 (39.8%) cases in 4-8 week age group and 2 (1.60%) cases in >8 week age group of chickens. These results clearly showed that the occurrence of coccidiosis was quite high in the chickens below 8 weeks of age.

**Table 2. Incidence of coccidiosis in different age groups of chicken in the monitored farms, Lalitpur, Nepal**

| | Age group of chicken | | |
|---|---|---|---|
| **Month** | **0-4 week** | **4-8 week** | **> 8 week** |
| January | 6 | 13 | - |
| February | - | 9 | - |
| March | 13 | - | - |
| April | - | 9 | - |
| May | 4 | 10 | - |
| June | 5 | - | - |
| July | 19 | - | 2 |
| August | - | - | - |
| September | 2 | 2 | - |
| October | 11 | - | - |
| November | 8 | - | - |
| December | 4 | 6 | - |
| **Total** | **72** | **49** | **2** |
| **Percent** | **58.6** | **39.8** | **1.60** |

Table 3 shows the incidence of coccidiosis recorded at the Central Veterinary Laboratory, Tripureswor. The mortality was 5.53% and morbidity 6.29%. The mortality due to coccidiosis alone seems to be high. Out of 133 cases recorded, 71 (53.4%) were intestinal coccidiosis and 62 (46.6%) caecal coccidiosis.

**Table 3. Incidence of coccidiosis recorded at the Central Veterinary Laboratory, Tripureswor, Kathmandu (FY 1997/98)**

| Month | Flock size | No. of dead birds | Mortality % | No. of sick birds | Morbidity % | No. of coccidiosis cases | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Intestinal | Caecal | Total |
| Jan-Feb | 3175 | 377 | 11.87 | 192 | 6.07 | 7 | 7 | - |
| Feb-Mar | 4625 | 163 | 3.52 | 267 | 5.77 | 11 | 8 | 3 |
| Mar-April | 3850 | 170 | 4.41 | 115 | 2.98 | 6 | 2 | 4 |
| April-May | 5600 | 293 | 5.23 | 389 | 6.94 | 14 | 9 | 5 |
| May-June | 3900 | 380 | 9.74 | 750 | 19.23 | 15 | 12 | 3 |
| June-July | 5076 | 163 | 3.21 | 321 | 6.23 | 14 | 3 | 11 |
| July-Aug | 6662 | 413 | 6.19 | 558 | 8.37 | 19 | 11 | 8 |
| Aug-Sept | 5200 | 116 | 2.23 | 299 | 5.73 | 11 | 4 | 7 |
| Sept-Oct | 3555 | 199 | 5.59 | 101 | 2.84 | 13 | 2 | 11 |
| Oct-Nov | 910 | 113 | 12.41 | 22 | 2.41 | 3 | 1 | 2 |
| Nov-Dec | 5230 | 456 | 8.71 | 288 | 5.50 | 9 | 7 | 2 |
| Dec-Jan | 8050 | 249 | 3.09 | 216 | 2.68 | 11 | 5 | 6 |
| **Total** | **55833** | **3092** | | **3517** | | **133** | **71** | **62** |
| **Percent** | | | **5.53** | | **6.29** | **4.30** | **53.4** | **46.6** |

The highest incidence of coccidiosis (61 cases) was found in 4-8 week age group followed by 0-4 week age group (52 cases), >12 week age group (13 cases) and 8-12 week age group (7 cases).

**Table 4. Incidence of intestinal and caecal coccodiosis in different age groups of chicken recorded at the Central Veterinary Laboratory, Tripureswor, Kathmandu**

| Months | Age groups | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | 0-4 week | | 4-8 week | | 8-12 week | | >12 week | | |
| | Int. | Caecal | Int. | Caecal | Int. | Caecal | Int. | Caecal | |
| Jan-Feb | - | - | 6 | - | 1 | - | - | - | 7 |
| Feb-Mar | 5 | 1 | 3 | - | - | - | - | 2 | 11 |
| Mar-April | - | 1 | 2 | 2 | - | - | - | 1 | 6 |
| April-May | 3 | 2 | 6 | 2 | - | - | - | 1 | 14 |
| May-June | 1 | - | 9 | 3 | - | - | 2 | - | 15 |
| June-July | 2 | 8 | 1 | 2 | - | - | - | 1 | 14 |
| July-Aug | 2 | 5 | 4 | 2 | 1 | 1 | 4 | - | 19 |
| Aug-Sept | 2 | 6 | 1 | - | - | 1 | 1 | - | 11 |
| Sept-Oct | - | 7 | 1 | 2 | - | 2 | 1 | - | 13 |
| Oct-Nov | 1 | 1 | - | - | - | 1 | - | - | 3 |
| Nov-Dec | 2 | - | 5 | 2 | - | - | - | - | 9 |
| Dec-Jan | - | 3 | 5 | 3 | - | - | - | - | 11 |
| | 18 | 34 | 43 | 18 | 2 | 5 | 8 | 5 | 133 |
| **Total cases** | **52** | | **61** | | **7** | | **13** | | |
| **Percent** | **39.1** | | **45.9** | | **5.3** | | **9.8** | | |

Anemic changes are easily recognizable signs due to haemorrhagic diarrhoea in caecal coccidiosis. Dehydrated carcass, soiled feather, ballooning of intestine with red markings, caecal haemorrhages, watery intestinal contents, pale mucosa and denuded surface with white markings were observed by several authors (Gupta and Chawla, 1986; Chauhan, 1993; Reddy and Kumar, 1994). Reddy and Kumar (1994) reported 2-3% mortality in broiler and more than 3% mortality in layers in a study conducted in 50 poultry units of Hyderabad. In all 4% of broiler and 7.8% of layers died due to coccidiosis. Johnson and Rajeswori (1990) recorded 86.8% mortality in 4-7 week old birds.

The results of the present study clearly showed that coccidiosis is rampant both in broiler and layer chicken. The following control measures are suggested:

**Litter management:** The litter should be kept dry since wet litter farms are ideal for sporulation of coccidial oocysts. This can be done by removing wet spots or forking fresh litter.

**Sanitation:** Spillage of water on litter and over-crowding should be avoided. Regular cleaning, washing and spraying germicides in the farm premises should be adopted.

**Drugs:** Anticoccidial drugs should be given by mixing with feed specially at growing stage (up to 12 weeks of age).

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