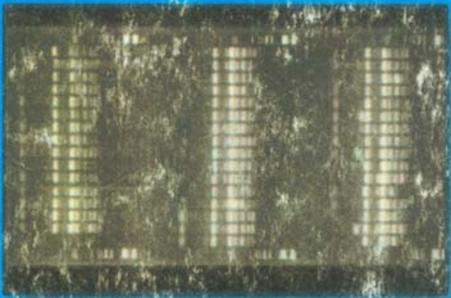
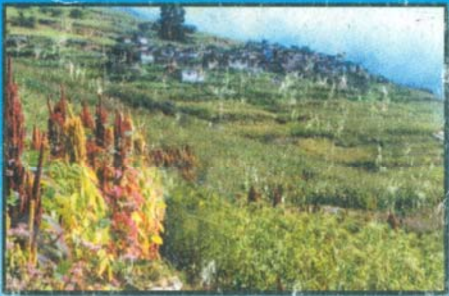
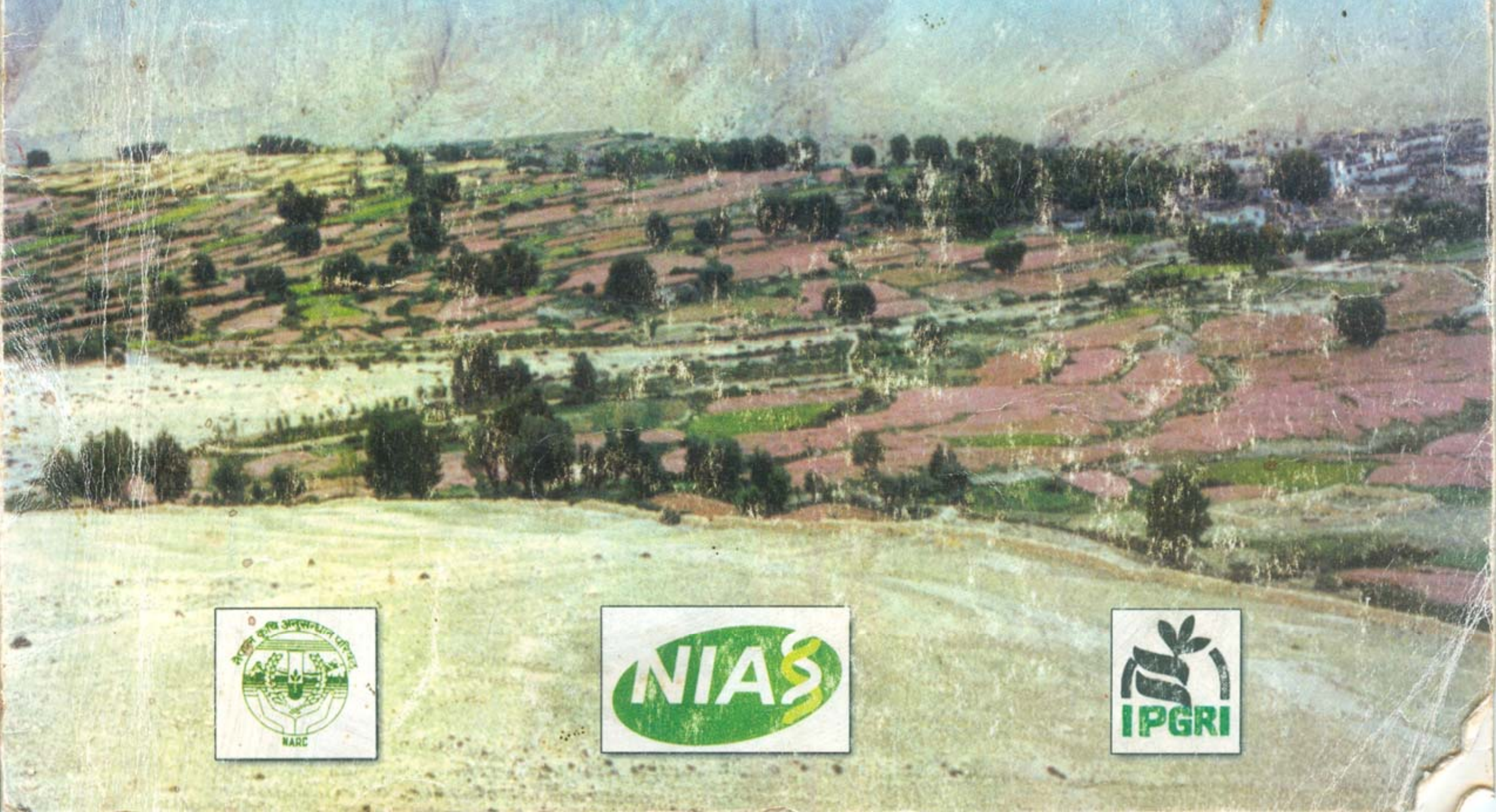
Research and Development on Buckwheat: An Important yet a Neglected Crop in Nepal

Proceedings of National Workshop, 13-14 Sept 2001, Kathmandu, Nepal


Hari P. Bimb and Bal K. Joshi, Editors



NARC NIAS IPGRI

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Foreword

Nepal contains plethora of agrobiodiversity. We have great opportunity in exploiting the genetic resources in judicious and sustainable ways, for improving yield and quality of agricultural crops. Buckwheat is an indigenous crop that plays a major role in food security of mountainous farming community. In addition, buckwheat has significant commercial, social, cultural and medicinal values in different niches of Nepal. Yet very little has been accomplished in research and development of this crop. Visualizing the importance of buckwheat, Nepal Agricultural Research Council (NARC), National Institute of Agrobiological Resources (NIAR, Japan) and International Plant Genetic Resources Institute (IPGRI/APO, Malaysia) jointly initiated a project that accomplished survey, collection and molecular study of buckwheat genetic diversity. Near to the end of this project, a workshop was organized in Kathmandu where researchers, policy makers, extension workers, traders and farmers presented papers in their respective fields and exchanged knowledge, skills and ideas relating to buckwheat. This book is the proceedings of the workshop, which shows the way forward. This endeavor is only a beginning and we anticipate that research and development of this unprivileged crop will be strengthened in near future by the support of existing partners of the project. Certainly, the recommendations outlined in the proceedings will serve as guidelines to undertake activities prioritywise.

I congratulate Dr. HP Bimb (Project leader) and his colleague Mr. BK Joshi for doing a commendable job in producing this valuable document in time. I hope that this volume will be of great value to persons interested in buckwheat.

RP Sapkota
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Preface

Buckwheat (*Fagopyrum* spp.) is grown in limited areas of Nepal. It is a staple food that warrants food security in some mountain regions while in other regions it is a neglected and under privileged crop mostly grown in marginal lands. A significant number of diversity exists in buckwheat in Nepal. Conservation of buckwheat resources hitherto on farm and *in situ* is the legacy owing to social, cultural economical and medicinal values of farming communities. However, very little has been done on the research and development of this crop. Recognizing the importance of plant genetic resources for food and agriculture and their role in conserving global environment, an effort has been made to improve the scientific aspect of the conservation approach and characterization of genetic diversity of buckwheat species in the project "Collaborative research program on genetic diversity characterization and *in situ* conservation of plant genetic resources in Nepal." This project is jointly undertaken by Nepal Agricultural Research Council (NARC), International Plant Genetic Resources Institute (IPGRI/APO, Malaysia) and National Institute of Agrobiological Resources (NIAR, Japan) for a period of three years (1999-2001). In the final year of the project, a national workshop was organized in which around 70 participants including NARC scientists, representatives from the farming communities, Department of Agriculture, NGOs, University, College of Agriculture and District Agriculture Offices attended the workshop with a theme on "research and development of buckwheat: an important yet a neglected crop in Nepal." held in Kathmandu, Nepal from 13-14 September, 2001. Representatives from NIAR, IPGRI (East Asia) and Kyoto University of Japan also attended the workshop. The national workshop was organized with the following objectives:

1. To bring out the knowledge in buckwheat diversity and its wild relatives.
2. To develop scientific basis for *in situ* conservation by analyzing and monitoring buckwheat populations with biochemical and molecular techniques.
3. To broaden the use of buckwheat diversity.

A total of 24 technical papers were presented in the workshop. The papers represented the latest research works and information on buckwheat. In the proceedings these papers were accommodated in four sub-divisions: (a) General Papers, (b) Master/PhD Thesis, (c) Biotechnology and (d) Characterization and Evaluation. In addition, workshop details are presented with photographs and other necessary information including workshop recommendations. The document includes very interesting and new information on buckwheat that helps to formulate strategies for *in situ* conservation on buckwheat species. The recommendations from the workshop will sketch the framework of guidelines for future works in research and development. Some papers are included in Nepali language to honor the feelings of the authors. The document in one compilation of information is believed to be useful to the people who are interested in buckwheat.

We are grateful to the Honorable Member of National Planning Commission of Nepal, Mr HS Tripathi for kindly accepting the chairmanship and inaugurating of the workshop. We are delighted with the presence of Secretary of Ministry of Agriculture and Cooperative, Mr RL Kayastha for his directives on buckwheat research and development. The project was supported by NIAR, Japan; IPGRI-APO, Malaysia and IPGRI, Rome, Italy and we record our thanks to Dr S Miyazaki (Project Coordinator, NIAR), Dr T Nagamine (Project Leader, NIAR) and Dr V Ramanatha Rao (Scientist, IPGRI-APO, Malaysia) for their constant inspiration and support for the project. We are thankful to Prof. Dr M Zhou (Coordinator, IPGRI- East Asia, China) and Dr K Tsuji (Kyoto University, Japan) for sharing their valuable experiences. We acknowledge the support of the then Executive Director of NARC Mr D Joshy for this project. We pay our sincere thanks to all the participants who made the workshop a successful event. We deeply appreciate the computer typing of these proceedings by Ms B Dangol and Mr S Shrestha of Agriculture Botany Division, Khumaltar.

HP Bimb
BK Joshi
Editors

Contents

Inaugural Session

A two-day national workshop on " Research and Development on Buckwheat: An Important yet a Neglected Crop in Nepal" was organized under the aegis of Nepal Agricultural Research Council (NARC), International Plant Genetic Resources Institute (IPGRI-APO), Malaysia and National Institute of Agrobiological Sciences (NIAS), Japan on 13 and 14 September 2001 in Kathmandu. The workshop is a part of the activities of the project- "collaborative research program on genetic diversity characterization and in situ conservation of plant genetic resources in Nepal".

On the first day, the workshop was inaugurated by the Hon'ble Member of National Planning Commission and Chairman of the opening session Mr. Hari Shankar Tripathi. He emphasized for the development of new varieties of buckwheat with package of practices. He also appreciated for the participation of concerned stakeholders in the workshop and suggested for the popularization of buckwheat in home and abroad.

The Secretary for Ministry of Agriculture and Co-operatives Mr. Ratneshwor Lal Kayastha advised to sensitize multipurpose uses and values of buckwheat through different communication media.

The Executive Director of NARC Mr. Dhruva Joshy, while welcoming the participants and invitees briefed about the useful research findings and values of the buckwheat project. He mentioned that to achieve the objectives of the project, a series of activities were undertaken as following:

1. Reviews were carried out of the research works on buckwheat in Nepal.
2. Preliminary rapid rural appraisal was done on *in situ* sites of Dolpa and Mustang where buckwheat is a major crop.
3. Expedition missions of experts from Nepal and Japan were sent to Dolakha, Kathmandu valley, Kaski, Mustang and Dolpa in 1999 and 2000 for the survey and collection of seed and plant samples.
4. Different species of buckwheat were identified and preserved as specimen in Agric. Botany Division and in National Herbarium Center, Godawari.
5. Genetic diversity studies in the populations of wild and bitter buckwheat were performed using random amplified polymorphic DNA (RAPD) technique.
6. Socio-economic study was initiated in the *in situ* sites of the project.

The senior scientist and project leader Dr. Hari Prasad Bimb introduced the project and its objectives as following:

1. To enhance and support a framework of knowledge on agricultural bio-diversity of buckwheat and its wild relatives in Nepal.
2. To develop scientific basis for in situ conservation by analyzing and monitoring diversity of buckwheat populations with molecular/biochemical techniques.
3. To broaden the use of buckwheat diversity.

The project leader and head, Plant Genetic Resources Laboratory of NIAS Dr. T Nagamine and Co-ordinator (IPGRI, East Asia) Prof. M Zhou expressed their views on the buckwheat project during the inaugural session.

On this occasion the chief of Agriculture Botany Division Mr. Raghunath Prasad Sapkota extended the vote of thanks. The senior scientist (Agronomist) and chief of Communication, Publication and Documentation Division, NARC conducted the inaugural session as the master of ceremony (MC).

Proc. National Workshop on Research and Development on Buckwheat, Kathmandu, Nepal,
(HP Bimb & BK Joshi, eds.): 13-14 Sept 2001

Buckwheat research in Nepal: An overview

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Abstract

Buckwheat is a minor crop in Nepal. Research works on this crop was started as early as 1973 and works were focused mainly on germplasm evaluation. After the establishment of National Hill Crops Research Programme in 1986, buckwheat genetic resources obtained from different sources were used to develop better genotypes. Varietal improvement, agronomical research and pathological research were initiated; and some improved genotypes were tested in the farmers' field. Presently, there is need to put more effort on buckwheat research in Nepal.

Key words: buckwheat research, evaluation, local germplasm, trial, varietal improvement

Introduction

Buckwheat (*Fagopyrum* spp.) is one of the minor food crops in the temperate and hilly countries of Europe, East Asia and the Himalayan region. Two cultivated species (*F. esculentum and F. tataricum*) are the staple and life supporting crops in the remote food deficit areas of Nepal. Buckwheat is an important crop in terms of its adaptation to diverse climatic conditions, moisture stress regime, nutrient limitation and cool temperature and it fits well to different cropping patterns due to its short growing period. It possesses high nutritional and medicinal values and is used as a raw material in preparation of different health foods.However, buckwheat has been an under-exploited and poor peoples' crop in Nepal. This pseudo-cereal generally receives low inputs and poor management and is grown traditionally only when some lands remain fallow after millet transplanting.

Buckwheat is called *kuanna* (ku = bad and anna = cereal) by Nepalese Hindu community and is a relatively newer crop for this region. Some people believe that buckwheat might have been introduced in Himalayan region during the *Vedic* Era (1500 to 1200 BC) by a hermit, Bishwamitra. In this context, it is a crop with 3200 to 3500 year's domestication history in Nepal. Currently buckwheat is grown in 43000 ha producing 23100 t with a productivity of 540 kg ha^{-1} (Sherchand et al., 1986).

The history of agriculture research and development in Nepal is very short, which started after fifties and received momentum during early seventies in major crops and animals. Some preliminary researches on buckwheat were started when National Hill Crops Research Programme (NHCRP) was established in 1986.

Research works before NHCRP establishment

The importance of buckwheat was well recognized in the Nepalese agricultural research system, but due consideration was not given with scarce resources. Dr SN Lohani was the pioneer to initiate buckwheat improvement works during 1973. He evaluated the local and exotic lines of buckwheat at the Agronomy Division, Khumaltar along with a number of minor crops ie finger millet, barley, buckwheat, grain amaranth, pros millet, foxtail millet and sorghum (Lohani, 1980) with limited resources and manpower. The buckwheat work was limited only in germplasm evaluation. Buckwheat research data before the establishment of NHCRP are not available, however if I recall correctly, a buckwheat observation nursery was regularly conducted at Khumaltar and Kakani from 1974 to 1980. The local selection Khumjung Tite from Solukhumbu and the exotic lines Tokyo and IR-13 performed well. The exotic lines were mainly obtained from Japan (Dr A Ujihara) and Canada (Dr CG Campbell). Most of the lines have already disappeared however IR-13, a Japanese line is doing well across Nepal as yet although its genetic purity has been greatly deteriorated. Many buckwheat smples were obtained during the first half of 1980s and were tested mainly at Khumaltar. The impact of buckwheat research during the past two decades, therefore was almost negligible.

Research works after the establishment of NHCRP

Buckwheat improvement work began in a systematic way after the establishment of NHCRP in 1986 with the mandate of research on finger millet, barley, buckwheat and grain amaranth (Baniya, 1990). NHCRP initiated buckwheat improvement in Agricultural Botany Division, Khumaltar and latter its headquarter was established at Kabre, Dolakha in 1987 (Baniya, 1993). This programme was funded and technically supported by IDRC, Canada. Agriculture Botany Division started buckwheat improvement work with germaplasm from the Agronomy Division, IBPGR multi-crop collecting missions of 1984 and 1985 and with a set of buckwheat trial and two broad based populations obtained from Dr CG Campbell. This was the starting point of recent buckwheat improvement in Nepal. All these materials were taken to Kabre and henceforth the buckwheat improvement activities were handled from NHCRP (Baniya, 1993a).

Chronology of works

1987
A Buckwheat Nursery was conducted at Kabre and Khumaltar. The materials were obtained from Canada, Japan, USSR, Poland, China, South Africa, Brazil, Mongolia and Nepal. HCRP took the lead role in buckwheat research activities.

1988
Three more locations were added to conduct Observation Nursery experiment including various genotypes at Kabre, Jumla, Khumaltar, Pakhribas and Marpha. The sources of the materials were from Canada, Japan, Yugoslavia, USSR, Poland, India, China, USA, South Africa, Sweden, Czechoslovakia and Nepal (Baniya, 1993a). Selections were made and some lines were promoted to yield trials. Two broad based populations were obtained from Dr Campbell and single plant selection was done at Khumaltar from which 174 plants were selected for further use (Baniya, 1993). The tetraploid variety Shinshu-o-Soba from Japan and determinant growth type Soumchanka from the former USSR were also introduced and evaluated under Nepalese environments. An Initial Evaluation Trial (IET) was initiated and conducted at Kabre and Khumaltar.

1989
In addition to the Observation Nursery and Initial Evaluation Trial an Advanced Observation Nursery and an Advanced Varietal Trial were also formulated and sent to the testing locations. Dolpa, Rampur and Todke (farmer's field near Kabre) sites were further added for conducting these experiments. The work of 1988 was refined and continued. A polycross nursery of sweet buckwheat was formulated to develop a broad based population from local and exotic lines and planted in isolation. Evaluation of 155 local germplasms from two cultivated species were done during the autumn season of 1990. During 1989, buckwheat outreach research activities were also started (Baniya, 1990b; Baniya et al., 1990c).

1990
The research works of the previous year were continued. Two sets of *tite* (tartary) and *mithe* (common) buckwheat were formulated in the Coordinated Varietal Trial. Recognizing the efficiency of the lattice design in finger millet and barley, this design was also used in buckwheat experiment. Outreach research activities were strengthened with the distribution of minikits and FFT. USAID/IAAS studied 288 *mithe* (common) buckwheat landraces.

1991
Varietal improvement and other research works were continued. A total of 155 local germplasms were morphologically characterized, documented and the seeds were preserved. Buckwheat agronomical trials and disease survey were initiated (Baniya, 1991; Prasad, 1993).

1992
Varietal trials, selection from broad-based populations, agronomical trials, outreach research activities and disease recording were continued. More than 507 local germplasms were evaluated (Baniya, 1992; Baniya et al., 1992a).

1993
Regular research works were continued. A group of local consultants prepared a comprehensive report on buckwheat (Adhikary, 1995).

1995
Few common buckwheat genotypes were selected from the Canadian Broad based population and evaluated in Jumla, Kabre and Khumaltar.

1996
Some *tite* buckwheat genotypes were selected from the local varieties by mass selection and tested across locations. NARC, IPGRI and NIAS (NIAR at present), Japan signed a Letter of Agreement on October 15, 1996 and started the project "On-Farm Conservation of Bitter Buckwheat in the Mountains of Nepal: A Feasibility Study."

1997
The previous research works were continued. NARC and IPGRI signed Memorandum on Understanding to start the project "Strengthening the Scientific Basis of *in situ* Conservation of Agricultural Biodiversity" which included buckwheat as a mandated crop and started research works in Jumla site. This project started isozyme analysis in buckwheat crop in the Biotechnology Laboratory at Khumaltar.

2000
Three *mithe* types and five *tite* types were identified as pipeline varieties that could be released for general cultivation.

1989-1999
Extensive observation tours, surveys and RRA were conducted in major buckwheat growing areas (Baniya, 1993a; 1993b).

1990-2000
Publications of articles by Nepalese and foreign scientists were done to popularize the status of Nepalese buckwheat around the world (Dongol et al., 1999; Baniya, 1990a; 1990b; 1999a; 1999b).

During 5 years period (1987 to 1992), germplasm collection, evaluation, development of varietal trials, acquisition and development of broad based populations and selection in different materials, initiation of agronomical trials, outreach research activities, disease survey and recording, documentation of information etc were accomplished and significant works were carried out. This was very important period of buckwheat research in Nepal (HCRP, 1988).

Buckwheat diversity studies in Nepal

Limited studies of buckwheat germplasm collection, characterization, evaluation, documentation, utilization and conservation are available.

Historical aspects

A Japanese expedition team traveled across Nepal during 1952 to 1953 and collected seed samples of different crops and flora. The report was published in a book "Land and Crops of Nepal Himalaya" in 1956. This book provided a comprehensive description on the crops, flora and climate of western Nepal. The team collected buckwheat seeds, which were evaluated in Japan (Kihara, 1956).

From the beginning of early sixties, several teams or individual scientist visited Nepal and collected crop landraces from different regions and carried out in-depth studies on the specific crops. Nepalese crop landraces have been used in Europe, North America, Japan, India, China and some other countries.

Recent work on buckwheat germplasm

In 1971, the Department of Agriculture/Nepal in collaboration with USAID/Nepal, collected germplasm of cultivated crops from 27 districts of Nepal (Shechand et al., 1986). Dr SN Lohani was a member of that exploration team, and it is believed that buckwheat germplasm was also collected, evaluated probably in 1973 and used for buckwheat improvement programmes. Thus, Lohani was the first Nepalese to collect, evaluate and utilize buckwheat landraces from 1971 to 1973.

Akio Ujihara, Professor of Shinshu University, Japan visited for about two months from late September 1975 in eastern and central hills and some plain areas of Central Development Regions. His mission of visiting Nepal was to collect and study buckwheat gene pools and to record the information on agricultural practices. He collected 34 common, 43 tartary and 14 wild buckwheat populations in 1975 (Ujihara, 1993). Ujihara studied the geographical distribution of common buckwheat and found information on the origin of buckwheat. From 1980 to 1986, he again collected buckwheat landraces and information on cultivation practices. He published many articles on Nepalese buckwheat and used these materials for his Ph. D. dissertation in 1982 (Ujihara, 1983). So, Ujihara is the pioneer in collecting and using Nepalese buckwheat landraces systematically.

Ohmi Ohnishi, Professor of Kyoto University, Japan also visited Nepal in 1986 and used Himalayan buckwheat landraces for allozyme studies from 1983 to 1993 and published many articles. Thus he further highlighted on Nepalese buckwheat resources (Ohnishi, 1985; 1986). NIAR, Japan was involved in buckwheat research in 1996, mainly on studies of *Fagopyrum* gene pools of Mustang, Dolpa and other areas. Dongol and Baniya compiled buckwheat germplasm studies in 1993 (Dongol, 1993).

Germplasm collection

The collection of buckwheat germplasm started long ago in 1802 (Kihara 1956) but the records of only past few years are available. Although, the Japanese scientists collected buckwheat germplasm from the early fifties, very little is known about the number of collections, their evaluation, documentation and conservation, except some references in the scientific papers. The Nepali scientist Dr SN Lohani collected some buckwheat landraces, but unfortunately, the complete record of these is still not available. During the eighties, IBPGR, Rome, initiated collection of Nepalese plant genetic resources and organized multi-crop collection missions in 1984, 1985 and 1986 in collaboration with the Japanese government. Information on some collections is available from 1984 onward. IBPGR/USAID deputed a Japanese student S Yanagihara in 1985 to collect germplasm of different crops for more than 2 years in Nepal. When the National Hill Crops Research Programme (NHCRP) was established in 1986, it started collection, evaluation, documentation and utilization of buckwheat germplasm. Also USAID provided funds for collection and evaluation of common buckwheat germplasm to IAAS Rampur during 1990-1994. The present status of collections of buckwheat germplasm is given in Table 1. In 1999, NARC and NIAR team of scientists collected germplasm of *F. cymosum*, *F. tataricum* spp. *potanini*, *tite* buckwheat.

Table 1. Nepalese buckwheat germplasm collection records

SN	Team/name of collector	Sponsor	Collection year	No. of sample collected	Evaluation year	Remarks
1.	SN Lohani	USAID/Nepal	1971	NA	1973	
2.	IBPGR, Multi-crop Collection Team-1984	Japan	Nov 1-Dec 12, 1984	115	1986, 1989, 1990	
3.	IBPGR, Multi-crop Collection Team-1985	Japan	Oct 8-Nov 26, 1985	151	1986, 1989, 1990	
4.	IBPGR, Multi-crop Collection Team-1986	Japan	NA	NA	NA	
5.	S Yanagihara	USAID/Japan	Oct 1985-Jan 1987	90	1989, 1990	
6.	NHCRP, Kabre	Nepal	1987-1992	85	1992	
7.	NHCRP, Kabre	Nepal	1993	27	-	
8.	M Yoshida	Jica/Japan	1989-1992	50	1992	
9.	Buckwheat Research Project (TU)	USAID/Nepal	1990-1993	288	1992, 1993	Only common type
10.	NHCRP		Different	507	1992	All available up to 1992
11.	NARC/NIAR	NIAR	1999-2000	50+108	2000, 2001	Wilds and tartary

Evaluation, characterization and documentation

Ujihara (1983; 1989), Ohnishi (1988; 1989), Tulachan (1989), Rajbhandari and Hatley (1993), Baniya et al. (1992) and others evaluated Nepalese buckwheat germplasm and documented the information in detail. Although SN Lohani evaluated the buckwheat germplasm in 1973 for limited traits to use in varietal improvement programmes and some landraces were evaluated in 1986 for agronomic traits, but the detailed information on these studies are not available.

Ujihara evaluated 16 Nepalese common buckwheat landraces of different origin in 1976 at Shinshu University, Japan. Data was presented on flowering days, plant height, number of branches, clusters and grains per plant. He found all Nepalese buckwheat cultivars mainly autumn type (Ujihara, 1983) and significance variations were observed. Tulachan also evaluated Nepalese tartary buckwheat populations and found variations in grain color, shape, size, texture and other agro-morphological characteristics (Tulachan, 1989).

Baniya et al. (1992a; 1992b; 1992c) evaluated 155 (75 common and 80 tartary buckwheat) local landraces in autumn (1989) and spring (1990). He characterized and documented them by using IBPGR descriptors for 23 traits (autumn 1989). The findings of this study were presented in national and international meetings (Baniya et al., 1990; 1991; 1992). During the autumn season in 1992, NHCRP evaluated a total of 507 buckwheat (common 309, tartary 196 and wild 2) using IBPGR descriptors for 27 traits (1995). Dr BP Rajbhandari also evaluated and characterized 288 common buckwheat at five agro-ecological regions of Nepal for 19 traits and documented the results under the Buckwheat Research Project, TU/USAID for the duration between 1991 to 1994 (Rajbhandari and Hatley, 1993). Ujihara and Matano (1982) evaluated Nepalese wild buckwheat. Dr HP Bimb studied 11 populations of *F. cymosum* and 8 populations of *tite* buckwheat by RAPD techniques and found variations.

Conservation

Currently, NHCRP is conserving more than 534 buckwheat landraces at Kabre in ordinary storage conditions. Some cultivars are also stored at Khumaltar in medium-term storage condition and at Godawari in deep freeze. The first set of 155 landraces and about 507 lines of other set are being stored in Canada under Dr Campbell's supervision in long-term storage conditions. All the landraces collected in 1984, 1985 and 1986 by the multi-crop missions are stored in Japan in the form of originally collected samples. Similarly, all the samples collected by Yanagihira and Yoshida and most of the samples collected by NHCRP teams were also taken to Japan for further study and use, and are conserved at the University of Shinshu University of Tsukuba, Japan. BP Rajbhandari is also conserving 288 common buckwheat cultivars in ordinary storage at Kirtipur, Nepal by multiplying the seed every year (personal communication). The seed and plant specimens of *F. cymosum* and *tite* buckwheat are conserved in Nepal. NIAR, Japan has also conserved some seeds samples.

Utilization

The available variability in Nepalese buckwheat genetic resources is partially used, and a lot still to be done in this respect. After evaluation of buckwheat landraces, some of the tartary populations were identified as varieties and others were improved by following the individual plant selection. Some of the common buckwheat cultivars were used in varietal improvement programmes by crossing with other lines and following the recurrent selection method. The Japanese scientists are using Nepalese buckwheat germplasm for basic studies but not for varietal improvement because Nepalese landraces are not suitable for their conditions (Ujihara, 1983). Rajbhandari and Hatley (1993) are using the common buckwheat landraces to identify superior ecotypes for breeding purposes, *in vitro* culture technique etc. Nepalese buckwheat gene pools can be used in the development of taller plant, resistance to stress and more branching.

The collection, evaluation, characterization, documentation, preservation and utilization of plant genetic resources of all crops are the responsibility of Nepal Agricultural Research Council (NARC). NARC has assigned the Plant Genetic Resources Section of the Division of Agricultural Botany to conduct regular explorations for collecting crop germplasm and undertaking activities on plant genetic resources. However, this section is not much engaged in buckwheat germplasm except in storing and small-scale collection. NHCRP, Kabre is taking the lead in handling and using the available genetic resources.

Tribhuwon University (TU), Nepal is also working on buckwheat germplasm research under the USAID funded project. However, it is carrying out only some basic studies and is not engaged in buckwheat improvement (Rajbhandari and Hatley, 1993).

Progress made in buckwheat research

Personally, I feel that no commendable achievements are available on buckwheat research work, but some of the achievements are worth mentioning as follows:

Technology generation
Three broad based populations have been established. Some genotypes such as GF 5233, IR-13, Shinano Natsu-Soba, Shinano Ichigo and Botan Soba were found to be superior. There are other lines that appear promising for different areas of Nepal. Some diseases of buckwheat have been identified. The basis for varietal improvement has been established and initial works on agronomy and plant pathology have been started.

Institutional development
Buckwheat has been recognized as a mandated crop of the NHCRP at Kabre. The testing sites for buckwheat have also been identified.

Collaboration
Technical collaboration has been established with Canada and Japan. They are supplying their germplasm and buckwheat literatures. We participated in the 4th and 5th International Symposium on

Buckwheat, which helped in the exchange of ideas and the establishment of relationships with other buckwheat scientists from around the world.

Transfer of technology

The results of work done on buckwheat are being documented and distributed to different interested people and institutions. Also, outreach research activities, training, visits, etc. helped to transfer buckwheat technology. Buckwheat seeds are being sold and minikits were distributed in a limited number. This also helped disseminate buckwheat technology. Some farmers are taking interest in improved technology on buckwheat processing and consumable products.

Conclusion

Research work on buckwheat has not received due consideration until recently. Thus, the package of practices on buckwheat is not available for common farmers. So, there is a need to strengthen the buckwheat research and development work in Nepal so that commercialization of buckwheat is possible. Although Nepal is rich in buckwheat gene pools, the scientific study, collection, conservation, characterization and diversity study, documentation and utilization of Nepalese buckwheat is lacking. There is a need to maintain the momentum of buckwheat research in Nepal and utilize this national resources for the benefit of Nepalese people.

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Field survey and collection of *Fagopyrum* species for *in situ* conservation in Nepal

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Abstract

Landraces and wild relatives of crop species are regarded as the indispensable gene sources for future genetic improvement. For effective conservation of genetic variation *in situ*, it is necessary to identify the target populations based on its genetic variation and sustainability in its habitat. During 1999 and 2000, collaborative field survey was conducted in Kathmandu valley, Kaski, Dolakha, Mustang and Dolpa districts. Common buckwheat (*F. esculentum*) and tartary buckwheat (*F. tataricum*) were commonly cultivated in Mustang and Dolpa districts. Variation in seed shapes of tartary buckwheat was observed. Wild form of *Fagopyrum* species, *F. cymosum* is distributed in Dolpa, Lumle (Kaski), Boch (Dolakha) and Kathmandu valley while it was absent in Mustang district. Wild and weedy forms of tartary buckwheat were found in Mustang and Dolpa districts. These forms were discussed in relation to Sichuan and Tibetan type of China. *F. megacarpum* was found only in Vyas gad of Dolpa district. Information on their geographical distribution, population sizes and habitats are also discussed.

Key words: *Fagopyrum*, field survey, *in situ* conservation

Introduction

Landraces and wild relatives of crop species are regarded as the indispensable gene sources for future genetic improvement. However, they continue declining rapidly and globally resulting in the extinction of their genetic variation. *In situ* conservation of spontaneous population has recently been considered as one of the promising method to conserve the genetic variation especially of wild species. For effective conservation of genetic variation *in situ*, it is necessary to identify the target populations based on its genetic variation and sustainability in its habitat.

A collaborative research project on *in situ* conservation of plant genetic resources in Nepal has been conducted between Nepal Agricultural Research Council (NARC) and National Institute of Agrobiological Resources (NIAR) since 1998 with the support of International Plant Genetic Resources Institute (IPGRI). This project focuses on the *in situ* conservation of *Fagopyrum* species (buckwheat) in Nepal. Since buckwheat is a staple food for local consumption in high altitude area in Nepal and this crop is well adapted to its local environments, NARC gives importance to conserve buckwheat species of indigenous population and utilize for genetic improvement of local cultivars out of the exploration and collection of such species.

During 1999, a collaborative field survey was conducted in Dolpa district, Kathmandu valley, Lumle Agricultural Experiment Station in Kaski district and Boch Horticultural Experimental Farm in Dolakha district. During this survey, seed samples were collected in each site, while the vegetation in all surveyed sites had already been senesced so that no ecological observation could be made.

The objectives of the research programme during 2000 were:

i) To re-visit the collection sites in Dolpa district, Lumle and Boch to collect seed samples as well as the information on the habitat such as population size and coexisting/associated species. Seed materials are to be used for studying and monitoring the genetic variation of each population in 1999 and 2000.

ii) To survey and collect seed of *Fagopyrum* species in Mustang district, which is adjacent to Tibetan plateau and therefore wild and weedy form of tartary buckwheat (*F.tataricum*) were expected to be distributed there in (Ohnishi, 1998; Vaidya et al., 1999; Fukuoka et al., 2000)

iii) To investigate the genetic variation within and among wild *Fagopyrum* populations using RAPD markers.

Materials and methods

Exploration and collecting of *Fagopyrum* species was conducted in Mustang district, Dolpa district, Lumle Agricultural Experiment Station in Kski district and Boch Horticultural Farm in Dolakha district and Kathmandu valley (Fig. 1). Itinerary of the overall field survey is shown in Table 1. In case of remote mountainous areas, we first entered the main part of the districts (Jomsom and Juphal) by air flight and conducted a series of surveys in fields, villages and roadside on foot. Lumle and Boch were visited by vehicle. We collected the seed samples in each site and gathered ecological information on the habitat such as population size, coexisting/associated species and grazing by herbivores.

Results and discussion

Common buckwheat (*F. esculentum*) and tartary buckwheat *(F. tataricum*) were commonly cultivated in Mustang and Dolpa district (Table 2). Smooth and notched wing seed shapes were recognised among cultivated tatary buckwheat as previously reported (Hirose et al., 1992) and referred to as 'Nepali type' and 'Tibetan type', respectively (Table 3). In Ruma of Dolpa, two samples of tartary buckwheat called 'rice type' (AccNo 96 and 99 in Table 3) were collected, which was claimed to be free of bitterness by a local woman farmer and this could be useful in improvement of grain quality after further evaluation.

In the case of wild forms of *Fagopyrum* species, *F. cymosum* is distributed in Dolpa district, Lumle, Boch and Kathmandu valley, while it appears to be totally absent in Mustang district (Table 2). In central Nepal including Bagmati, Janakpur and Sagarmatha district, Ujihara and Matano (1976, 1982) observed that *F. cymosum* was distributed at 1500-3000 masl. Since the altitude of most collection sites in Mustang district is more than 3000 masl, whereas that of other sites is between 1360 masl (Imadol, Kathmandu valley) to 2911 masl (Rasi, Dolpa) (Table 3), our observation is generally in accordance with the previous observation.

Wild and weedy forms of tartary buckwheat were found to be distributed in Mustang and Dolpa district (Table 2). Previously, the wild form of tartary buckwheat has been discovered in mountainous areas of southern China, Tibet, Nepal and northern Pakistan (Ohnishi, 1993a; Ohnishi, 1994; Tsuji et al., 1999). Ohnishi (1993b) reported on the morphological differences between wild populations from Sichuan province of China and those from wests of Tibetan plateau and concluded that Tibetan population more or less resembled the cultivated ones. Similarly, wild form of tartary buckwheat collected in this survey in Nepal could be classified into two types. We designated those as 'Sichuan type' characterized by short and tiny growth habit and the others as 'Tibetan type' with tall and vigorous growth habit (Table 3). Both of these types were found in Mustang district, whereas only Tibetan type was observed in Dolpa district. In addition to cultivated and wild forms, 'weedy type' of tartary buckwheat was discovered in Mustang and Dolpa district, whose plant type was generally identical except for seed shattering habit. So far, overlapping of geographical distribution of wild tartary buckwheat and *F. cymosum* was not observed in southern China but only in two sites in eastern

Tibet. Although these two species usually did not grow at the same site, they were found to coexist in the field of common buckwheat and common millet in Ruma village of Dolpa district (Table 3).

Sinchuan type of wild tartary buckwheat distributed sporadically at gravelled river bank or along road side with relatively little humidity. The size of each community (ie the distance between distal and proximal end of community) is about 10 to 20 m in length and varying sizes of width. Although these places were easy to access for herbivores, evidence for significant level of grazing was not recognized. A fairly large community of Sichuan type of tartary buckwheat was found in a village called Bhena in Mustang district. The place was surrounded by a stonewall and probably used as crop field or pasture and their size was about 20 m by 30 m. This wild tartary coexisted with Compositae species such as *Artemisia* spp. Tibetan type of wild tartary buckwheat was usually found in field of legume, maize or abandoned field mixed with crop plants both in Mustang and Dolpa districts.

F. cymosum usually grew on river bank, roadside or the edge of terraced fields in and around villages. Most of the habitats of *F. cymosum* were sandy terraces or stonewalls close to river, which was well drained and relatively humid. Their population sizes varied from site to site and the smallest was that in Rasi of Dolpa district, which was about 4 m and with about 100 individuals. In Lumle Agricultural Experiment Station and Boch Horticultural Experiment Farm, by contrast, spontaneous populations were observed throughout the sites and the sizes of population were extremely large.

Table 1. Itinerary of field survey

Date	Movement
Aug 29 (Tue)	Move from Tsukuba to Kyoto
Aug 30 (Wed)	Move from Kyoto to Kathmandu via Kansai airport (by international flight
Aug 31 (Thu)	Discussion and preparation for the field survey in Mustang district at Nepal Agricultural Research Council (NARC)
Sept 1 (Fri)	Move from Kathmandu to Pokhara (by domestic flight)
Sept 2 (Sat)	Move from Pokhara to Jomsom (by domestic flight)
	Survey in the fields, villages and roadside between Jomsom to Kagbeni (on
Sept 3 (Sun)	foot)
Sept 4 (Mon)	Survey between Kagbeni and Chele (on foot)
Sept 5 (Tue)	Survey between Chele and Shyammochen (on foot)
Sept 6 (Wed)	Survey between Shyammochen and Ghami (on foot)
Sept 7 (Thu)	Survey between Ghami and Tsarang (on foot)
Sept 8 (Fri)	Survey between Tsarang and Lo Manthang (on foot)
Sept 9 (Sat)	Survey at Lo Manthang (on foot)
Sept 10 (Sun)	Move from Lo Manthang to Ghami (on foot)
Sept 11 (Mon)	Survey between Ghami and Samar (on Foot)
Sept 12 (Tue)	Survey between Samar and Chhuksang (on foot)
Sept 13 (Wed)	Survey between Chhuksang and Kagbeni (on foot)
Sept 14 (Thu)	Survey between Kagbeni and Muktinath (on foot)
Sept 15 (Fri)	Survey between Muktinath and Jomsom (on foot)
Sept 16 (Sat)	Data arrangement and cleaning the collected samples at Jomsom
Sept 17 (Sun)	Survey at Jomsom (on foot)
	Move from Jomsom to Pokhara (by domestic flight)
	Move from Pokhara to Lumle agriculture experiment station (by vehicle)
Sept 18 (Mon)	Survey at Lumle agriculture experiment station
	Move from Lumle agriculture experiment station to Pokhara (by vehicle)
Sept 19 (Tue)	Move from Pokhara to Kathmandu (by domestic flight)
	Arrangement and drying of the collected samples at NARC and the
Sept 20 (Wed)	preparation and discussion for field survey at Dolpa distric.
Sept 21 (Thu)	Move from Kathmandu to Nepalgunj (by domestic flight)
Sept 22 (Fri)	Stand by at Nepalgunj due to flight cancellation
Sept 23 (Sat)	Stand by at Nepalgunj due to flight cancellation
	Move from Nepalgunj to Juphal (by domestic flight)
Sept 24 (Sun)	Survey between Juphal and Dunai (on foot)
Sept 25 (Mon)	Survey between Dunai and Sahatara (on foot)
Sept 26 (Tue)	Move from Sahartara to Juphal (on foot)
Sept 27 (Wed)	Survey between Juphal and Rashi (on foot)
Sept 28 (Thu)	Move from Juphal to Kathmandu via Nepalgunj (by domestic flight)
Sept 29 (Fri)	Cleaning and drying of collected samples at NARC
Sept 30 (Sat)	Survey at Boch horticultural farm (by vehicle)
Oct 1 (Sun)	Cleaning and arrangement of collected samples at hotel Narayani
Oct 2 (Mon)	Cleaning and arrangement of collected samples at hotel Narayani
Oct 3 (Tue)	Discussion for the research program on DNA analysis of collected samples in
Oct 4 (Wed)	Japan
	Departure from Kathmandu to Japan (by international flight)
	Arrival at Tsukaba via Kansai air port

Table 2. Summarized list of collected samples of *Fagopyrum* species in 2000

Species	Cultivated /weedy/ wild	Region / District					
		Dolpa	Mustang	Lumle	Kathmandu	Boch	Total
F. esculentum	Cultivated	17	1	-	-	-	18
F. tataricum	Cultivated	22	7	-	-	-	29
	Weedy	15	2	-	-	-	17
	Wild	27	5	-	-	-	32
F. cymosum (4x)	Wild	0	7	1	2	1	11
F. megacarpum	Wild	0	1	-	-	-	1
Total		81	23	1	2	1	108

Table 3. List of samples of *Fagopyrum* species collected in Nepal

Acc No	Species	Status	District	Village	Altitude, m	Date	Note/ type
1	*F. tataricum*	Weedy	Mustang	Kagbeni	2850	2 Sept	
2	do	Cultivated	do	Chele	3050	3 Sept	
3	do	do	do	Samar	3496	4 Sept	Tibetian
4	do	do	do	do	do	do	Nepali
5	do	do	do	1km NE of Samar	3505	do	Nepali
6	do	Weedy	do	do	do	do	
7	do	Wild	do	do	do	do	
8	do	do	do	Bena	3720	do	
9	do	Wild or weedy	do	do	do	do	
10	do	Wild	do	0.5 km NE of Bena	3780	do	
11	do	Cultivated	do	Geling 1	3467	5 Sept	
12	*F.*	do	do	do	do	do	
13	*esculentum*	do	do	Geling 2	do	do	
14	do	do	do	do	do	do	
15	*F. tataricum* do	do	do	Ghami 1	3510	do	Tibetian
16	do	do	do	do	do	do	Nepali
17	do	Weedy	do	do	do	do	
18	do	Cultivated	do	Ghami 2	do	do	Nepali
19	do	Weedy	do	do	do	do	Red stem
20	do	do	do	do	do	do	Green stem
21	*F.*	Cultivated	do	do	do	do	
22	*esculentum*	do	do	Dhakmar	3610	6 Sept	
23	do	do	do	do	do	do	
24	*F. tataricum* do	wild	do	0.3 km SW of Marang	3660	do	
25	do	do	do	Marang 1	3700	do	
26	do	Cultivated	do	Marang 2	do	do	Red stem
27	do	Weedy	do	do	do	do	
28	do	Cultivated	do	do	do	do	Green stem
29	*F.*	do	do	do	do	do	
30	*esculentum* do	do	do	Tsarang 1	3587	do	

Acc No	**Species**	**Status**	**District**	**Village**	**Altitude, m**	**Date**	**Note/ type**
31	*F. tataricum*	do	do	Tsarang 2	3526	6 Sept	
32	do	wild	do	do	do	do	Red stem
33	do	wild	do	do	do	do	Green stem
34	*F.*	cultivated	do	Tsarang 3	3480	7 Sept	
35	*esculentum*	do	do	do	do	do	
	F. tataricum						
36	do	Wild	do	Lo	3720	do	
				Manthang			
37	*F.*	Cultivated	do	1	3740	do	
	esculentum			Lo			
38		Wild	do	Manthang	-	do	Tibetian
	F. tataricum			2			
39		Cultivated	do	Lo	-	do	Nepali
40	do	do	do	Manthang	-	do	
	F.			3			
	esculentum			do			
				do			
41	*F. tataricum*	do	do	Gharpu	3720	7 Sept	Nepali
42	*F.*	do	do	do	do	do	
43	*esculentum*	wild	do	do	do	do	
44	*F. tataricum*	do	do	do	do	do	Tibetian
45	do	cultivated	do	Lo	3670	do	Nepali
	F. tataricum			Manthang			Nepali
				4			
46	*do*	Wild	do	do	do	do	Sichuan
47	*do*	do	do	do	do	do	Tibetian
48	*F.*	Cultivated	do	do	do	do	
49	*esculentum*	Wild	do	0.5 km S of	3780	10 Sept	
	F. tataricum			Bene			
50		Cultivated	do	Chele	3020	11 Sept	
	F.						
	esculentum						
51	Do	do	do	Chhusang	2930	do	
52	*F. tataricum*	Weedy	do	do	do	do	
53	do	(Wild?)	do	do	do	do	
54	do	Wild	do	do	do	do	
55	do	do	do	Tangbe	2920	12 Sept	Tibetian
56	*F. tataricum*	Wild	Mustang	Tangbe	2920	12 Sept	Nepali black seed
57	do	do	do	do	do	do	do, red seed
58	do	Weedy	do	do	do	do	
59	do	Wild	do	Khingar	3240	do	
60	do	Weedy	do	do	do	do	
61	do	Wild	do	do	do	do	
62	do	Cultivated	do	do	do	do	
63	do	do	do	Jarkot 1	3298	do	
4	*F.*	do	do	Jarkot 2	3317	do	
65	*esculentum*	do	do	Jarkot 3	3332	do	
	F. tatarcum						
66	do	Weedy	do	do	do	do	
67	*F.*	Cultivated	do	Jarkot 4	-	do	

Acc No	Species	Status	District	Village	Altitude, m	Date	Note/ type
68	*esculentum*	Wild	do	Muktinath	3515	14 Sept	Sichuan
69	*F. tataricum*	do	do	1	do	do	(giant)
70	do	Weedy	do	do	do	do	
	do			do			
71	do	Wild	do	Muktinath	3460	do	
72	do	Weedy	do	2	do	do	
73	do	Cultivated	do	do	-	do	
74	do	do	do	(Muktinath	3365	do	
				)			
75	do	Wild	do	0.3 km E of	2710	16 Sept	
				Jarkot			
				Dhumpha			
76	do	Weedy	do	do	do	do	
77	*F.*	Cultivated	do	do	do	do	
78	*esculentum*	Weedy	do	Thini	2705	do	
79	*F. tataricum*	Wild	do	do	do	do	(giant)
80	do	do	do	do	do	do	Red seed
	do						
81	*F.*	Cultivated	do	do	do	do	
82	*esculentum*	Wild	Dolpa	Juphal	2410	23 Sept	
83	*F. cymosum*	do	do	Dangiwada	2260	do	
84	do	do	do	(Dangiwad	-	do	
85	do	(Wild)?	do	a)	2170	do	
	F. tataricum			2 km E of			
				Juphal			
86	do	Cultivated	do	do	2155	do	
87	do	do	do	Suligad	2076	do	
88	*F. cymosum*	Wild	do	Dunai	2050	24 Sept	
89	*F.*	do	do	Vyasgad	2170	do	
90	*egacarpum*	do	do	Shahartara	2303	do	
	F. cymosum						
						Table 3. Continued…	
91	*F. tataricum*	Cultivated	do	do	do	do	
92	do	do	do	Ruma 1	2342	26-Sep	Red stem
93	do	do	do	do	do	do	Green stem
94	do	wild	do	do	do	do	
95	*F.*	Cultivated	do	do	do	do	
	esculentum						
96	*F. tataricum*	do	do	Ruma 2	do	do	Rice
97	do	Wild	do	Ruma 3	do	do	
98	do	Weedy	do	do	do	do	
99	do	Cultivated	do	do	do	do	Rice
100	*F. cymosum*	Wild	do	do	do	do	
101	*F. tataricum*	do	do	Rasi 1	2911	do	
102	do	Wild	do	do	do	do	
103	do	Wild	do	Rasi 2	2902	do	
104	do	do	do	Rasi 3	2900	do	
105	do	do	Lalitpur	Imadol	1360	2 Nov	
				(Balkumari			
				)			

Acc No	Species	Status	District	Village	Altitude, m	Date	Note/ type
106	do	do	Kathmandu	Machhe Gaun	1410	Do	
107	do	do		Boch	2062	9 Nov	
108	do	do	Dolakha Kaski	Lumle	1721	8 Dec	

Conclusions and recommendations

Field survey in Mustang district revealed extensive distribution of the wild form of tartary buckwheat. Since the wild form might be well adapted to the environmental conditions of Mustang district and thus could be of use for future genetic improvement. It is advisable to investigate their genetic variation and to take a measure to conserve their genetic variation.

Population sizes of *F. cymosum* were greatly varied from site to site. Since the size of some populations were too small to be easily in danger of extinction, the strategy of their conservation should consider the population size at each site as well as its genetic variation revealed by further RAPD analysis. RAPD analysis of *F. cymosum* samples collected in 1999 suggested the subtantial level of genetic differentiation among the populations from Lumle and those from Dolpa and between those of Nepal and southern China (Bimb et al., 2000). Based on these results, Nepali scientist from NARC would visit NIAR to conduct RAPDs analysis and this will have two main objectives firstly, to examine the change in genetic variation from 1999 to 2000 within and among four populations; ie one from Boch in central Nepal, one from Lumle in western Nepal and two from Juphal and Sahartara in mid-western Nepal. These four sites are selected because they are geographically distant to each other and under different climatic conditions (Majupuria and Kumar, 1999). Secondly, the genetic relationships among *F. cymosum* populations from Nepal would be investigated based on RAPD analysis. Up to now, local populations of *F. cymosum* from Asia were classified into two groups, one including the populations from southern China and Thailand and another including Tibet, India, Bhutan and Nepal based on the variation in allozyme and chloroplast DNA (Yamane and Ohnishi, 2000; Yamane et al., 2000). To elucidate the level of genetic distinction in Nepali populations and confirm the above results, one sample from India and three from southern China was also analysed.

Acknowledgment

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A global buckwheat trading

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Abstract

Buckwheat (*Fagopyrum* spp.) or p*hapar* is known historically for its nutritional and medicinal importance to oriental culture extending from Asia to other continents. Due to its limited volume for trade, the trading figures do not normally come under world trade statistics, yet few importing and exporting countries are attempting to maintain their figures. At present, the world export figure exceeds the import. The present volume of world export centers around 200,000 t, whereas the import around 175,000 t grains yield. Nepal's production figure is estimated to be around 20,000 t. Since late eighties, there has been some export from Nepal to India. Due to this export, farmers of Chitwan and Nawalparasi, Nepal were encouraged to grow buckwheat during winter but the trading trend has been very unstable. The statistics of Nepal shows the current export of buckwheat about 1000 t to India. This paper attempts to highlight a scenario of world trading of buckwheat and its prospects and limitations for Nepal.

Key words: buckwheat trading, export, import

Introduction

Buckwheat (*Fagopyrum* spp.) is a pseudo cereal crop known to have been domesticated to southern China and moved to other parts of the world. The history of buckwheat cultivation in Nepal dates back to pre-historic period in the Himalayan Mountains because of its probably secondary center of diversity and adaptation to short season, marginal land and poorer management. Later the crop tended to move to lower hills. Today buckwheat is also known to be grown in the inner *Terai* belt of Nepal.

Mountain people of Nepal prefers to eat as a *dhindo* (a kind of thick porridge), more tasty than any other cereals to eat in this form. Other forms of recipes are *roti* or *rota* (an unleavened bread), pancake, *alung* (a kind of dumpling) and so on. Among the most popular is the *dhindo*, easy to prepare, easy to eat and tasty but limited to the poor and marginal and high mountain people. The other food recipe is the buckwheat's dried leaf turned into a powder to make soup (*ti-une*) to provide sufficient *rutin* to our health, which is quite common in the high mountains of western region of Nepal.

Buckwheat adheres to the oriental culture for its aesthetic and medicinal values. Therefore, although its production is limited to certain countries, the crop is still an important food for them. In eastern Asia, the buckwheat is consumed by making noodles but in Eastern Europe their preferred food item is dehulled turned into buckwheat rice. On the other hand in Northern America and Western Europe, it is popular for making pancake eaten in breakfast.

Trading

Trading statistics are presented in the following graphs. World buckwheat trading normally does not come under world food trade statistics because its volume of trade is limited to little buckwheat loving countries. The biggest producer is China (1.3 million t) followed by USSR (0.85 million t). The figures here present the volume of trade from 1995 to 1999. The global trade figure (both export and import) in 1999 stands around 375, 000 t by volume (Fig. 3) and about $75 millions by value (Fig. 1). Looking back to previous five year's figures (1995 to 1999), the import figure has steadily continued to decline whereas it export volume has likely to increase. This is probably the indication that those buckwheat-consuming countries are maintaining their status to produce more and at the same time importing more to other countries.

By continent, Asia is the home of the buckwheat culture accounting more than 50 percent trade volume (Fig. 4) followed by Europe. Europe has shown a progressive sign of export from 20,924 t of 1995 to 70, 218 t of 1999 (Fig. 6). This shows that trading of buckwheat can occur within and outside Europe. Europe particularly the Eastern Europe considers it as one of the important basic foods. North America comprising Canada and USA (Fig. 10 and 11) is primarily known for their export to Japan and Korea although limited consumption in terms of breakfast pancake mixed with honey or syrup is known to exist. The figure (Fig. 9) however shows that there is a declining trend of export volume over the years. On the other hand, Australia shows the sign of increased export to other countries from a 594 t of 1995 to 1812 t of 1999 (Fig. 7). The figure however is not steady from year to year. Africa's import of buckwheat has steadily fallen from 19,743 t of 1995 to 4,098 t of 1999 (Fig. 5). Trading volume of buckwheat in South America is also small (Fig. 8). Their traditional import figure has now significantly reduced but the export is occasionally rising up although the trend is quite fluctuating.

Countrywise, China (Fig. 12) is the biggest exporter followed by USSR (Fig. 14) and Japan is the biggest importer. Japan's domestic production steadily declined constrained by higher cost of production. Japan currently imports about 100,000 t (Fig. 13) mainly from China, USA, Canada and Australia. Japan now prefers to import cheaper buckwheat than to produce by herself. That is why volume of import from other countries has gone up to maintain their domestic consumption. The other potential countries to import buckwheat are Republic of Korea and DPR of Korea (Fig. 15 and 16), although their volume of import are relatively small.

International buckwheat price

Buckwheat importing countries particularly Japan considers a food of high aesthetic value to maintain their traditional culture and their health. That is why buckwheat noodles and other products are more expensive that even rice. The price of a unit of buckwheat floor is determined by its quality. Qualities are measured in terms of varietal purity, uniformity, size, and then taste, flavor, rutin contents. High *rutin* (a flavonol glycoside) content is the main ingredient known for its medicinal use to maintain health. Rutin is known for controlling cardiovascular related problems such as maintaining cholesterol level, keeping blood vessels strong and flexible, reduction in fat deposition in the blood vessels thus reduces the chances of heart attack. The unit price of buckwheat from each country is given in Fig. 2. From the figure it is evident that price of buckwheat from China is almost half of the price of North America. The price of China which Japan imports is about $200 per ton whereas the price of Canada and USA is $350 and $440 per ton respectively. Because buckwheat from North America is considered of high grade thus fetches higher price. Trading cost of buckwheat from Australia is still higher. And price of buckwheat in Eastern Europe is in between.

Status of buckwheat in Nepal

Nepal records buckwheat production at about 20,000 t in an area of about 30,000 ha. Buckwheat concentration is mostly in the high altitude districts where it is being grown during summer. Higher rainfall does not favour its production, thus in the mid hills, it is being grown during autumn and spring season to avoid rain and frost. It cannot be grown during winter in the mountains because it cannot survive frost thus needs frost free period. The quality of buckwheat from the western mountain to eat is considered superior than from the west because rainfall during its growth cycles deteriorates its quality.

The high mountain districts are the producers of buckwheat both sweet and bitter. Many northern districts grow buckwheat and consider a main food. Preparation made out of buckwheat flours is commonly *dhindo*, *roti* and *ryale roti* (a kind of pancake). *Roti* is more common towards the west and *dhindo* towards the east but both find a common place too. It is quite customary to mix up both the *mithe* and *tite* buckwheat flour to cherish its satisfaction to the eater. The mixed one is considered having a better medicinal value than the *mithe* alone.

Buckwheat trade in Nepal

Surprisingly, buckwheat production expanded from traditional hills to Chitwan valley in eighties. The reason was simple. Buckwheat started being exported to India to fulfill their demand and fetched higher prices than wheat and other winter crops. Buckwheat cannot be grown during summer and rainy season in Chitwan and surrounding area but best thrived the frost-free winter. Chitwan remained an ideal place. The production area went over 2000 ha in 1990 (ADO, Chitwan, Personal Comm.). More than 90% of the total production used to be exported. The price of buckwheat trading went as high as Rs 22.00-25.00 per kg at the farm gate. The buckwheat broker started contracting the buckwheat field well advance of its harvest. The brokers spread all over Chitwan and Nawalparasi. The price of buckwheat seed to plant went as high as Rs 40 kg^{-1}. The Chitwan farmers rushed to grow this crop to replace traditional wheat and other winter crops because farmers saw the buckwheat did not need much fertilizer and care, still can produce about a ton ha^{-1} and can be marked at the its own doorstep. However, its quality grown in the plains of Nepal has not been tested to satisfy the customer's preference overseas.

Box 1. Legacy of Chitwan Buckwheat

The legacy of buckwheat in Chitwan does not go very far. In India a Hindu community is not traditionally prepared to eat rice or any other cereal grain during fast dedicated to religious ceremony such as Ram Nawami or any other festival. Those affluent Marwadies in Delhi and around in India used to get buckwheat from Indian mountains. While fasting, non-cereal grain such as buckwheat known as ***Ku-anna*** *(a false-cereal) is allowed to eat as a preferred dish. In one year of eighties buckwheat grain could not come to the market due to crop failure. Thus, they searched for Nepal. Grain traders living in Nepal started collecting buckwheat seeds and exported. Raj Kumar Marwadi and Hajari Shaha (Giri) were the first traders who initiated to export buckwheat from Chitwan. Chitwan became a preferred place to grow hill buckwheat during winter. Current marketing of buckwheat from Chitwan is reported to be about 600 tons per year (Fig.17). The current farm gate price in Chtwan is about Rs 11000.00 per ton. The traders also reported that this practice of buckwheat marketing is continuing since last 15-20 years. More than 90% of the produce is exported to India but the demand and the price of the buckwheat is determined by the production of buckwheat in India. The export price of buckwheat at present years ranges around Rs 16000.00 per ton.*

The quality of buckwheat remains much better in the high mountains for taste and flavor even to eat as a local dish such as *dhindo.* But as the buckwheat area moves down, the quality deteriorates. This is something that has to be looked into from trading point of view.

Few years back, there used to be a demand of buckwheat to be exported to Japan provided it meets their standard. In the past in late nineties, about 2 tons of buckwheat was airlifted to Japan whose transport charge rose very high. This was done to show that quality of Mustang buckwheat proved to be of higher grade and acceptable to buckwheat noodle eaters in Japan. From the Mustang experience, it is judged that buckwheat grown in the high mountains of Manang, Dolpa, Jumla, Mugu and Humla could be of good quality. Although Chitwan and Nawalparasi proved to be an ideal place to grow buckwheat during winter, their quality acceptable to the customer needs to be verified. The other important factor to be considered is genetic purity to maintain uniformity, bold seed size and lusterness to prepare dough.

Prospect of buckwheat marketing

Although there had been some attempt to export buckwheat from Nepal, there is not yet any initiative on behalf of the government to facilitate. Quality to meet the standard of the importing nation will be the prime factor. Whether or not quality of our buckwheat can meet their demand should be explored first. Our varieties growing in the highlands of Nepal can do better if those ecotypes are selected and examined for quality from different environments. It is really difficult to judge the quality of buckwheat grown in Chitwan and Nawalparasi at this point. NARC can do something to gear up the quality standard. If the qualities are properly met, prospect still exists there to export buckwheat to country like Japan.

Fig. 1. Buckwheat Total Import and Export in US $ (1999)

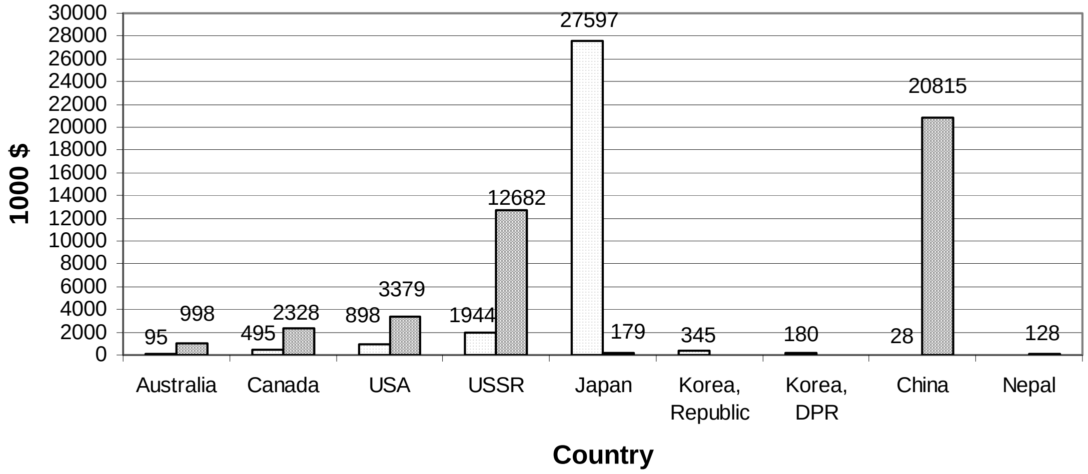
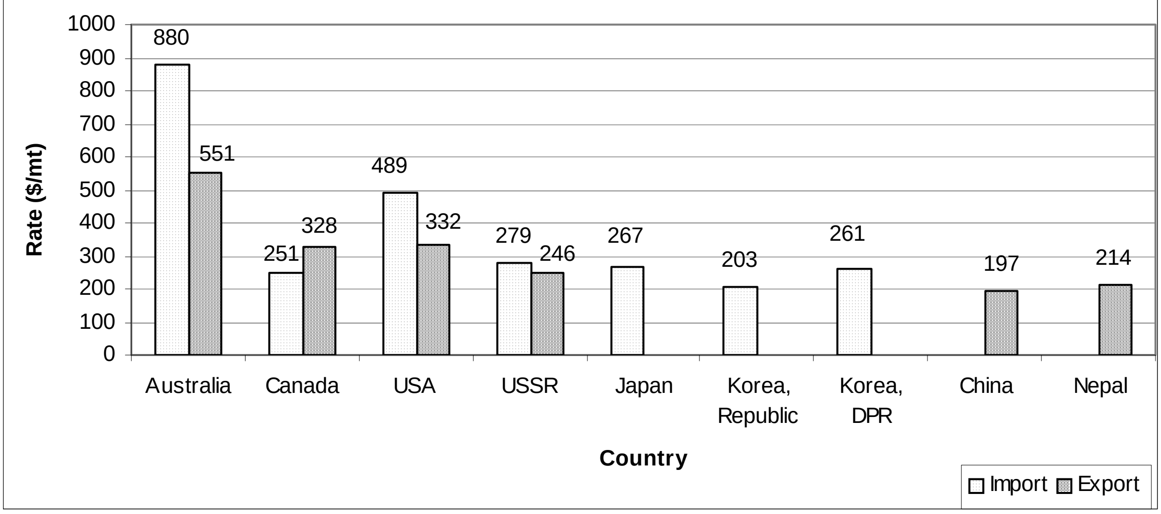


Fig. 2. Buckwheat Import and Export Rate in US $ / mt (1999)



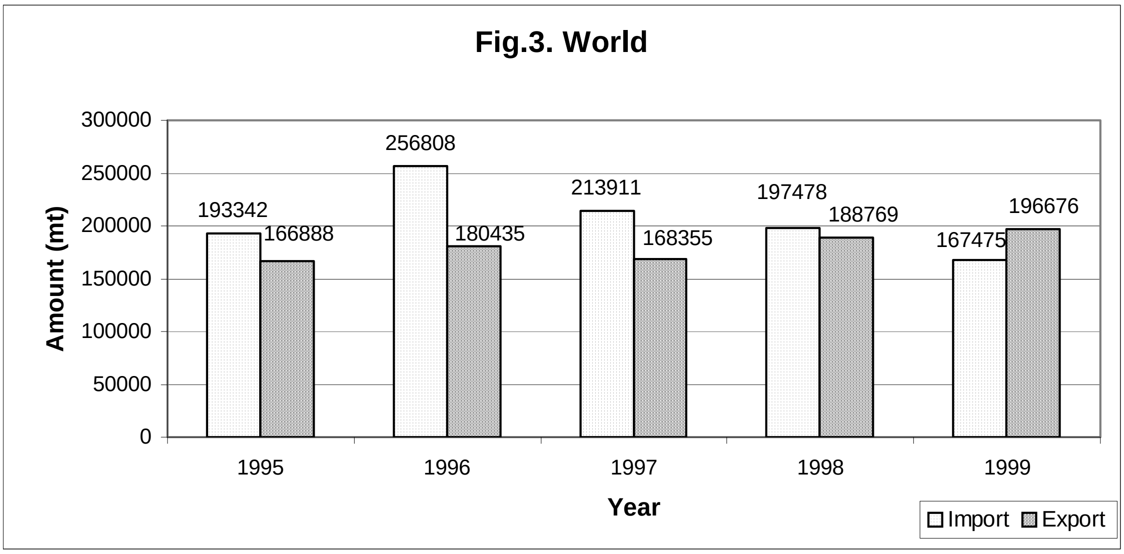


Fig.3. World
Amount (mt)
300000
250000
200000
150000
100000
50000
0
193342
166888
256808
180435
213911
168355
197478
188769
167475
196676
1995
1996
1997
1998
1999
Year
Import
Export

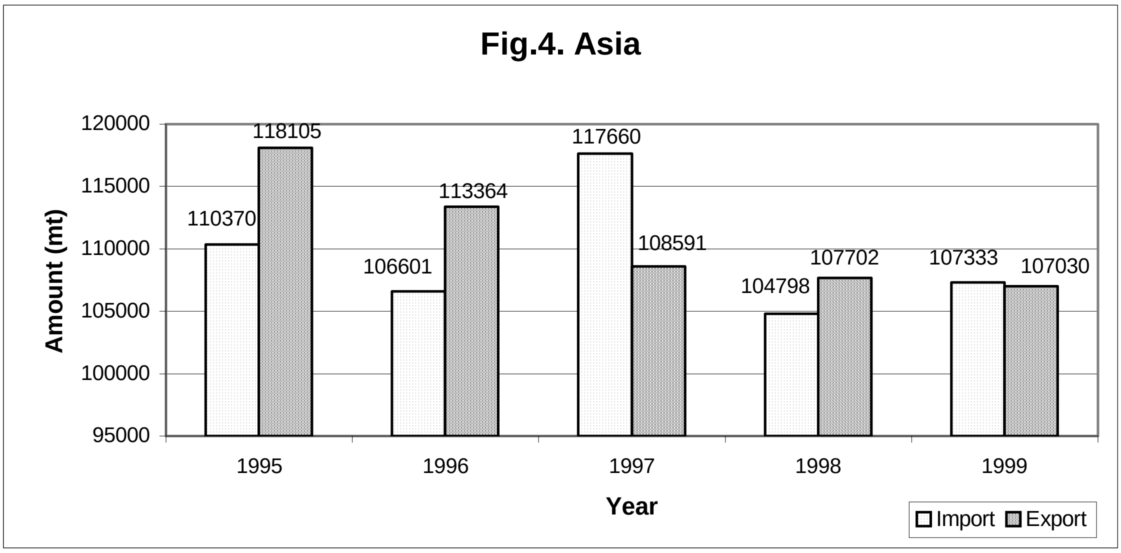


Fig.4. Asia
Amount (mt)
120000
115000
110000
105000
100000
95000
110370
118105
106601
113364
117660
108591
104798
107702
107333
107030
1995
1996
1997
1998
1999
Year
Import
Export

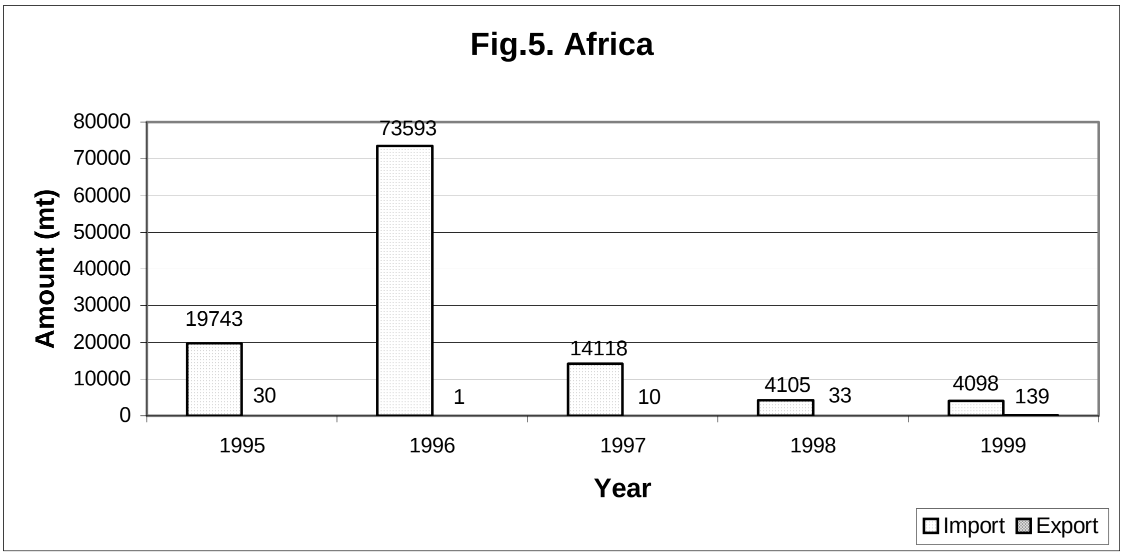


Fig.5. Africa
Amount (mt)
80000
70000
60000
50000
40000
30000
20000
10000
0
19743
30
73593
1
14118
10
4105
33
4098
139
1995
1996
1997
1998
1999
Year
Import
Export

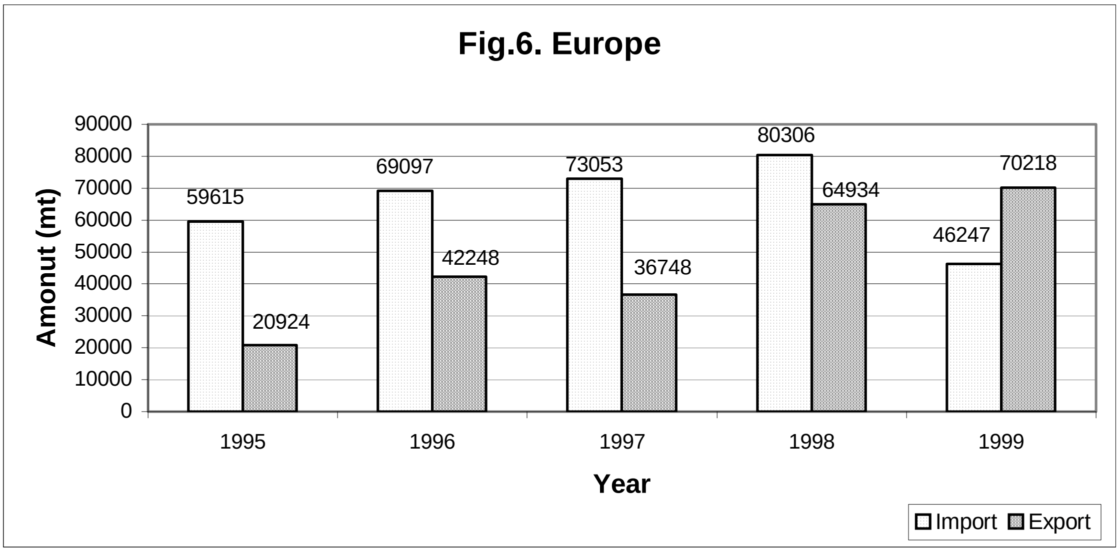


Fig.6. Europe
Amonut (mt)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
59615
20924
69097
42248
73053
36748
80306
64934
46247
70218
1995
1996
1997
1998
1999
Year
Import
Export

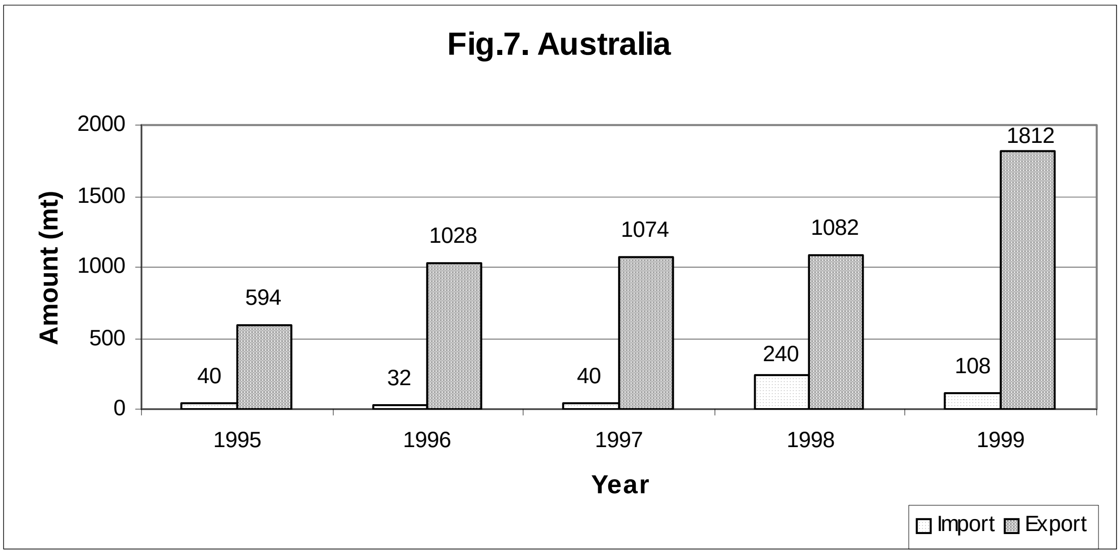


Fig.7. Australia
Amount (mt)
2000
1500
1000
500
0
40
594
32
1028
40
1074
240
1082
108
1812
1995
1996
1997
1998
1999
Year
Import
Export

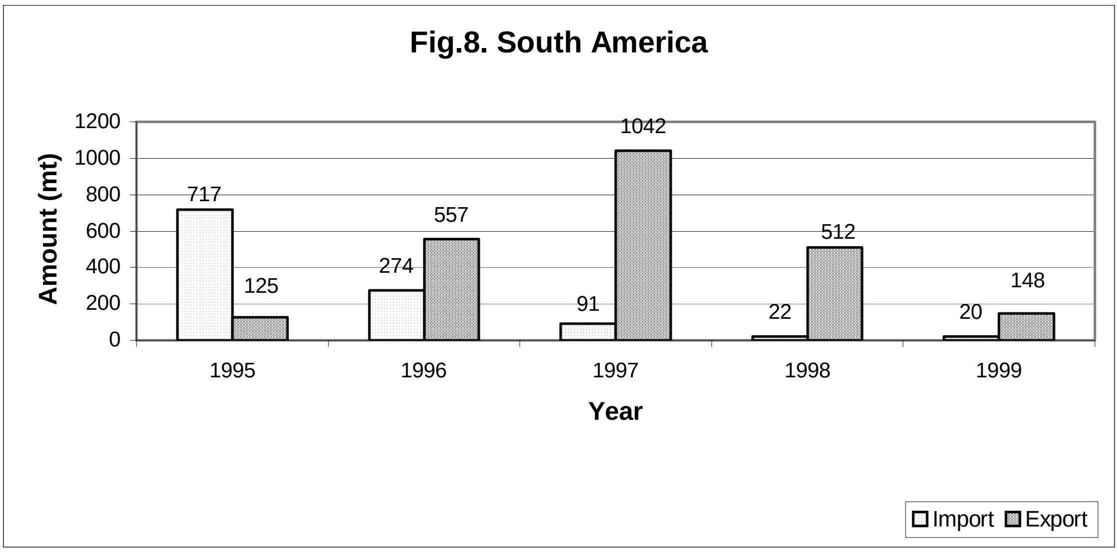


Fig.8. South America
Amount (mt)
1200
1000
800
600
400
200
0
717
125
274
557
91
1042
22
512
20
148
1995
1996
1997
1998
1999
Year
Import
Export

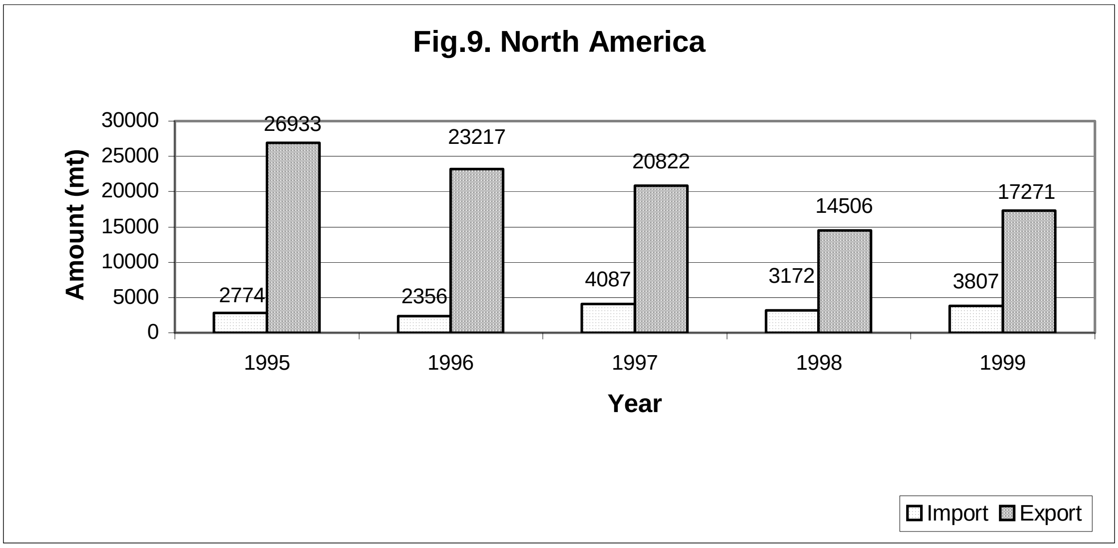


Fig.9. North America
Amount (mt)
30000
25000
20000
15000
10000
5000
0
26933
23217
20822
14506
17271
2774
2356
4087
3172
3807
1995
1996
1997
1998
1999
Year
Import
Export

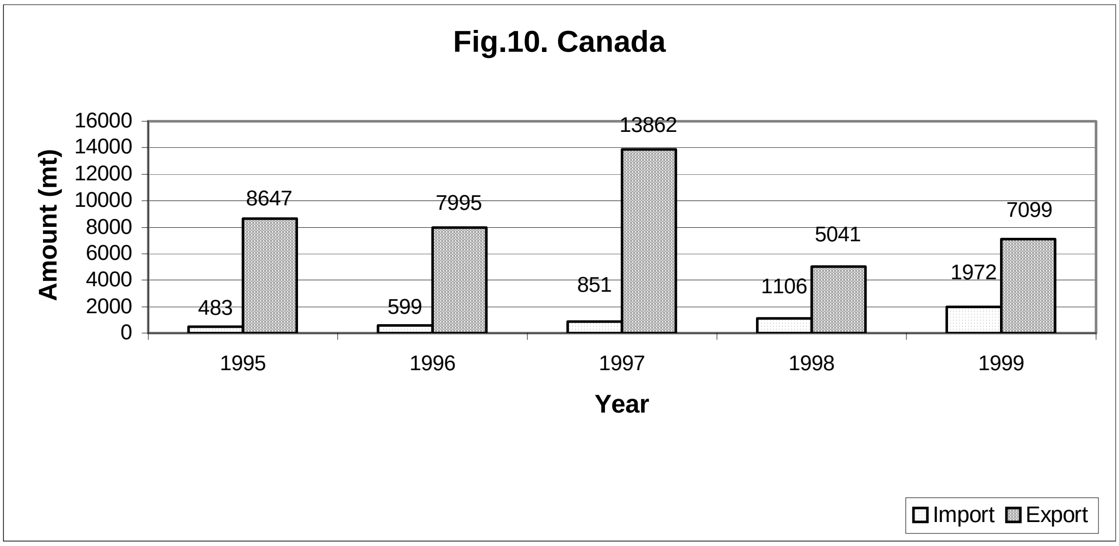


Fig.10. Canada
Amount (mt)
16000
14000
12000
10000
8000
6000
4000
2000
0
8647
7995
13862
5041
7099
483
599
851
1106
1972
1995
1996
1997
1998
1999
Year
Import
Export

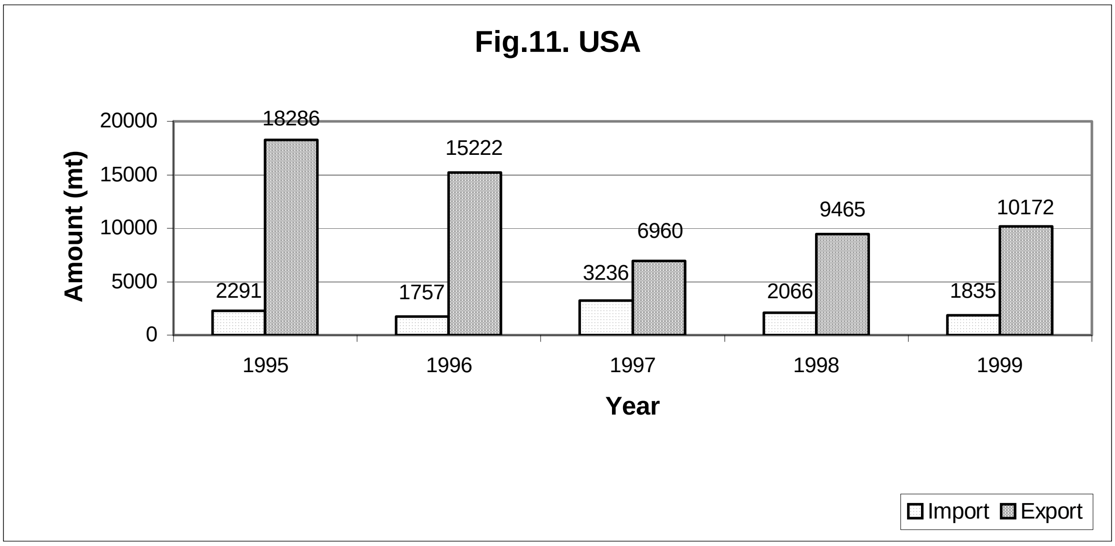


Fig.11. USA
Amount (mt)
20000
15000
10000
5000
0
18286
15222
6960
9465
10172
2291
1757
3236
2066
1835
1995
1996
1997
1998
1999
Year
Import
Export

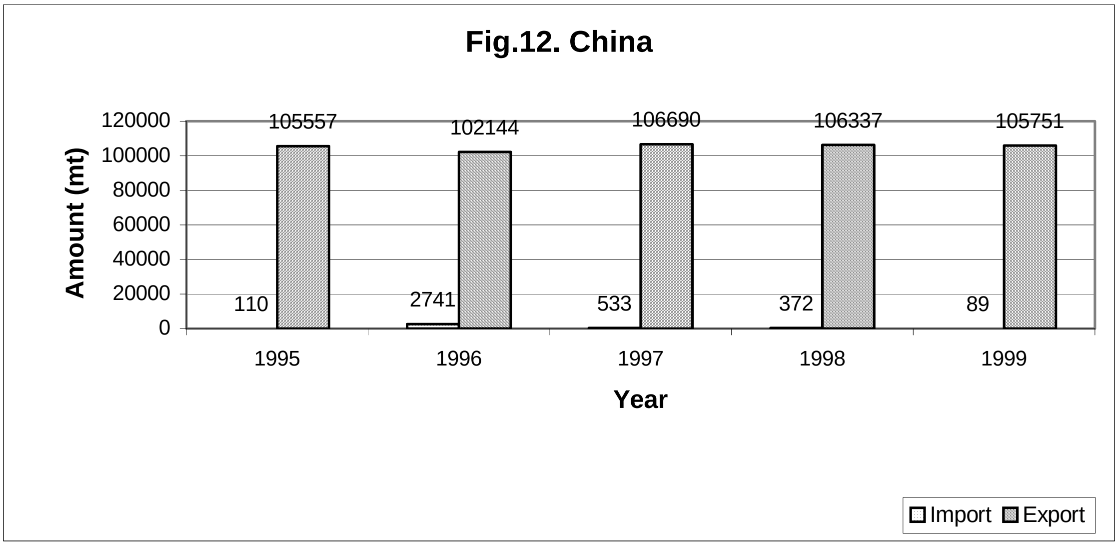


Fig.12. China
Amount (mt)
120000
100000
80000
60000
40000
20000
0
105557
102144
106690
106337
105751
110
2741
533
372
89
1995
1996
1997
1998
1999
Year
Import
Export

Fig.13. Japan

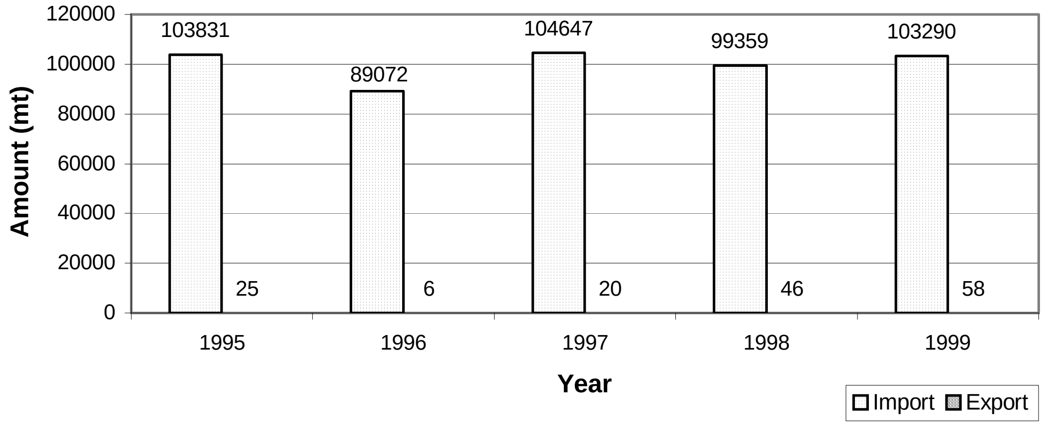


Fig.14. USSR

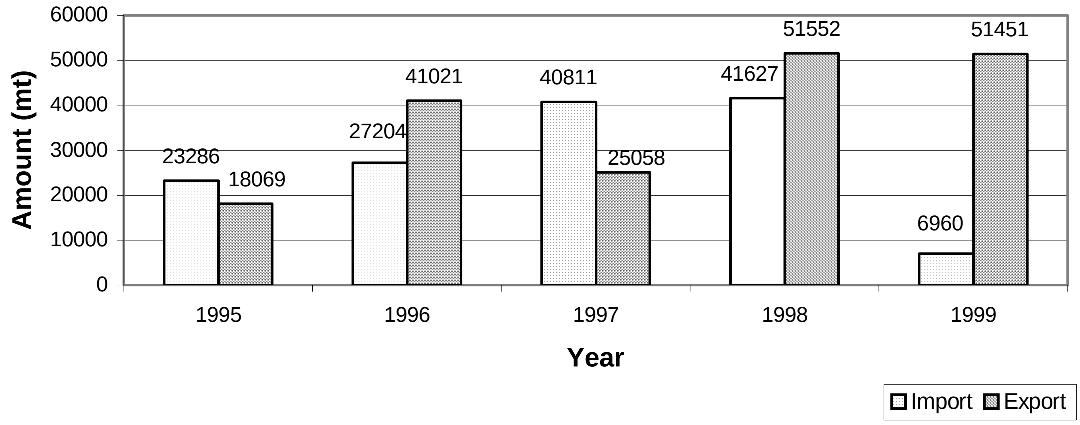
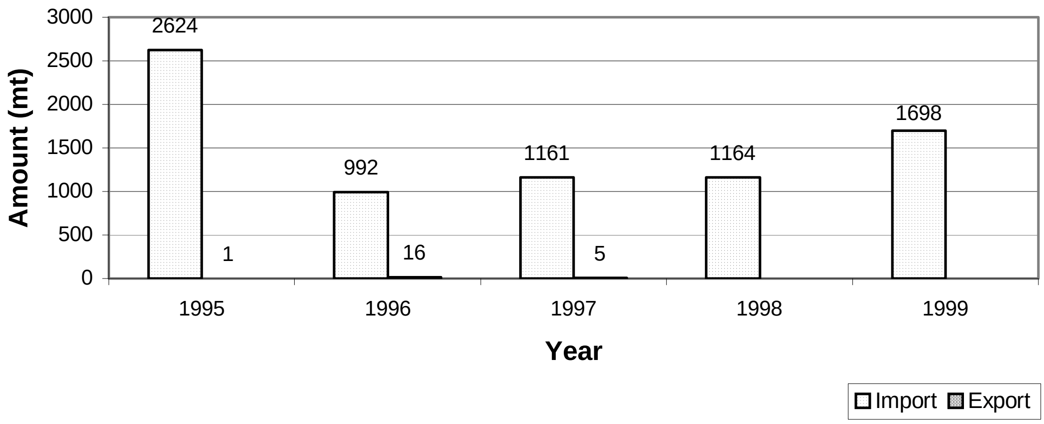
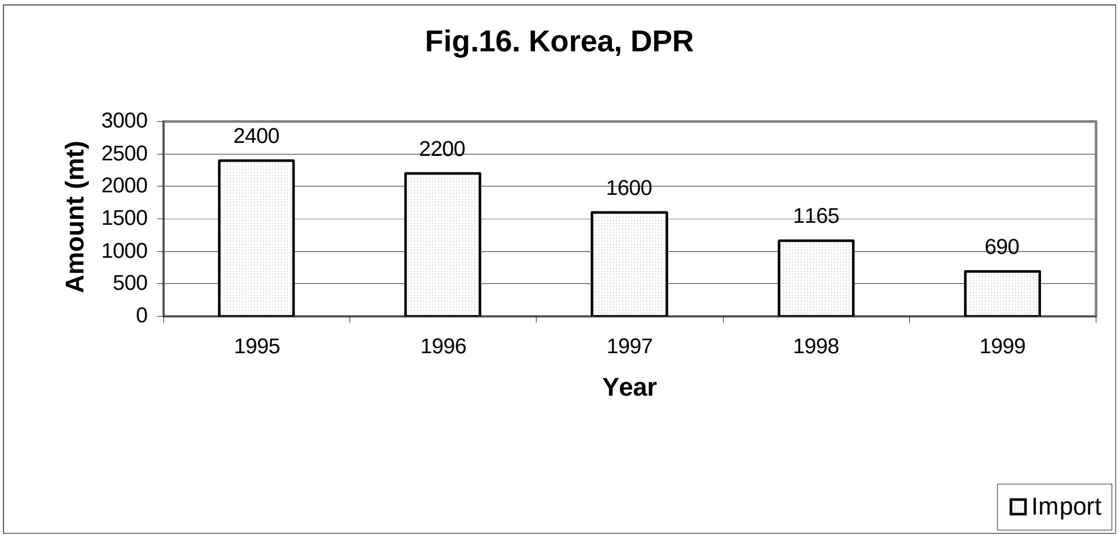
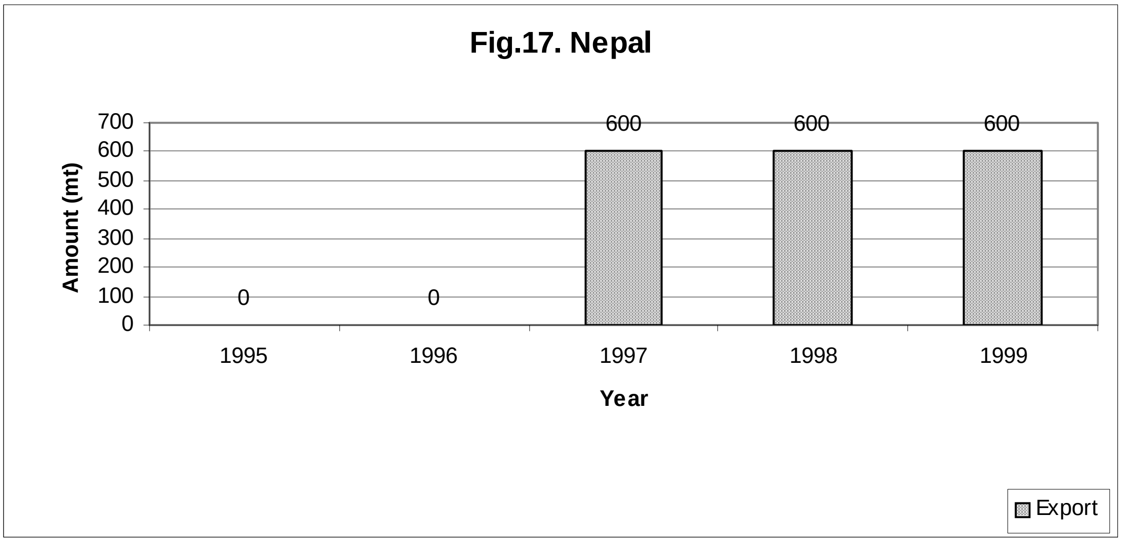


Fig.15. Korea, Republic







(Fig. 3-17 are the buckwheat trading in different countries.)

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Buckwheat marketing and commercialization in Nepal

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Abstract

The detail marketing information is necessary for commercialization of buckwheat in Nepal. Preliminary market price and socioeconomic survey tools (RRA and PRA), cooperative works with farmers, visual observation during the explorations and literature review revealed that buckwheat is highly valuable crop in terms of food consumption and fodder, dietary purposes, medicinal uses, socio-religious values, beekeeping and beverage uses. Having high demand in foreign countries, at present it could be high value exporting cash commodity for Nepal. Price of grain and flour of buckwheat varies (Rs 20-35 kg^{-1} and 40-55 kg^{-1} respectively) which is one of the key factors for commercialization. Production of more buckwheat and its products increases national economy to some extent, which economically benefits buckwheat farmers, traders and exporters.

Key words: buckwheat export, commercialization, marketing, price, socio-economic

Introduction

World's buckwheat trade and its early recorded history of cultivation

Although Hunt (1910, cited by Campbell, 1976) considered buckwheat is known to have been cultivated in China for 1,000 years, but Chinese scripts of the fifth and sixth centuries are the written evidence of buckwheat cultivation since ancient time. It was introduced into Europe in the middle ages, reaching Germany early in the fifteenth century. From there it was disseminated and cultivated for centuries in England, France, Spain, Italy, Germany and Russia. It has also found a place in the agriculture of Africa and Brazil. It was introduced early into the American colonies having been relatively much more important than now (Campbell, 1976). In 1918 buckwheat was cultivated in more than 4,00,000 ha in USA but by 1965, the area decreased to 17,000 ha. This was due to better return from alternate cereal crops cultivation for animal feeding. Similar situation has been implied to the decrement of this crop in Europe. In recent years, both common and tartary buckwheat cultivation has been in declining trend. The USSR is by far the biggest producer but even there, the crop has gone down, as it has also in France and USA. Canada's acreage declined steadily until early 1960s but has increased since then as a result of demand for export (Campbell, 1976).

The crop is usually consumed more or less locally though international trade is increasing (Campbell, 1976). The major worlds' buckwheat growing countries are Russia, France, Poland, Canada, Japan, Austria, Germany and Romania (Lohani, 2037 BS). However, the leading buckwheat exporting countries are China, Canada, Russia and USA at present. Similarly, some of the other countries including Australia, Newzealand, Argentina, India, Nepal, Myanmar and East European countries also export limited amount of buckwheat.

Buckwheat cultivation in Nepal

Buckwheat (*Fagopyrum* spp.) is generally known as hundred days crop (*Ghyabre*) in Mustang and is one of the major food crops in high hill regions of Nepal. It contains high percentage of essential amino acids like lysine and tryptophan as compared to other cereals (Joshi and Paroda, 1991). Besides, it is a very good source for high quality amino acids of 18-20 types having high biological value. Because of its food value and wider adaptability under Nepalese conditions, common buckwheat needs to be sufficiently tipped for its further development in future (Regmi, 1982).

Buckwheat plant is able to do well on the marginal land, with or without fertilizer supplement, adapts well in stress environment and harsh climatic conditions, it has widespread usages and it is also an environmentally friendly crop. Therefore it is a useful crop for Nepal, which has diverse and harsh agroclimatic conditions with a lot of neglected sloppy and marginal land. It is obvious that buckwheat is mainly grown in remote and difficult areas so it is a bit difficult for commercialization. However, it can be easily fit in cropping patterns of high hills, mid hills and Terai regions. Thus its production can be increased by introducing it into crop rotation with maize and rice in Mid-Hill and Terai regions respectively. However, the price of buckwheat grain should be substantially higher than its present farm gate price.

The objective of this paper is (a) to assess the market price and socio-religious importance of buckwheat in the crop growing areas, (b) to assess the present situation and future prospects of commercialization of buckwheat in Nepal and (c) to identify possibility to promote buckwheat trade and its commercialization in Nepal and abroad.

Materials and methods

Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) tools were used to assess preliminary market price and socioeconomic study of buckwheat growing areas including cooperative works with farmers and visual observations during the exploration after the establishment of National Hill Crops Research Programme (1988-1999; 2001). Besides, information was also adapted from literature review and personal communication.

Findings

Trade route

Buckwheat was bartered with salt, wool, sheep and goat, yak, etc in Tibetan autonomous region of China and also marketed to India via mid hill and Terai regions. Preliminary report suggested that Nepalese buckwheat is being exported to Japan through India, which is still to be confirmed. Nepal itself is exporting buckwheat to Japan to some extent (Fig. 1).

- Nepal to Tibet – Buckwheat and others
- Tibet to Nepal – Salt, wool, sheep and goat, yak etc

Market price (buckwheat grain and flour)

In higher hills, there is no organized system of marketing in general and most of the local peoples have been practicing barter system in exchanging buckwheat with salt, wool, sheep and goat, yak etc. from China and the buckwheat grower exchange their buckwheat with rice in Nepal. Barter value of buckwheat was found varying from place to place (Table 1). There are some of the data available in monetary unit (Table 1, Table 2a, 2b). The buckwheat has been exported to go to China (autonomous Tibet) from higher hills and to India from Mid hills and Terai.

Table 1. Barter value of buckwheat (1993, 1995, 1999)

District	Bartered with	Ratio/volume†	Source
Dolpa (Jhyu and Shyu)	Salt	B 3 (pathi):1 pathi salt	Baniya et al., 1993
Dolpa	Common salt	MB 2.5:1 a part salt	Adhikari et al., 1995
Dolpa	Wheat/Barley	TB 4:3 wheat/barley	Adhikari et al., 1995
Dolpa	Salt	B 2-3:1 Salt	Vaidya et al., 1999
Manang	Salt	B 2 pathi:1 pathi salt	Adhikary et al., 1995
Okhaldhunga	Maize	1:1 Volume	Adhikary et al., 1995
Jajarkot	Salt	1:1 Volume	Adhikary et al., 1995

† MB = *Mithe* buckwheat; TB = *Tite* buckwheat; B = Buckwheat.

It is ironic to note that price of buckwheat has been found to decrease as we go further in the south eastern districts where less demand might be due to easy accessibility of transport resulting availability of other foods as well as also due to less preference of buckwheat by the local ethnic communities who are less user group due to their cultural and social background (Table 2a).

Table 2a. Trend of market price of buckwheat grain and flour across Nepal, 1988 - 2001

District	Year	Average price Rs /Pathi (2.8 kg)			Source
		Mithe grain	*Tite* grain	Flour	
Dolpa	1993	43	31		Baniya et al., 1993
	1995	80	55		Adhikary et al., 1995
Mustang	1993	38	30	70	Baniya et al., 1993
	1995	40	25	60	Adhikary et al., 1995
	1999	76	67	105	Vaidya et al., 1999
Manang	1995	30			Adhikary et al., 1995
Solukhumbu	1995			90	Adhikary et al., 1995
Taplejung	1993	24			Baniya et al., 1993
Terhathum	1995	21			Adhikary et al., 1995
Kavrepalanchok	1990; 1995	22		105	Serchan et al., 1990; 1995
Chitwan	1988	59			Sherchan et al., 1991
	1989	45			”
	1990	28			”
	1991	14			”
Kathmandu	2001			126	-
Lalitpur	2001			126	-

Table 2b. Market price of buckwheat food items at Kathmandu, 1998-2001

Place and year	Shop/owners name	Price of different food items, Rs			
		Roti/ piece	Dhindo/ plate	Noodles/ plate	Special dish/ plate
Naya Baneshwor (2001)	Sunset View Hotel (Soba Restaurant, Arjun Tulachan)	-	-	200-300†	700
Kesharmahal (1998)	Fuji Restaurant	-	-	400-500††	-
Durbarmarg (2001)	Tukuche Thakali Restaurant (Rekha Bhattachan)	30	165	-	-
Thamel (2001)	Thakali Bhansa (Lelin Sherchand)	20	95	-	-

† Noodles of Nepalese buckwheat flour manually made, †† Noodles imported from Japan (also known as Sukuti noodle).

Kathmandu

At present, the price of local buckwheat flour kg^{-1} at Kathmandu valley is about Rs 45 (45-60). Mainly restaurants for tourist have been using the buckwheat dishes. Price varies (Roti/piece: Rs 20 and 30 and Dhindo: 95 and 165) from place to place. Uses of buckwheat in preparation of pancake and noodles for tourists are increasing in Nepal, but noodles and flour for pancake preparation were imported from Japan until few years back (DB Aale, Fuji Restaurant, Katmandu, Personal Comm.). Recently, it is learnt that Mr. Arjun Tulachan, owner of Hotel Sunset View, Baneshwor, Kathmandu has started to produce buckwheat noodles by his two staff who were trained in Japan for several years. In our information, he is the first noodle producer manually (without flour processor and noodle plant) in Nepal and has ben contributing to commercialize buckwheat product to some extent, although he is using the noodles in his own hotel. The price of noodles for a person is Rs. 200-300 (Hotel Sun Set View, Nayabaneshwor, Kathmandu). Mr Tulachan mentioned that foreigners including Japanese liked and appreciated Nepalese buckwheat noodles in terms of taste and quality with respect to noodles from abroad and thus highly successful. He further added that at present, buckwheat products including noodles are in increasing demand by foreigners and thus commercialization is feasible provided government has to prioritize the crop in terms of varietal investigation, quality research, extension and subsidy in air freight charge to export Himalayan buckwheat abroad.

Buckwheat noodles imported from Japan cost approximately double (Rs 400-500 for a plate of cooked noodles, DB Aale, Fuji Restaurant, Katmandu, Personal Comm.) as compared to the locally made noodle (Rs 200-300). If buckwheat noodle is made locally, price will be reduced to half than the imported one with a high quality in taste, freshness. So, by increasing common buckwheat production in Nepal, it is possible to reduce import and increase national economy.

Export and international market price

The detailed data on export and international market price of Nepalese buckwheat are not available yet. Preliminary report suggests that there are only few exporters and traders of buckwheat and they are exporting buckwheat abroad until now from Katmandu, Lalitpur, Chitwan and traders from Mustang districts (Table 3). Some of these traders are the pioneers in commercializing the buckwheat in Nepal. The international market price of buckwheat and its products is quite higher than the Nepalese price in recent days (Table 4).

Table 3. Buckwheat traders, exporters and retailers

SN	Name and address	Form of trade	Amount (approx.)	Price/Remark
1.	Arjun Tulachan, Hotel Sunset View (owner), Baneshwor, Kathmandu	Export to Japan by contact and (probably) first producer of buckwheat noodles in Nepal		
2.	Dr BB Thapa, Chitwan (Researcher)	Export to Japan	5-10 t yr^{-1}	
3.	Mr Raju Shahi, Patan (Businessman), Lalitpur	Contact trade and export to Japan		
4.	Mr K Dulal, Flour Miller and Wholeseller, Bhattedanda, Lalitpur	Flour supplier, Flour Wholeseller		
5.	Mrs. Shanti Sharma, Godawari, Lalitpur	Export to Japan by contact		
6.	Flour shop, Ason, Katmandu	Flour Retailer		Rs45 kg^{-1}
7.	Grocery shops (Swojan etc), Lagankhel, Lalitpur	Flour Retailer		Rs40-50 kg^{-1}
8.	Sherpa/Tourist Restaurants, Bouddanath, Kathmandu	Retailer or producer of dishes like Roti etc		
9.	Sherpa/Tourist Restaurants, Swoyambhunath, Katmandu	Retailer or producer of dishes like Roti etc		

Source: DR Sharma, 2001, Personal Comm.

Table 4. International market price of buckwheat products, 2001

Product	Price, Rs kg^{-1}
Whole Grain	157
Japanese Noodles	704
Buckwheat flour (organic)	300
Groats (Kasha)	610
Grits	400
Hull pillow (small sized)	520
Hull pillow (large sized)	3700

Source: www.sealwell.com, Sept 2001.

Socio-religious values and uses

Buckwheat is cultivated and preferred for consumption mostly by the Mongolian origin people living in high hills and mid hills of Nepal (ie Sherpa, Thakali, Tamang, Magar, Gurung, Rai, Limbu, Tareli, etc). Besides, Kami (Mustang, Solukhumbu, Jumla, Dolpa), Thakuri (Jumla, Humla, Mustang), Chhetri (Jumla, Humla), Bista-Mongoloid (Mustang) are also reported to use the crop (Table 6). In Kathmandu valley it is largely used by Tibeto-Burmese ethnic community (Dongol et al., 1999). People usually prefer sweet buckwheat but it is less popular due to its lower yield (Adhikari et al., 1995). *Tite* buckwheat is yielding higher than *mithe* buckwheat but having *tite* taste it is usually used for animal feeding.

In Hindu community, cultivation and consumption of tartary buckwheat are considered as sign of poverty and low social status and thus rich and high caste Hindu people neither cultivate nor consume the tartary buckwheat. Brahmin and Chhetri (higher Hindu caste) prefer common buckwheat as it is relatively more prestigious grain (Baniya, 1999).

The younger generation likes *mithe* buckwheat more and older people preferre *tite* buckwheat due to its health benefits. Different parts of buckwheat are used to prepare different items in different forms. Among these most popular uses are shown in Table 5.

Table 5. Local utilization of buckwheat plants, grains and its products

SN	Items	Form of use	Usage
1	Food	Flour	Dhindo, Bhat, Sel, Sen-sweets, etc.
2	Vegetables	Leaves, tender shoots	Fresh and dry vegetables, pickles, soup, sausage, Dorpa-dal, salad etc
3	Alcoholic drinks	Fermantation and distillation	*Rakshi* and *Jaand*
4	Medicinal use	Usually flour and grain	*Tite* buckwheat bread by people with stomach problem
5	Animal feed	Fresh and dry straw	Fresh and dry straw use as fodder
6.	Fuel	Straw	Straw used as fuel supplement
7.	Soil improvement	Plant, straw etc.	Used as green manure and compost, as bedding material for cattle, which is then spread onto the farmland

Source: Adopted and modified from Adhikary et al., 1995.

Nepalese people in the hills prepare some special and delicious food items from common buckwheat on the day of Maghe Sankranti (around 15 Jan) as their special custom (Baniya, 1999). Similarly, in Terai region and in India common buckwheat is used during fasting period on special religious occasions when cereal consumption is prohibited. The grains are popped (dried), ground and eaten with milk or made into noodles. In eastern mid hills of Nepal also many people consume buckwheat during fasting period. Nepalese people believe that tartary buckwheat gives more strength and is better for health, it is easy to digest and has medicinal values as compared to common buckwheat, which is good food for hard physical workers by providing energy for prolonged periods (Baniya, 1999).

Buddhist Newar community (native people of Kathmandu valley) sacrifice buckwheat grain to one of the satellites called “*Ketugraha*” for peace to guard against the devil effect (Baniya, 1999). There is a perception that it is a healthy and delicious food, which is worth to eat in eye ache, poor eyesight and health weakness. The summary of traditional, religious, medicinal and socio-economic importance of buckwheat is presented in Table 6.

Table 6. Comparative values of buckwheat in terms of uses and economic importance

District	Social groups	Uses	Economic importance at local market	No. of landraces growing per community and village name
Mustang	Gurung Thakuri Bista Kami	Food consumption Traditional/Religious use Medicinal use Commercial use	*Mithe*-High *Tite*-Low	2 Nagarkot, Chusang, Kagbeni Ranipauwa, Jhong, Lomanthang
Manang	Gurung Lama Ghale	Food consumption Traditional/Religious use Medicinal use Commercial use	*Mithe*-High *Tite*-Low	3 Manang, Pishang, Honde, Bagarchhap
Solukhumbu	Rai Magar Sherpa Kami	Food consumption Traditional/Religious use	*Mithe*-Low *Tite*-High	1 Basa, Garma, Mulkharka, Taksindo
Jumla	Chhetri Thakuri Kami	Food consumption Traditional/Religious use Medicinal use	*Mithe*-No *Tite*-High	3 Guthichaur, Manisagu, Dillichaur, Padmara, Kurigaon, Bhumromadichour
Humla	Lama Thakuri Chhetri Brahman	Food consumption Traditional/Religious use Medicinal use	*Mithe*-No *Tite*-High	3 Bargaon, Simikot, Dadaphaya, Kharkunanath, Shyda, Muchu, Khayalgaon, Chitra, Kirma, Hyakppa, Raya
Dolpa	Tareli Magar Kami	Food consumption Traditional/Religious use Medicinal use	*Mithe*-Low Bhate-High *Tite*-High (especially in Tibet market as barter system exchanged with salt or goods or sheep)	3 Sahartara, Rasi, Juphal, Phoksundo, Rumagaon, Laungaon, Kaigaon, Saldang, Charka, Dunai

Source: Adapted from Vaidya et al. 1998.

Discussion

Buckwheat factory and milling quality

Only local water mill (Ghatta) and hand mill (Jato) are available to process buckwheat, but they cannot separate hull completely. Thus, flour quality will be poor. These could be replaced with modern mill or machine to imporve efficiency and quality of the prodcut as in Japan and other developed countries. Evidence is lacking on the consumption of *tite* buckwheat in urban area due to bitter taste.

Feasibility of promotion and commercialization of buckwheat

There is lack of contact among the growers, traders and researchers to promote the overall promotion of buckwheat trade and research. For example, traders in Kathmandu and Pokhara argued that sufficient amount of buckwheat is not available and they are willing to accept buckwheat in as much as quantity whereas farmers are compaining for less market and price. If such problems are solved, there are a lot of possibilities of its commercialization and promotion in near future. The trend of market price is not rising satisfactorily in remote districts like Dolpa, Mustang, Manang, whereas the market price in Chitwan district has been declining (Table 2a) in recent years. There is urgent need to survey market for revealing the cause. It is interesting to note that market value of buckwheat is encouraging in Kathmandu valley. Hotels and restaurants have included many dishes of buckwheat like noodles, *Roti, Dhindo*, etc and the prices are resonable (Table 2b). Neverthless, the demand of buckwheat flour and food products in Kathmandu valley has been increasing in recent days (Rekha Bhattachan and Lelin Sherchan, Personal Comm.) due to foreigners as well as due to health conciousness of the public except with some reservations of the quality of flour (mixing of other flours, foreign particles, milling quality, etc). The international market price of buckwheat products (2001) is higher in recent years (Table 3). There is possibility of exporting Nepalese buckwheat to Japan and other countries (Dongol et al., 1999).

There is a big scope of expanding buckwheat cultivation in Nepal due to the food shortage and the presence of malnutrition and disease problems (cardiovascular diseases: blood pressure, arteriosclerosis, cholesterol, strengthening blood vessels, haemorrhoage, coronary heart diseases; diabetes, tumor, peridentitis, low and high weight, body immune system, malnutrition and physical and mental development of children). Thus if their knowledge on medicinal, nutritive and cash values are extended, commercialization of this crop in Nepal is highly possible, where many diseases associated with cardiovascular (eg blood pressure), sugar, cancer etc are increasing and there is scientific evidence that the diseases have been controlled and also cured by use of buckwheat in different forms. Besides, buckwheat has high percentage of essential amino acids like lysine and tryptophan as compared to other cereals (Joshi and Paroda, 1991). Buckwheat is a very good source of dietary protein and food resource having high protein utilization due to its high biological value. Buckwheat flour contains high level of carbohydrates and provides high energy (Table 7).

Table 7. Protein quality of different crops

Crop	Protein, %	True protein digestibility, %	Biological value, %	Net protein utilization, %
Buckwheat	12.3	79.9	93.1	74.4
Barley	11.4	84.3	76.3	64.3
Wheat	12.6	92.4	62.5	57.8
Maize	10.1	93.2	64.3	59.9

Source: Baniya, 1993.

Recent market survey in Kathmandu has established that the trend of buckwheat consumption is increasing as compared to past. Retailer (Laxmi Flour Store, Ason, Personla Comm.) reported that he has been selling about an amount of 500 kg/month buckwheat flour, whereas he used to sell about 200-250 kg/month in previous years. Flour retailer of Kathmandu (Laxmi store, Ason) reported that the increasing demand is mainly due to the following reasons:

(a) Mongolian origin people living in Kathmandu valley consume buckwheat as their regular foods and their number is increasing slowly as other peoples from different districts.

(b) There is high demand of buckwheat food in Kathmandu valley by patients such as diabetic, blood pressure etc and search for the buckwheat flour is increasing in recent years.

Commercialization

Promotion of following points may help to commercialize buckwheat in Nepal. Some of these are discussed here.

Dietary purposes

As we know that there is feasibility to produce more buckwheat in Nepal provided the price is higher than present, which is considerably lower in Nepal, there are lots of room to commercialize buckwheat in terms of nutritious and health food industries. Some of the food items included in international market (except Nepalese food items) are listed in Table 8. There is demand of these products at international levels.

Table 8. List of food items from buckwheat and its products

Part used	Foods items
Flour	Noodles, Pancake
Flour	Bakery products mixed with wheat flour
Dry leaves and grain	Soup ingredients
Flour	Mixed in breakfast cereals
Dehulled grains (groats)	Cooked and served as rice
Roasted and ground grains	Tea
Grain	Fermented liquor (alcohols)
Tite buckwheat	Vinegar
Grain	Jam
Tite buckwheat	Macaroni
Grain	Sweets
Green leaves and succulent stem	Vegetable (*Tarkari*)
Green leaves and succulent stem	Salad
Green leaves and succulent stem	Soup (Sausage)
Green and dry leaves	Pickles
Grain	Biscuit, soup bread
Flour	Blending with other foods items
Miscellaneous items	
Leaf, stem, grain etc	Medicinal extracts
Tite flour	Tooth paste
Tite extracts	Cosmetics
Hull	Pillow

Source: Baniya, 1993.

Bee keeping

Buckwheat is a suitable crop in bee keeping due to its longer blooming period (around one months) and having numerous flowers per plant with higher amount of nectar. Buckwheat has been regarded as one of the high honey bearing crop plant (Morse et al., 1990, cited by Singh, 2001). This crop primarily depends on insect pollination and honeybees and leaf-cutter bees are effective pollinators. A minimum of 2.5 colonies of honeybees ha^{-1} (one colony per acre) is currently recommended. They increase seed set and seed yield. Besides the honey produced by the bees has a good market value (Campbell and Gubbeis, 1977).

In Japan and other western countries including Canada, it is also cultivated as a honey crop. *Mithe* buckwheat cultivating in a hectare of land produced 150 kg honey in a research conducted in USA (Lohani, 2037 BS). In another study in Japan, 300 kg of honey was harvested from a single hectare of land (Regmi, 1982). However, in Nepal honey culture (bee keeping) can be recommended in *mithe* buckwheat cultivating areas (Lohani, 2037 BS), which would be more beneficial to the farmers and contribute to the national economy to some extent. In an analytical survey of composition of 74 different American honeys (White et al., 1962) revealed that buckwheat honey has high content of essential enzymes such as diastase (amylose) and sucrose but it has lower levulose (Table 9).

Table 9. Relative grading of buckwheat honey

	Grading		
	Higher	**Average**	**Lower**
Components	Diastase (amylose) Sucrose Free acidity Total acidity Colour	Granulation Dextrose Maltose Higher sugars Undetermined pH Lactose Lactonic (free acid) Ash Nitrogen	Levulose

Source: Modified from White, 1975.

Buckwheat honey is dark in colour and has strong flavour as compared to other, which is popular in Europe and America. Thus beekeeping for honey purpose could be one of the effective ways in commercialization of buckwheat.

Beverage products

The local beer (Jand) and alcohol (Raksi) have been reported to be very good for health especially for stomach problem and common cold. So there is possible to use buckwheat as a raw material for distillery industries and thus could be a way of its commercialization.

Research for medicinal use

Extensive research works for medicinal purposes in China, Japan and western countries are underway. There is possibility of using it for medicinal purposes. Protocols are available in extracting rutin (Rutin-alpha a-glucoside) and other medicinal compounds from buckwheat. Besides, raw materials could also be exported to outside country for commercial purposes.

Possibility to export

Some sources (informal enquiries) reported that Nepalese exporters are trying to promote and export buckwheat to Japan and other countries beside local trade (Table 1). Report suggested that Nepalese buckwheat has demands from Japan, South Korea, Russia, Australia and other countries.

Import of buckwheat by Japan is 97,050 t during 2000. The statistics indicated that China is the major exporter, which covers most of the Japanese market demand (81,842 ton) followed by USA (7,922 t) and Canada (5,969 t). Other exporters are Australia, Newzealand, Argentina, India, Nepal and Myanmar (1,311 t). Nepal is exporting very little amount of buckwheat (Table 10).

Table 10. Buckwheat imported by Japan, 2000

Countries	**Import, t**
China	81,848
USA	7,922
Canada	5,969
Australia, Newzealand, Argentina, India, Nepal, Myanmar	1,311
Total	97,050

Source: Arjun Tulachan, Sunset View Hotel, Naya Baneshwor, Kathmandu, 2001, Personal Comm.

However, there are some standards need to be strictly followed in order to compete the international market. These may includes (a) Grain quality; (b) Flour milling and taste quality; (c) Nutritional quality, etc.

TIBET
⇑
High Hill
⇓
Mid Hill
⇓
Terai NEPAL
⇓ ⇓
INDIA……⇒ JAPAN

Fig. 1. Trade route of buckwheat in high mountains of Nepal.

Constraints

- Lack of exploration of world market
- High yielding varieties are not available at present
- Less prioritized crop in National Agricultural Research
- Lack of export quality buckwheat
- Lack of consciousness about medicinal and nutritive values

Suggestions

- Establish network and relationship between the buckwheat growers, traders, research workers and even with consumer for the ease of marketing, commercialization and knowing status of world buckwheat research and trade.
- Study of buckwheat quality (grain quality, flour milling and taste quality, nutritional quality, etc) for in-country use and outside export is needed.
- Encourage the establishment of buckwheat related industries. These may include flour processing, food items preparations, extraction of medicinal compounds, beverage and to use of its byproducts (eg buckwheat hull and others) for industrial purposes.
- Due to extensive working for medicinal purposes in China, Japan and western countries, there is high possibility of research work in extracting rutin and other medicinal compounds from Nepalese buckwheat for in country use and supplying raw materials abroad.
- Explore world buckwheat market.
- There should be national priority and facility to export buckwheat. Such facility may be considered in transportation and airfreight, tax exempt, etc to encourage buckwheat exporters.
- Beekeeping can be recommended for both the purposes ie yield benefit in buckwheat and honey harvest for commercial purposes.
- Government has to list and prioritize buckwheat as a cash commodity/crop and encourage in research and development.

More marketing and socio-economic study is needed in future to understand, predict and explore the market price and socio-religious values of buckwheat, which help for the commercialization of buckwheat at national and international levels.

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Medicinal, religious and cultural values of buckwheat in Nepal

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Abstract

Buckwheat is one of the principal components in the cropping patterns of mountainous agro-ecological regions of Nepal. This is a irreplaceable crop in the high hills. Buckwheat is called *KUANNA* (*KU* = bad and *ANNA* = cereals,) in Nepalese community. Some religious people believe that one of the prominent authors of the Great VEDA Bishwamitra introduced buckwheat in the Himalayan region during Vedic era (1200-1500 BC). Brahmin and Chhetri prefer common buckwheat as it is relatively more prestigious grains while other people grow more tartary buckwheat due to its yield advantage. Some special delicious food item prepared from common buckwheat *Maghe Sankranti* festival (around 15 Jan) in the hill of Nepal has the religious and a traditional custom. Buddhist of Kathmandu sacrifices buckwheat grains to one of the Satellites called *KETU GRAHA* for peace to guard against the devil effect. In addition, local people use buckwheat for treating different kinds of diseases. Such types of cultural, religious and medicinal values are supposed to be helpful for *in situ* conservation.

Key words: buckwheat**,** culture, medicines, religious

Introduction

Buckwheat is a neglected crop in Nepal. It is also called as "*kuanna*". Certain Nepalese communities do not want to use it and hesitate to take as a food. On the other hand, Mongolian communities have been using this cereal in many cultural and religious occasions. Buckwheat has been cultivated in Nepal since ancient times and it is major crop in the high hills of Nepal (Vaidya et al., 1999). The recent cultivation area of buckwheat is not available, but it is estimated more than 4500 ha (Khatri-Chetri, 2050 BS) of land. Buckwheat is cultivated from *Terai* to high altitude upto 4000 m and extended east to west of Nepal. Lack of improved varieties, improved technology, awareness, chemical fertilizer, problems of shattering and bitterness, low yield, lack of knowledge of its importance are the major constraints in its popularization (Baniya, 1993; 1999; 2000; Sharma and Vaidya, 1994). To increase its production like other crops, environment, variety, seed, crop management and crop protection are to be considered in its research and development.

Methodology

The informations about buckwheat were collected by observation, RRA survey, review of available literatures and simple surveys. Some of the information were collected by personal communication with different people working in buckwheat (Spencer, 1995; Chmielewski, 1999).

Results and discussion

Medicinal uses

Nepalese people are using buckwheat for several medicinal purposes. The following practices are locally adapted for medicinal uses by some people.

- For cold, cough and fever problems, local people make paste from the *tite* buckwheat flour and it is applied on the throat, forehead and nose. The thin paste of *tite* buckwheat flour is also applied on the burnt wound.
- For the gastric problem, people make large and thick bread and eat it when it is hot. This type of bread is locally called *Lagar* or *Dhensu*.

- In stomach problem and pain people they use *tite* buckwheat as food.
- The wounds are washed with boiled water and *tite* buckwheat paste is applied on the wounds.
- In case of head pain, *tite* buckwheat paste is applied on the forehead and eyelids
- Mostly the women wash their head by the *tite* buckwheat flour to make their head clean and safe from dandruff and hair dropping problem.
- Epileptic patients drink the drained green water *tite* buckwheat flour which is dipped overnight.
- In dysentery, use of tender leaves of *tite* buckwheat mixed with the flour and curd is common.
- For jaundice patients, people use *tite* buckwheat flour soup in boiled water.
- It is used to reduce the effect of poison in the body.
- In pimples and skin scratches, people apply *tite* buckwheat flour paste in affected areas.
- In case of sudden stop of stool and urine *tite* buckwheat flour soup is given to the patients to resume normal functions.
- *Tite* buckwheat flour is applied dental gum bleeding and swelling.
- Buckwheat is used to control the bleeding during birth of a baby.
- It is used during cholera and dysentery.
- Fresh flour of *tite* buckwheat is used for allergy like skin drying and itching.
- It is used to check pneumonia in child.
- During bone and hair blockage in throat the thick bread is eaten to open the blockage.
- Buckwheat is used as paste to relief from tonsil problem.

Religious and cultural values

In Nepal, buckwheat has several religious and cultural values. Some consider it as an essential commodity in their religious occasions. There are many ethnic communities in the country and among them Mongolian communities have been using buckwheat in many cultural and religious occasions. Thus, so buckwheat has great bright future in the hilly areas of Nepal. Some of the specific examples of religious and cultural values are as follows.

- Buckwheat is a sacred cereal and farmer believes that Gods likes it (Dolpa village).
- In the full moon day of Kartic (Oct-Nov) *tite* buckwheat bread is offered to God.
- In the full moon day of Margh (Jan-Feb) ball prepared from the *tite* buckwheat is offered to the God. (Majhpha VDC, Dolpa).
- When some persons are believed to be affected by ghost, *tite* buckwheat flour is used to make dummy of a man which Lama uses it to cure from ghost problems.
- After the death a person in a certain house, they make 18 bread from each neighboring house, cooked in the oil and distribute them in each household (Shahartara VDC, Dolpa).
- When the newly married bride returns to her father's house from her husband's house, she has to bring 7 back loads of buckwheat bread.
- In Chaite Puja, (in the month of Jan-Feb) people prepare buckwheat bread, eat together and distribute to other people and excess breads are saved for the guests to offer as *prasad* (sacred food).
- *Tite* buckwheat grains are also popped to worship God in Chaite Puja (Sahartara VDC, Dolpa).
- Before planting buckwheat, *tite* buckwheat grains are popped and offer for worshiping God by the Lamas and only farmers start to sow buckwheat. Farmers believe that God will be happy and no problems of diseases, insect pests and weather will be encountered in the crop fields.

Consumption and utilization of buckwheat by farmers

The buckwheat flour is used for the preparation of bread (*roti*), *dhindo, lagar, dhensu, chhang* and alcohol.

Bread: Flour is mixed with water like slurry and cooked on the hot pan called *roti* (pancake)

Dhindo: Buckwheat flour is poured in the boiling water and continuously stirred by ladle until it becomes thick paste and well cooked.

Lagar: Flour is mixed with water and knead to dough stage and put on hot pan to cook and then again put on the fire (red charcoal) to be fully cooked. Each *lagar* is about ½ kg in weight.

Dhensu: Preparation process is same as *lagar*, but it is more than 1 kg weight and more thick. It can be gradually consumed even over one week.

Plants: Tender plant leaves are used for fresh vegetables. Also used as tea or green salads.

Dried leaves: These are also used as vegetable in off-season after boiling.

Buckwheat flour: It is mixed with the sugar and sour and eaten freshly without cooking. It is easily digestible with no harm.

Buckwheat flour: Some time, farmers use to mix buckwheat flour with salt and hot chilly powder and eat directly without cooking.

Tender plants and leaves: These are picked up and mixed with salt and hot chilly and eat it as pickle.

Soup: They make the soup from the buckwheat flour and drink it.

Chhyang (beer): Local farmers use the *chhyang* made from buckwheat flour mostly in cold season.

Alcohol: People prepare alcohol from the buckwheat flour and drink it, however it is believed that more intake of buckwheat alcohol is not beneficial for persons with uric acid problem which may cause joint pain, backbone pain and muscle pain.

Animal: Buckwheat flour is given mostly to animals during parturition and gestation period. It is good food for young cattle also.

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Status of buckwheat in Chitwan

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Abstract

An attempt is made to give some highlights of common (*mithe*) buckwheat (*Fagopyrum esculentum*) production, cultivation practices and prospects in Chitwan, Nepal. Since last few years Chitwan has been the place of buckwheat cultivation from where buckwheat is mainly exported to India. Currently buckwheat is cultivated in 670 ha area producing 840 t grains. Source of seed for cultivation is local originally introduced by the hill migrants. Two ecotypes are being cultivated. Buckwheat fits in the rice-buckwheat as well as maize-buckwheat cropping patterns. Due to market opportunities and low management requirement, buckwheat became popular in Chitwan and partially replaced other winter crops. Local consumption is minimal and district office's role to popularize buckwheat is not significant.

Key words: Chitwan, cultivation practices, cropping pattern, production

Introduction

Though buckwheat is one of the important crops in the mountainous and hill area, it is one of the neglected crop in Chitwan. The research and developmental institutions have put very less effort for increasing the productivity of the crop in Chitwan. Despite the institutional efforts, there is gradual increasing trend of buckwheat cultivation since 25 years. However the productivity of the crop is decreasing gradually. The objective of this paper is to analyze the present situation of buckwheat and its scope in Chitwan.

Methods

The study on buckwheat was conducted in 20 village development committees (VDCs) and town municipality areas of Chitwan. The nine hilly VDCs were not included in the study. Focus Group Discussion (FGD) with farmers were carried out during the study. The discussion was held both with male and female farmers. Individual interview was also done with farmers and other personnel such as traders of the district. Secondary information such as participatory rural appraisal (PRA) was conducted in Chitwan in the 2000. PRA data were also analyzed.

Findings and discussion

Area covered by buckwheat in Chitwan

The PRA revealed that the total buckwheat growing area as yet was 670 hectares. The total area covered by the crops is reported to be increasing since last few year. The reasons of cultivating buckwheat are as follows:

- Lower productivity of other crops due to lack of irrigation facilities in winter season
- In wildlife prone area, this crop is relatively safe due to fragrance of the flowers.
- Declining productivity of rapeseed or mustard.
- Good marketing value
- Low cost of cultivation

Seed sources and varieties

Initially the hill people introduced the crop during their migration from hill to Chitwan. Currently most of the farmers use their own seed and a few collect from their neighbors and local shops. No improved varieties have been introduced in Chitwan. The farmers mainly grow local varieties namely, *Sano* local and *Thulo* local. Both are *mithe phapar* (common buckwheat). Marketing is the problem for *tite* (tartary) type of buckwheat although it has higher grain yield than *mithe* type.

Cultivation practice adopted in Chitwan

Seed rate: Seed rate reported by the farmers in Chitwan varies depending upon the soil types and soil moisture at the time of sowing. Seed rate was higher in *tandi* or *bari* (upland) condition than in low land (*Khet)*. Seed rate also varies according to the cultivation practices because some farmers plow land before sowing while others sow in the fallow land without plowing. The average seed rate ranges from 60-80 kg ha^{-1}.

Fertilizer: Farmers reported that no compost and fertilizer were used in buckwheat as a basal dose. Only few farmers reported that they applied urea as a top dress at the vegetative growth stage at the rate of 30 kg ha^{-1}.

Time of sowing and harvesting: Time of sowing and harvesting varies on land types because farmers sow buckwheat in *bar*i land earlier than in *khet* land as shown in the table 1.

Table 1. Sowing and harvesting time of buckwheat in Chitwan

Land types	Sowing time	Harvesting time
Bari land	Last week of Sep to 2nd week of Oct	Jan 2nd week
Khet land	Nov	Mar

Buckwheat based cropping pattern

Buckwheat is reported to be cultivated in both maize and rice dominated systems that replace rapeseed or other winter crops (Table 2).

Table 2. Buckwheat based cropping pattern, Chitwan

Land types	Cropping pattern
Bari land	Maize- buckwheat-spring maize
	Sesame-Maize- buckwheat
	Maize-buckwheat- fallow
Khet land	Rice- buckwheat- spring maize
	Rice- buckwheat- rice
	Rice- buckwheat- fallow

Production and productivity

The average productivity is about 1250 kg ha^{-1}. Thus, the average annual buckwheat production in Chitwan is about 840 t.

Uses

In Chitwan, buckwheat has not been processed so far in the industries. It is locally processed in the home made *janto.* It has been reported that major portion of the production (>90%) is exported to India and remaining is used for seed as well as home consumption. Though it has been not used by industrial sectors, however it has various uses as reported by farmers and traders of Chitwan. It is used in religious occasion both in India and Nepal. It is considered *Chokho* (holly) during the festivals when peoples do *vrata* (fasting) in Nawaratri, Shivaratri, Janmastami etc. The major dishes prepared are bread, *haluwa, puri* in which sugar and ghee is added instead of salt. A very little amount is used for food by making *roti* (bread) and for livestock feed. Buckwheat straw is used for feeding to livestock during lean season by mixing with rice straw and green grass. Buckwheat bran (*bhush*) is used for feeding animals by mixing with other concentrates.

Cost benefits analysis

Simple comparison was done to know the total cost of production and total gross income from the cultivation of the crop. The cost and benefits analysis was done from the available information from farmers (Table 3).

Table 3. The cost of production and gross income from buckwheat cultivation in Chitwan

Cost of production ha^{-1}, Rs		**Income ha^{-1}**	
Land preparation	1500.00	Average production	1254.00 kg ha^{-1}
Sowing of seeds	150.00		
Price of seeds	960.00	Average price of the produce, Rs	10.75 kg^{-1}
Fertilizers (Urea)	500.00		
Harvesting	1050.00		
Threshing and cleaning	1050.00		
Total cost (A)	5210.00	Gross income, Rs (B)	13480.50
Net income from one ha of land = Rs8270.00			

Marketing and trading system

About 10 traders has been reported to be involved in collecting and exporting of buckwheat from Chitwan to India. Since last three years the export amount of buckwheat has been reported to 500-600 ton per year. The traders reported that collected produce is exported mainly to Banaras, Lucknow, Delhi, Agra, Gaziabad etc. The traders also reported that this practice of buckwheat marketing has been continuing since 20-25 years. Raj Kumar Marwadi and Hajari Shaha (Giri) were the first Indian traders who initiated to export buckwheat from Chitwan to India. At present more than 90% of the produce is exported to India but the demand and the price of the buckwheat mainly depends upon the production of buckwheat in Asam and Madya Pradesh of India. The maximum and minimum price recorded since last five years range from Rs3000 qt^{-1} to Rs400 qt^{-1} respectively.

Marketing channel

Most of the farmers sell their produce to the collectors who directly contact farmers at their respective farms. Approximately, 85% of the production is sold through this channel. Remaining 10% is sold to local traders and 5% directly to market. They get competitive price in the first option.

Conclusions

Although, buckwheat occupy substantially higher area of Chitwan than other winter crop the contribution of the extension and research system is almost negligible to the development of this crop. Unlike other commonly grown winter crops the cost of cultivation of this crop is relatively low thus farmers are getting substantially good net income from this crop. Since it has very good export potential and religious value, the produce can be easily sold and thus farmers can make money easily from this crop. Thus the research and extension system should focus their attention to the development of appropriate technology. Since buckwheat is very common among the Hindu communities, as a religious food (*falahar*) it could be a prospective industrial crop if its industrial uses could be channelized. Regarding marketing of the crop, there should be proper agreement for the export of the produce. The uncertainty of market and fluctuation of the price are the constraints. Study on identifying the prospects and potentiality for the development of the crop is an important issue. Industrial value should be identified for the high consumption of the produce.

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A situational context on buckwheat cultivation in Dolkha

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Abstract

Buckwheat (*Fagopyrum* spp.) is an important cereal crop from the very beginning of agriculture in Nepal. It has special importance on social, cultural, agro-climatical as well as medicinal values. However this crop has been almost neglected for its scientific development and indirectly rejected indirectly crop along with the passage of time. Therefore, its cultivation is at the decreasing rate as compared to the past. Indeed, it is to be backed by the scientific research for its improvement in association with a sharp extension program to reach to the rural farmers so that good performance varieties will come out and ultimately contribute to the well being of rural people.

Key words: buckwheat, cultivation, Dolkha, extension

Introduction

Buckwheat (*Fagopyrum* spp.) is one of the important and popular cereal crops among all the traditionally cultivated crops in Nepal. This crop has also been well distributed all over the country however is predominantly to the northern part in lower hills to mid and high hills. Dolakha is a northern high hill district of Nepal and almost represents the geographic variations of Nepal from sub-tropical, sub-temperate and temperate to Himalayan range. Dolkha rang from 732 to 7148 masl consisting of lower hills, mid and high hills with the Mt. Gaurishankar. Although buckwheat is cultivated in these areas under traditional agro-systems, this crop has not been considered as a major crop and is grown under negligible nutritional requirements.

Importance of buckwheat

- In the very beginning buckwheat was considered as an important food crop for the rural poor people that contained more nutritive value with soft quality in texture. There is a rural proverb on buckwheat that if you have financial problem, go for buckwheat cultivation to resolve it.
- This crop can be cultivated in diversified climatic condition from tropical to temperate zone in different seasons such as spring, summer and autumn crop, however, it is a pre-dominant crop in winter season.
- Buckwheat has a special ceremonial value in Nepalese culture as a special food in the form of *phuraula* at the first day of Margh in each year.
- This crop has got a medicinal value for the control of diabetes or sugar, gastrick and dysentery due to its *tite* taste and its digestible properties.
- Buckwheat flowers attract bees specially by the common type, which contributes significant amount of honey up to 150 kg ha^{-1} in a season.
- It creates beautiful environment, which is pleasant to eye, when it is flowering.
- Buckwheat (*tite* type) has a good storing quality against stored grain pests and widely used as food in famine or hunger.
- The *tite* buckwheat grain pop is necessarily used to offer to the aquatic souls in social function by different ethnic groups.
- Buckwheat is short duration crop as it matures within 90 to 120 days.

Utilization

- Buckwheat both *mithe* as well as *tite* is used mainly as bread.
- The *tite* type is also used as *dhindo* the cooked dough (flour is cooked in boiling water) and whole and crushing grains of both *mithe* and *tite* are cooked as rice for food.
- Buckwheat flour makes soft mixed with other grains giving yellowish color by *tite* and grayish color by *mithe* type.
- It is also used to make local beer, alone or mixed with maize millet, wheat or barley.
- Buckwheat pop is specially used for praying the aquatic soul in social functions.
- The buckwheat grain is used as feed for animals and its straw is also used as dry fodder. Its gruel is very useful specially, for milch animal.
- The rich family does not use *tite* type where as *mithe* is used rarely by poor family.
- Modern recepies of buckwheat are not yet introduced among the rural farmer.

Type of buckwheat

There are two types of buckwheat under cultivation, *tite* type buckwheat (*Fagopyrum tataricum* Gaertn.) and *mithe* type buckwheat (*Fagopyrum esculentum* Moench.). Although the buckwheat crop is grown in every corner of the district, the cultivation practice differs from place to place according to agro climatic zone. The *tite* type is grown as summer crop in the high hills, but it is autumn crop for mid hills and winter and spring crop for lower hills to Gangatic plains. The *mithe* type is cultivated very less in high hills and it is not grown as summer crop. That is why the *tite* type is more predominant in this area where as the *mithe* type is dominant to the lower hills and it is successfully grown in low rainfall areas. *Mithe* species is less productive due to cross-pollination crop where as the *tite* species is more productive due to self-pollination.

Area covered by buckwheat cultivation

Earlier buckwheat was grown I 3148 to 4197 ha (15-20%) of the total cultivated area (20987 ha) in Dolakha. Every farmer family cultivates buckwheat in an area ranging from 0.05 ha (2 *ropany*) to 1.5 ha (30 *ropany*). On an average buckwheat is grown in 0.4 ha (8 *ropany*) per family.

By now, after three decades the buckwheat cultivation is gradually declining at significant rate of about 70-75% which comes to be around 4-6% of the total cultivated area.

Currently, the average buckwheat area in 55 VDCs (including 4 VDCs = A Municipality) is as follows: the total minimum area is 15740 rapanies (787 ha) and maximum being 25184 ropanies (1259.2 ha).

Agronomical pattern

- Buckwheat is cultivated as summer crop in the hills as autumn crop in mid hills and as winter or spring crop in lower hills.
- It is grown normally in less fertile to unfertile lands. It is less labor-intensive crop that does not require fine land and soil preparation, weeding and labor. It is a short duration crop.
- It is cultivated mainly in irrigated condition.
- Broadcasting of seed is a common practice.
- It is less prone to disease and insects especially in the *tite* type.
- It is cultivated as a bonus crop between wheat and maiz in the high hills.
- It is recognized as a cover crop to the barren land.
- Earlier it was cultivated without compost or manure or chemical fertilizers. Only the fresh dung and urine from rotational camping of domestic animals were used in the fields. But now farmers

are inclined to use chemical fertilizer especially nitrogenous and phosphatic fertilizers in small quantity in buckwheat fields of mid to lower hills.

Cropping pattern of buckwheat

Buckwheat has been cultivated under different cropping patterns depending upon the climatic conditions and the need of farmers. The following cropping patterns are predominantly adopted by the farming communities year round.

High hills

1 Fallow - buckwheat - potato
2 Potato - buckwheat - fallow
3 Fallow - buckwheat - fallow
4 Wheat - buckwheat - potato
5 Buckwheat - wheat - buckwheat

Mid hills

1. Maize - buckwheat - maize
2. Fallow - buckwheat - maize
3. Fallow - buckwheat - maize
4. Fallow - buckwheat - potato
5. Maize - buckwheat - fallow
6. Potato - buckwheat - fallow
7. Buckwheat - rice - wheat

Lower hills

1. Buckwheat - rice - wheat
2. Wheat - rice - buckwheat
3. Maize - rice -buckwheat
4. Fallow - buckwheat - rice
5. Wheat - buckwheat - rice
6. Buckwheat - rice - maize
7. Potato - buckwheat - fallow

There is a general belief among farming communities that land becomes unfertile and poor after buckwheat cultivation.

Mix cropping

Generally mix cropping wit buckwheat is uncommon in high hills. In mid and lower hills following patterns of mix cropping are practiced by the farmers.

a) Buckwheat + mustard
b) Buckwheat + root crops specially, vegetable/brassicae family
c) Buckwheat + peas, beans (popular in mid hill)
d) Maize + buckwheat as relay and inter cropping during June-Aug called Chiniya buckwheat

Factors to declining cultivation of buckwheat

In fact, area under buckwheat cultivation is declining due to following factors.

- In the past there was lack of food due to low productivity of the crops in the rural areas. There was lack of easy access and transportation for food supply. So farmers adopted buckwheat cultivation as a supplementary crop to fight against hunger. Later, the extension program on agriculture development resulted a significant increment of productivity of different major cereal crops in a large area. Again the transportation infrastructure has also been developed. Use of chemical fertilizers and improved variety of wheat brought a significant increment in the production, thus the food availability was also increased. That is why the rural farmers gradually left the cultivation of buckwheat.

- Farmers are motivated to the diversification of crops and they were diverted to vegetable and cash crop production.
- New irrigation infrastructures were developed so that unirrigated areas were converted into irrigated area in which rice and wheat were grown.
- Growing human population affected land size holding to be smaller than before. Buckwheat is only grown in a plot left after millet.
- Buckwheat makes soil poor for next crop due to high up take of soil nutrients.
- In mid hills, farmers are intended to grow millet due to grain productivity and straw for livestock.
- The price value is lower than other crops especially for the *tite* type, where as the *mithe* type is less productive.
- As in the past, the 'bukma' system in potato and deforestation for new agricultural land is almost stopped.
- The lifestyle is changed and the social status of rural farmer has been improved due to social development so they are able to get the alternative food materials.
- National policy on buckwheat development is absent.
- The trend indicates that buckwheat cultivation may be almost nil after 20-25 years in Dolakha district.

Research program on buckwheat

- The National Hill Crops Research Program (NHCRP) under Nepal Agricultural Research Council (NARC) was established in 1986 at Kabre (1740 masl) in Dolakha district, where the research activities on buckwheat have been conducted regularly since 1992. For the first time 105 varieties of Nepalese buckwheat germplasm were collected from different agro-climatic regions of Nepal. These germplasms were characterized, evaluated and multiplied at HCRP.
- Some exotic varieties of buckwheat especially the *mithe* type was also imported in Nepal by the HCRP and varietal experiments were performed at HCRP.
- Some trials under farmers' field condition have also been conducted in limited number and still study is under way.
- Although HCRP is involved regularly in different experimental programs, no new improved variety is released yet and again no any scientific package of agronomical practice is recommended to the farmers.
- Finally, there is not a coordinated effort on improvement of buckwheat btween research and extension.

Researchable problems

- Still we have not any one of improved variety on buckwheat.
- The improvement program on local varieties has not been yet.
- There is lack of technical package of practice on buckwheat
- Infertility problem is very high in *mithe* type.
- The medicinal value of *tite* type is not under account
- The commercial value of buckwheat must be under information channel.
- Different new products or dishes add by buckwheat are developed by food technology sector.
- There is a lack of exposure program to the extension sector about buckwheat improvement activities.

Conclusions and suggestions

- Buckwheat cultivation is really under negligence of social and technical crop development sector, which must be taken under regular and serious attention by the researchers.
- It has been considered as a primary need to be released immediately a new improved variety of buckwheat by the researchers.
- Buckwheat crop must be considered as an important material for the research on its multi use.
- The occasionally organized buckwheat related program must be connected to the point of live co-ordination with regular agricultural extension programs, making exposure to the related development and research activities.

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General information of buckwheat in Lalitpur

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Area

Out of 15296 ha cultivated land, corn is grown in 9470 ha and buckwheat in a miagre area of 32.6 ha in the 21 village development committees (VDCs) (5 VDCs within valley and 16 VDCs outside valley) in Lalitpur district. None of farm family has cultivated buckwheat in more than 0.1 ha.

Types, planting time and productivity

Mithe and *tite* types are cultivated in this district. *Tite* buckwheat is cultivated in higher altitude (1500 masl) with 25% coverage and *mithe* buckwheat is grown in lower area. Both types are grown after corn (Saun-Bhadau) and as an alternate of mustard in an area of low fertility and low water holding soil type. Yield is 600-800 kg ha^{-1} in *mithe* buckwheat and 800-1100 kg ha^{-1} in *tite* buckwheat. From shattered seeds green plants germinate at Baisakha, Which is used for green vegetable. Price of green vegetable harvested at Baisakha is higher than that of Aswin as Baisakha is lack period for green vegetable. Unlike mustard, green vegetable from buckwheat can be grown round the year, which will lead no further grain harvest.

Consumers, consumption pattern and marketing

More than 80 percent of the buckwheat flour buyers are migrated hilly women especially Mongolians (Gurung, Magars, Rai, Thakali and Limbu) and rest buyers are sick, old people and foreign returners of other ethnic group according to Bhattendanda Cooperative Society (BCS) stall at Lagankhel. People from high hills like *tite* buckwheat as compared to those of lower hills. The grains and green vegetable of buckwheat are consumed as *roti, dhindo* and *fulaura* and as *gundruk* from succulent plant. According to BCS about 11,000 kg of flour was sold in the year 2057/58 and 2200 kg in 2054/55 BS. At present price of buckwheat is Rs45 kg^{-1} as against Rs21 kg^{-1} at farm gate price. Similarly about 2000 kg of green vegetable was sold by BCS in the year 2057/58 BS at the rate of Rs20 kg^{-1}.

Reasons for using buckwheat as perceived by the consumers

- Reduction in diabetes
- Laxative to stomach
- Reduction in lipid content
- Reduction in high blood pressure

Reasons for cultivating buckwheat

- Utilization of unfertile land
- Medicinal value for family
- As a cash crop due to BCS
- Green vegetable at a time when it is not available
- Gift for relatives living in town areas
- No extra effort for cultivation

Reasons for not expanding buckwheat cultivation

- Low production, no knowledge/skill, no high yielding variety, no priority from government and others.
- Mustard oil is essential for home consumption
- Low price as against other medicinal crops
- Little quantity is used in home as no one like to eat.
- Introduction of other alternative crop (peas, radish, vegetables) with higher income

In a situation such as size of land holding/farm family is decreasing, soil fertility and other supporting facilities is increasing, and alternative crop with higher income is available, it is difficult to recommend farmers of valley surrounding districts to cultivate buckwheat.

*ल्पा जिल्लामा फाप/ खेती

भीम बहादु/ धा/ला[१]

[१] जिल्ला कषि विकास कार्यलय, *ल्पा

पा/चय

*ल्पा जिल्लामा चा/ किसिमका फाप/को स्थानीय जातहरु छन् . -कं चुचे फाप/ (ख) भाते फाप/ (ग) लेखा/ फाप/ / (घं मिठे फाप/ .

फाप/को क्षेत्रफल । १६०० हेक्ट/ .
उत्पादन । प्रति हेक्ट/ ६०० देखि ८०० केजी उत्पादन हुन्छ .
फाप/ खेती गर्ने ता/का । फाप/ खेती स्थानीय ता/काबाट छरुवा गा/न्छ . फाप/ खेतीस.ग सर्सु, चोती वाली मिक्स गा/ खेती गा/न्छ .
खेती गर्ने समय । यो क्षेत्रमा बैशाखमा छा/न्छ आश्विनमा भित्राइन्छ . तल्लो क्षेत्रमा फाप/ खेती जेष्ठ महिनामा छा/न्छ / भाद्र महिनामा भित्राइन्छ .
गो*मेल गर्ने ता/का । फाप/ छ/को एक महिना पछि एक पटक गो*मेल गा/न्छ .
फाप/को उपयोगिता । मानिसले लग/, ढेसु, जा.*, ढि*ो / भात पकाए/ खाने गर्छन् . साथै जनाव/को लागि फाप/को *ा.ठ, भुस घा.सको लागि प्रयोग गा/न्छ . अमिलो / मकैस.ग पिठोमा मिसाए/ का.चै खाने पनि गा/न्छ .
****ल्पामा यसको सा.स्कृति / धार्मिक महत्व ।*** लामा, मग/, गरु*०ग जातीले धार्मिक कार्यक्रमको लागि / लामाहरुले पुजाको लागि मुर्ति बनाउने / पुजा गर्ने गर्छन् . जा.*को झोल (निगा/) बनाए/ बुद्ध भगवानलाई चढाउने / फाप/ भुटे/ फुले पछि गोब/ /ाखे/ (मेहन्दोक) बनाए/ पुजा गर्ने चलन छ . भोट क्षेत्र बस्ने जातीले ठूलो मान्छे आए पछि मिठे फाप/को लग/ खान दिने चलन /ाम्रो मानिन्छ .
औषधीमा प्रयोग । ज/ा आउ.दा पिठोको झोल बनाए/ निदा/मा लेप लगाउने गा/न्छ . आ.खामा धुवा लाग्दा आ.खाको व/िपा/ पिठोको झोल बनाए/ लगाए सञ्चो हुने हु.दा झोल लगाउने गा/न्छ . छाती दुख्दा पनि यही ता/काले छातीमा लेप लगाइन्छ .
फाप/को महत्व । धै/ जसो लामा, गुरु*०ग, मग/ जातीहरुले यसको ठूलो महत्व /ाख्दछन् .

फाप/को उत्पादन पहिलाको तुलनामा घट्नाको का/ण

क+ नेपाल खाद्य स.स्थानले खाद्यान्न ढुवानी गा/ यस जिल्लामा खाद्यान्न वित/ण गर्नु
ख+ यस जिल्लामा ज*ीबुटी प्रशस्त पाउनु

ग+ टेक्नि*oकको का/णबाट फाप/ खेती गर्न छाड्*नु
घ+ फाप/को स्वादमा तितो पन बढी हुनु
*o+ /ोग कि/ाको जानका/ी नहुनु
च+ उन्नत जात नपाउनु
छ+ प्राविधिक जानका/ीको अभाव हुनु
ज+ बजा/ भाउ नपाउनु आदि .

स्टो/ गर्ने त/ीका

क+ खा*ल खने/ भोजपत्रलाई खा*लमा /ाखे/ .
ख+ माटोको भका/ी बनाए/ .
ग+ काठको (खाट) भका/ी बनाए/ .

खेतीको समस्या

फाप/को जातहरुको ज्ञान आफैलाई थाहा नहुनु / जसले गर्दा प्रसा/ प्रचा/ गर्न गाह्रो छ . फाप/को विभिन्न अवस्थामा /ोग कि/ाको समस्या भै त्यसको /ोकथामको ज्ञान कृषकलाई दिन नसक्नु आदि .

समस्या

फाप/को /ाम्रो जात नपाउनु . तितो फाप/ तितो बढी हुनु . भर्ने, ढल्ने / पानी नपर्नु पानी बढी पर्नु, फाप/को ज्ञान नहुनु तथा फाप/को महत्व थाहा नहुनु .

मुस्ता*ञग जिल्लामा फाप/ खेतीको वर्तमान स्थिति। एक झलक

माधव प्रसाद खनाल[१]

[१] जिल्ला कृषि विकास कार्यालय, मुस्ता*ञग

पी/चय

फाप/ (Buckwheat, *Fagopyrum essculentum* Moench., Polygonaceae) खेती नेपालमा प/ापूर्व काल देखि गर्दै आएको पाइन्छ तापनि यस बालीलाई देशको खाद्यान्न आपूर्ति आ.क*ामा नगन्य नै मानिन्छ . तथापि उच्च पहा*ी हिमाली जिल्लाहरुमा गहु., मकै, उवा, जौ, आलु बाली स/ह नै फाप/ खेतीले अग्रस्थान ओगट्न सफल भएको छ . आलु बाली जस्तै फाप/ पनि त/ाई देखि उच्च पहा*ी भाग सम्म सफल रुपमा खेती गी/एको पाईन्छ . फाप/लाई धार्मिक कार्यहरुमा कुअन्नको रुपमा हेी/न्छ भने औषधी प्रयोजनमा सबैले खोजी खोजी खाने गो/को पाइन्छ . फाप/लाई विभिन्न पी/का/हरुको रुपमा खाइन्छ जस्तै। /ोटी, ढि*ो, सलाद -दहिमा फाप/को पात मिसाउने अनि नून, मसला /ाखें/ फाप/को दाल -ही/यो पातलाई सुकाइ पिठो बनाएं/, फाप/को ही/यो साग त/का/ी साथै जनाव/हरुलाई दाना तथा घा.सको रुपमा पनि प्रयोग गी/न्छ .

मुस्ता*ञग जिल्लामा फाप/को वर्तमान स्थिति

मुस्ता*ञग जिल्लामा फाप/ प्रमुख खाद्यान्न बाली हो . हाल जिल्लामा गहु.वाली ८७८ हे+ मा खेती भै २००९ टन उत्पादन भएता पनि खाद्यान्न उपभोगमा ५५८ टन मात्र भएको पाइन्छ भने त्यसको अनुपातमा फाप/ खेती ७६१ हे+ मा खेती हु.दै आएको / उत्पादन १५१४ टन भएको छ भने जिल्लाको खाद्यान्न उपभोगमा सबैभन्दा बढी १०२७ मे+टन भएको पाइन्छ . जुन तालिका १ बाट स्पष्ट हुन्छ .

तालिका १+ विगत पा.च वर्षमा बालीले ढाकेको क्षेत्रफल उत्पादन / उत्पादकत्व

ऋा / ब	०५२/०५३	०५३/०५४	०५४/०५५	०५५/०५६	०५६/०५७
वलीको क्षेत्रफल, हे+	८७३	८४५	७१६	७६१	७६१
एत्पादन, टन	१४७०	१७७५	१५१४	१५१४	१५१४
एत्पादकत्व, टन / हे+	१+९९	२+१	१+९९	१+९९	१+९९

श्रोत। जि+ कृ+ वि+ का+, मुस्ता*ञगको आ+ब+ ०५६.०५७ को वार्षिक पुस्तिका .

तालिका २+ मुस्ता*०ग जिल्लाको खाद्यान्न स्थिति -टनं

बली	क्षेत्रफल, हे+	एत्पादन, टन	बीउको लागि	/ोग कि/ाबाट नोक्सान	पशु आहा/	जा.* /क्सीमा	प्रशोधनमा नोक्सान	उपलब्ध खाद्यान्न
फाप/	७६१	१५१४	४६	१५१	७५	-	२१५	१०२७
गहु+	८७८	२००९	११०	२०१	३८०	७६०	ङ-	५५८
मकै	५३८	९६७	१६	९७	६१८	१४३	२	९१
एवा	४८१	५५३	६०	५५	ङ-	ङ३०६	ङ-	१३२
जौ.	५४४	९७९	६८	९८	५६९	२४४	ङ-	ङ

श्रोत। जि+कृ+वि+का+ मुस्ता*०गबाट प्रकाशित आ+ब+ ०५५.०५६ को वार्षिक पुस्तिका .

माथि उल्लेखित आ.क*ाबाट मुस्ता*०ग जिल्लामा /हेका कि/ब १४,५०० जनस.ख्यालाई मुस्ता*०ग जिल्लामा नै उत्पादित खाद्यान्नबाट खान पुग्ने देखिन्छ . त/ हिमाली जिल्ला भएको का/ण जा*ोबाट बच्न अत्यधिक खाद्यान्न जा* /क्सी बनाई कुहाए/ खे/ा जाने एकाति/ छदैछ भने उजा* हिउ. क्षेत्रभित्र पर्ने यो जिल्लामा पशु आहा/को लागि घा.सको अभाव भएको वखत पनि अत्यधिक अन्न खपत हुन्छ . यस वाहेक अन्य /ोगकि/ा तथा प्रशोधन आदिबाट पनि खाद्यान्न बढी नोक्सान भएको पाइन्छ . यसबाट के प्रष्ट हुन्छ भने फाप/ बाली मानिसहरुले जा.*/क्सी / पशु आहा/मा पनि खर्च गर्ने हु.दा यस वाली तर्फ अनुसन्धानबाट केही यस्ता नया. जातहरु आउन सकोस / स्थानीय जातहरुले हाल दिई /हेको उत्पादनलाई विस्थापित ग/ी कृषकहरुको मन जित्न सकोस जसले गर्दा फाप/को क्षेत्रफलमा समेत वृद्धि भै खाद्यान्न समस्या जिल्लाको केही हदसम्म टर्न सक्ने छ .

तालिका ३+ जिल्लाको मौसमी विव/ण ¶

Parameter	Rep time	Jan	Feb	Mar	Apr	May	Jun	Aug	Sept	Oct	Nov	Dec
Maximum	-	10.3	16.6	17.4	21.2	21.1	21.5	22.2	21.8	21.2	17.8	14.9
Minimum	-	-1.9	2.2	3.5	6.4	10.1	12.0	14.4	13.7	12.3	6.6	-2.5
Rainfall	-	10.4	1.8	3.0	6.8	8.8	00.0	54.2	28	22.4	19.8	0.0
Relative, %	08.45	58	41	41	35	56	64	76	65	72	57	48
Humidity, %	17.45	69	64	64	73	62	77	68	70	69	74	65

श्रोत।- जि+कृ+वि+का+ को आ+ब+ ०५६.०५७ मा प्रकाशित वार्षिक पुस्तिका .

¶ July को विव/ण नभएको . Rep, reporting.

माथि देखाईएको मौसमी विव/णबाट के स्पष्ट हुन्छ भने स/द/ वार्षिक १५५ मि+मि+ वर्षा हुने तथा सापेक्षित आद्रता न्यून / तापक्रम ज्यादै कम हुने स्थानहरुमा पनि वाली लगाउने समयको चा.जोपा.जो मिलाउन सकेको खण*मा अत्यधिक उत्पादन लिन सकिने /हेछ भन्ने देखाउ.छ .

बाली पात्रो

मुस्ता*०ग जिल्ला एक हिमाल पा/ीको जिल्ला हो / यहा.को अधिका.श क्षेत्रफल हिम क्षेत्र भित्र पर्दछ . यसै का/ण यस जिल्लामा बाली लगाउने, काट्ने समय देशका अन्य

जिल्लाहरुमा भन्दा भिन्न पाइन्छ . जुन कु/ा तालिका ४ बाट स्पष्ट थाहा पाउन सकिन्छ .

तालिका ४+ बाली पात्रो

बाली	लगाउने समय	बाली काट्ने समय	कैफियत
गहु., उवा, जौ	कार्तिक - मार्ग	ज्येष्ठ - आषाढ	छुक्सा*०ग देखि तलका १०
फाप/	आषाढ	आश्विन	गा+वि+स+ हरुमा
आलु	माघ - फाल्गुण	आषाढ - श्रावण	
गहु., उवा, के/ाउ	चैत्र - बैशाख	भाद्र - आश्विन	छुक्सा*०ग देखि माथि
फाप/, तो/ी	बैशाख - ज्येष्ठ	,, ,,	उत्त/का ६ गा+वि+स+
ऋालु	,, ,,	,, ,,	,, ,,
एवा	फाल्गुण	आषाढ	ढी, ता*०ग्या, सुर्खा*०ग
फाप/	आषाढ	आश्विन	

श्रोत ।- जि+कृ+वि+का+ मुस्ता*०ग .

बाली चक्र -Cropping Pattern

मुस्ता*०गमा विभिन्न गा+वि+स+मा विभिन्न वाली चक्रहरु अपनाइन्छ .

१+ फाप/ - खाली	छोसे/, लोमान्था*०ग, छोन्धुप, च/ा*०ग, घमी
२+ फाप/ / तो/ी-खाली	,, ,, ,, ,,
३+ गहु / उवा / के/ाउ - खाली	,, ,, सुर्खा*०, या/ा, घा/ा
४+ गहु. - खाली	,, ,, मुक्तिनाथ, घमी
५+ उवा / जौ / मकै सिमी	जोमसोम देखि तलका गा+वि+स+ हरु
६+ जौ. / गहु. - मकै	कोबा*०ग, कुन्जो
७+ फाप/ - खाली - आलु	छुक्सा*० देखि तलका गा+वि+स+ हरु
८+ जौ / गहु / उवा / आलु - फाप/	,, ,, ,,

जातहरु -Varieties

मुस्ता*०ग जिल्लामा हाल सम्म खेती भै/हेको जातहरुमा स्थानीय मिठे फाप/ / तिते फाप/ नै हुन . अन्य उन्नत जातहरु अनुसन्धानबाट निस्किएको पाइएको छैन . आ+ब+ ०५२.५३ मा पहा॰ी अनुसन्धान वाली विकास आयोजना काभ्रेमा कार्य/त जापानीबाट मुस्ता*०ग जिल्लाको ठिनी गाउ..मा पि/क्षणको लागि जापानी जातको भाते फाप/ लगाईएको /हेछ त/ उक्त जात छिटो पाक्ने, होचो, दाना ठूलो, पिठो नपर्ने भएको का/ण मन नप/ाएको कु/ा स्थानीय कृषकहरु बताउ.छन् . आ+ब+ ०५७.५८ मा मार्फा गा+वि+स+का अध्यक्ष श्री धन बहादु/ पन्नाचनले क/िब एक /ोपनीमा जापानी जातको फाप/को वीउ जापानबाट झिकाई लगाउनु भएको थियो . उक्त जातको फाप/ स्थानीय भन्दा होचो क/िब २०-३० दिन अगा॰ि पाक्ने, फूल स्थानीय भन्दा बग्लै -सेतों, फल /ाम्रो

नै देखिएको दाना स्थानीय भन्दा अति ठूलो छ भने त्यसको उत्पादन आउन बा.की छ . कृषकहरुको भनाईमा यदि सबैले नै लगाउने भएमा मात्र ठीक हुने अन्यथा चा.*ो पाक्ने हु.दा च/ा, मुसा आदिले खाई बढी नोक्सान हुने कु/ा बताउ.छन .

/ोग कि/ाको समस्या

फाप/मा खासै /ोगको समस्या देखिएको छैन त/ कि/ाहरुको समस्या भने सालवसाली बढदै गएको पाईको छ . खुम्रे, थ्रिप्स / फौजी कि/ाले प्रमुख रुपमा हानी पु-याएको पाइन्छ .

समाधान

फौजी कि/ाले सालबसाली नै दुाख दिने हु.दा कृषकहरुले साइप/मेथ्रिन, सुमिसिि*न, नुमाईट जस्ता बिषादि स्प्रे गा/ बालीलाई जोगाएको पाइन्छ . यसमा जि+कृ+वि+ कार्यालय मुस्ता*ञगले बिषादि पोख/ाबाट जोमसोम सम्म झिकाई शत प्रतिशत ढुवानी छुट दिई कृषकहरुलाई विषादि उपलव्ध ग/ाउ.दै आई/हेको छ .

सुझावहरु

- मुस्ता*ञग लगायत अन्य हिमाली जिल्लाहरुको प्रमुख खाद्यान्नको श्रोत फाप/ भएकोले नया. जातहरुको खोजी अनुसन्धान केन्द्र बाट हुनु पर्ने .
- विषादिको अत्यधिक प्रयोग हुने हु.दा वाताव/ण प्रदुषण भै जनमानसमा प्रतिकूल अस/ पर्ने हु.दा एकिकृत शत्रु जीव व्यवस्थापन कार्यक्रम स.चालनमा जो* दिनु पर्ने .

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Cyme, flower cluster and seed setting dynamics on buckwheat and their relation to grain yield

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Abstract

Grain yield of buckwheat is very low at farm level. Common buckwheat (*Fagopyrum esculentum* Moench.) was evaluated during winter season of 2000-2001 at Rampur in the rice based cropping system under Chitwan conditions. Studies were undertaken to determine the effect of organic matter, nitrogen, weed control and irrigation on cyme, flower cluster and seed setting dynamics and their relation to grain yield. The experiment was carried out in a RCBD with four replications consisting of fourteen management levels. The number of cyme, flower cluster, seed setting and grain yield was higher in the treatment receiving high management as compared to treatment receiving only farm yard manure (FYM). The similar trend was observed on main stem, first, second and third branches. The number of cyme and flower cluster was highest on second branch followed by main stem, third and first branches. But the highest number of seed setting was observed on main stem followed by second, third and first branches. The grain yield was highest (1495 kg ha^{-1}) in the treatment having 5 t FYM + 40 kg N ha^{-1} + 2 irrigation + weeding. The yield obtained with the application of 40 kg N ha^{-1} was statistically higher than the treatment receiving no chemical fertilizer and FYM only but at par with all other treatments except highest yielding treatment. Generally the high management practices enhanced the growth of reproductive parts resulted in the increment of grain yield of buckwheat.

Key words: cyme, flower cluster, grain yield, management, seeds setting

Introduction

Buckwheat (*Fagopyrum esculentum* Moench.) is one of the minor pseudo cereal crops, which occupies an important place in Nepalese farming system. It occupies significant part of the staple diet in Russia, Japan, China and mountainous regions of India (Koirala, 1995). It is staple and life-supporting crop in high altitude regions of Nepal since ancient times and used for various purposes such as feed, fodder, vegetable, weed control, medicinal herbs, green manure, honey crop, dye etc. In Nepal buckwheat is a major summer crop of higher elevation (above 2000 masl) whereas it is autumn and spring crop of mid hills but it is winter crop of Chitwan. The average yield of buckwheat in Nepal is as low as 540 kg ha^{-1}which is two to five times lower than USSR, Canada and Japan (Rajbhandari and Mishra, 1989). The common yield level of common buckwheat in the USSR is being as high as 2500 to 3000 kg ha^{-1} (Yakimanko, 1982). Bhandari e*t* al. (1993) reported that the yield stability of buckwheat is a major problem in Chitwan and its yield fluctuation ranges from 300-1875 kg ha^{-1}. The factors responsible for poor yield are strong wind during flowering, poor pollination and fertilization, shattering of grains and other unknown factors. Buckwheat yield is less than the cereal because of its short growing season, poor response to N fertilizer, low inputs and management, inadequate irrigation, poor soil fertility and lack of improved varieties.

At national level with respect to buckwheat improvement in Nepal, priority has been given to the germplasm collection and characterization though some agronomic work has been initiated in recent years (Baniya, 1989). Although some of the researches have been carried out by the Hill Agriculture Research Program, Kabre but its findings may not be representative for whole agro-ecological zones of the country. Thus maximum productivity per unit area as well as horizontal area expansion is hindered due to insufficient package of practices. As a result farmers are reluctant to adopt and continue it in their cropping system on commercial basis.

Farmers of Nepal are changing their cropping pattern giving high priority to short duration crop at low production cost. Market price of buckwheat is comparatively higher than the other winter cereals and thus has great potential for export. The area under this crop could be expanded if farmers are confident for maximum productivity per unit area through improved technology. The objective therefore, is to determine the effect of nitrogen, organic matter, weed control and irrigation on cyme, flower cluster production, seed setting dynamics and yield of buckwheat.

Materials and methods

The experiment was conducted at Agronomy Research Farm of Institute of Agriculture and Animal Science, Rampur, Chitwan during winter, 2000-2001. The soil of the experimental plot was sandy loam with pH 5.35, organic matter 3.07%, total nitrogen 0.15%, available phosphorus 32.80 kg ha^{-1} and available potassium 114.65 kg ha^{-1} at 0-10 cm soil depth. The cropping pattern was rice in the rainy season followed by wheat in winter season. The experiment was laid out in a Randomized Complete Block Design consisting of fourteen treatment combinations with four replications. Individual plot size comprised of 4- × 3-m. Plants were spaced at 25 cm between rows and continuous spacing between the plants. The combination of treatments is given in Table 1.The well-decomposed farm yard manure (FYM) and full dose of N, P and K were applied before sowing as per the treatments. The seeds were sown in lines for improve management practices while broadcasting was done in farmers' practice. Sowing was done on 20 Nov 2000. Hand weeding was practiced at 35 days after sowing in weeding treatment plots. The first irrigation at 36 days after sowing was done by supplying 120 liters of water per plot to cover one-cm soil depth. Similarly, the second irrigation was given at 56 days after sowing by supplying 240 liters of water per plot to cover 2 cm soil depth as per requirement of treatments. The crop was harvested from the net plot (4.5 m^2) of central 6 rows leaving 3 rows from both sides and 50 cm from 4 m long row. The number of cyme, flower cluster and seed setting on main stem, first, second and third branches were counted during 75 days after sowing. The whole measurements were carried out from randomly selected five plants of second row of each plot.

Table 1. Treatments structure

Treatment No.	Treatment combination†
1	Farmers practice (broadcasting without fertilizer
2	Line sowing without fertilizer
3	Farm yard manure (FYM)
4	20: 40: 20 kg N, P and K ha^{-1}
5	40: 40: 20 kg N, P and K ha^{-1}
6	60: 40: 20 kg N, P and K ha^{-1}
7	FYM + 40: 40: 20 kg N, P and K ha^{-1}
8	FYM + 20: 40: 20 kg N, P and K ha^{-1}
9	FYM + 40: 40: 20 kg N, P and K ha^{-1} +Weeding
10	40: 40: 20 kg N, P and K ha^{-1}+ Weeding
11	40: 40: 20 kg N, P and K ha^{-1} + Single irrigation
12	40: 40: 20 kg N, P and K ha^{-1}+ Single irrigation + Weeding
13	FYM + 40: 40: 20 kg N, P and K ha^{-1}+ Single irrigation + Weeding
14	FYM + 40: 40: 20 kg N, P and K ha^{-1}+ Two irrigation + Weeding

† FYM @ 5 t ha^{-1} was used.

Results and discussion

The plot, which received only 5 t FYM ha^{-1} had similar number of reproductive parts (cyme, flower cluster and seed) as in farmers' practice (Fig. 1, 2 and 3). This shows that only 5 t FYM ha^{-1} was not sufficient to enhance the reproductive growth. Among the nitrogen fertilizers, 20 kg N ha^{-1} applied plot had comparatively less influenced on reproductive growth than 40 kg N ha^{-1} and 60 kg N ha^{-1} in which the number of cyme and flower cluster were statistically similar. The number of seed produced with the application of 20 kg N $ha^{-1}$was similar to 40 kg N ha^{-1} and 60 kg N ha^{-1}. The treatment containing 5 t FYM + 20 kg N ha^{-1} was not better than the plot where only 20 kg N ha^{-1} was applied in terms of cyme and flower cluster production. Similarly, the plot which received 5 t FYM + 40 kg N ha^{-1} and plots having only 40 kg N ha^{-1} had similar number of cyme, flower cluster and seed. Thus 5 t FYM had no advantages over 40 kg N ha^{-1}. The effect of irrigation and weeding + irrigation did not show significant difference with respect to reproductive growth on main stem, first, second and third branches even it was similar to 40 kg N ha^{-1}. The highest number of seed setting was observed in main stem followed by second, third and first branches while the number of cyme and flower cluster was the highest in second branch followed by main stem, third, and first branches but the number of cyme and flower cluster production on the main stem, first, second and third branches were not significantly different (Fig. 4). Yang et al. (1995) reported that phosphorus absorption was the highest in the main stem followed by third, second and third branches.

The application of 5 t FYM ha^{-1} had similar yield as in farmers' practices where no fertilizer was applied (Fig. 5). The lowest yield in this plot was probably because of low quantity of FYM applied in the experimental plot. There was lower number of seed setting in the FYM applied plot as compared to other better managed plots. Feng et al. (1989) reported that for getting more than one ton yield of buckwheat per ha requires 15 t manure plus 67.5 kg N and 22.5 kg P along with other optimum production management practices. Similarly, Horiuchi et al. (1995) also obtained least crop yield on sole FYM as compared to chemical fertilizers and chemical fertilizers in combination with FYM.

The application of 20 kg N ha^{-1} gave significantly lower yield than 40 kg N ha^{-1} and 60 kg N ha^{-1}. It seems that 20 kg N ha^{-1} was not optimum to get the desired yield of buckwheat. The yield was similar between 40 kg N ha^{-1} and 60 kg N ha^{-1}. Thus it can be interpreted that 40 kg N ha^{-1} was better for achieving the economic yield of buckwheat .The yield obtained from FYM + 20 kg N ha^{-1} was not better than the plot where only 20 kg N ha^{-1} was applied. So 5 t FYM + 20 kg N ha^{-1} was not even good for getting higher yield of buckwheat equal to 40 kg N ha^{-1}. It was observed that number of cyme, flower cluster and seed setting per plant was lower in the plot applied with 20 kg N ha^{-1} and even in the plot having FYM + 20 kg N ha^{-1} as compared to the plots receiving 40 kg N ha^{-1}. Saini and Negi (1988) reported that the application of nitrogen fertilizer increased the yield significantly up to 40 kg N ha^{-1} and there was no differences in yield between 40 kg N ha^{-1} and 60 kg N ha^{-1}.

The plots which received FYM + 40 kg N ha^{-1} and the plots with only 40 kg N ha^{-1} had similar yield. Thus FYM had no advantages over 40 kg N ha^{-1}. Moreover, FYM would maintain physical, chemical and biological properties in the long run. The higher yield in 40 kg N ha^{-1} is because of higher number cyme, flower cluster and seed setting per plant as compared to FYM + 40 kg N ha^{-1}. Lin and Tao (1999) also reported that application of nitrogen increased buckwheat yield several times but overdose of N decreased grain yield due to excess vegetative growth and lodging of the crop.

The treatment containing FYM + 40 kg N ha^{-1} + single irrigation + weeding gave higher yield than 40 kg N ha^{-1} + single irrigation. Thus it showed that effect of irrigation was better only when it was combined with weeding. It was also evident from the facts that yield obtained by the application of 40 kg N ha^{-1} and 40 kg N ha^{-1} + irrigation were the same. The plots received 40 kg N ha^{-1} + weeding produced more grain yield (1323 kg ha^{-1}) than plot which received 40 kg N ha^{-1} + irrigation (1269.5 kg ha^{-1}) though they were at par with each other. It was also evident from cyme, flower cluster and seed setting per plant.

When two irrigation were applied one at 36 days after seeding (DAS) and the another at 56 DAS along with FYM + 40 kg N ha^{-1} + weeding produced significantly higher yield (1495 kg ha^{-1}) than 40 kg N ha^{-1}, 60 kg N ha^{-1}, FYM + 40 kg N ha^{-1} but it was similar to FYM + 40 kg N ha^{-1} + weeding, 40 kg N ha^{-1} + weeding, 40 kg N ha^{-1} + irrigation + weeding and FYM + 40 kg N ha^{-1} + irrigation + weeding. Thus, it seems that weeding and second irrigation was more important for improving yield of buckwheat. This was evident from cyme, flower cluster and seed setting per plant in the highest yielding treatment. Lakhanov (1995) reported that the maximum water was required during generative period in which one-gram dry matter of seed consumed 250 to 450 g of water as compared to 200 to 250 g water for one gram of dry matter during vegetative period.

Conclusions

It should be concluded from the experiment that the highest yield (1495 kg ha^{-1}) was obtained with the application of 5 t FYM ha^{-1} + 40 kg N ha^{-1} + 2 irrigation + weeding in which the number of cyme, flower cluster and seed setting was higher than in farmers practice and FYM only. The use of only FYM 5 t ha^{-1}showed no significant effect while weeding had positive effect in combination with irrigation on reproductive growth and yield of buckwheat. The highest management practices as specified in the experiment is not possible so at least 40: 40:20 kg N, P and K ha^{-1} should be applied to enhance the reproductive growth which influenced the maximum yield of buckwheat under minimum management.

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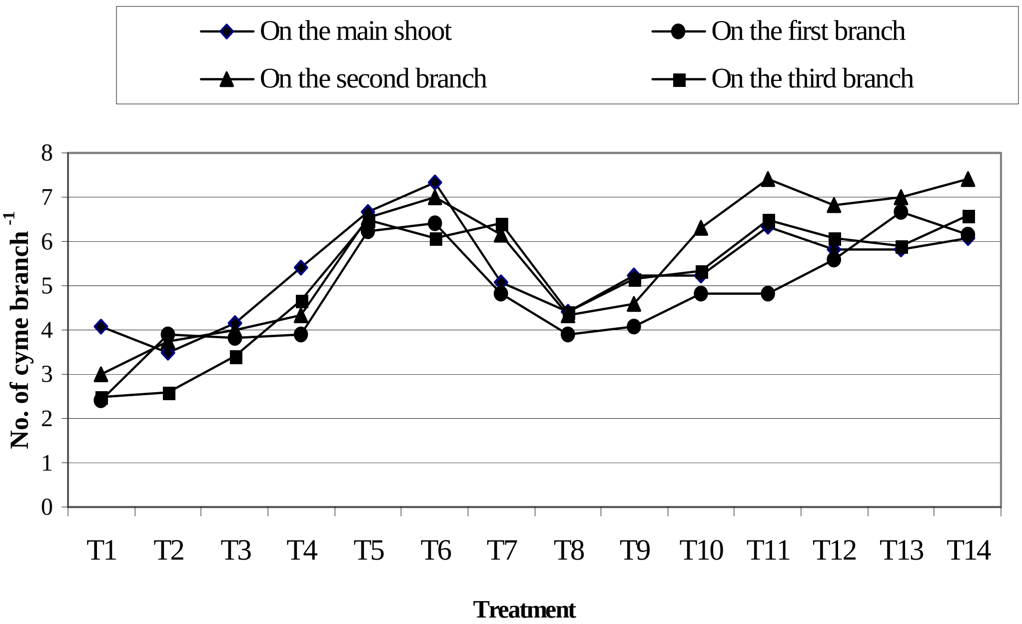

Fig. 1. Cyme dynamics on buckwheat.

T1 = Broadcast no$_{fert}$, T2 = Line sown no$_{fert}$, T3 = FYM, T4 = 20 kg N ha^{-1}, T5 = 40 kg N ha^{-1}, T6 = 60 kg N ha^{-1}, T7 = FYM + 40 kg N ha^{-1}, T8 = FYM + 20 kg N ha^{-1}, T9 = FYM + 40 kg N ha^{-1} + Weeding, T10 = 40 kg N ha^{-1} + Weeding, T11= 40 kg N ha^{-1} + Irrigation, T12= 40 kg N ha^{-1} + Irrigation + Weeding, T13 = FYM + 40 kg N ha^{-1} + Irrigation + Weeding, T14 = FYM + 40 kg N ha^{-1} + 2 Irrigation + Weeding

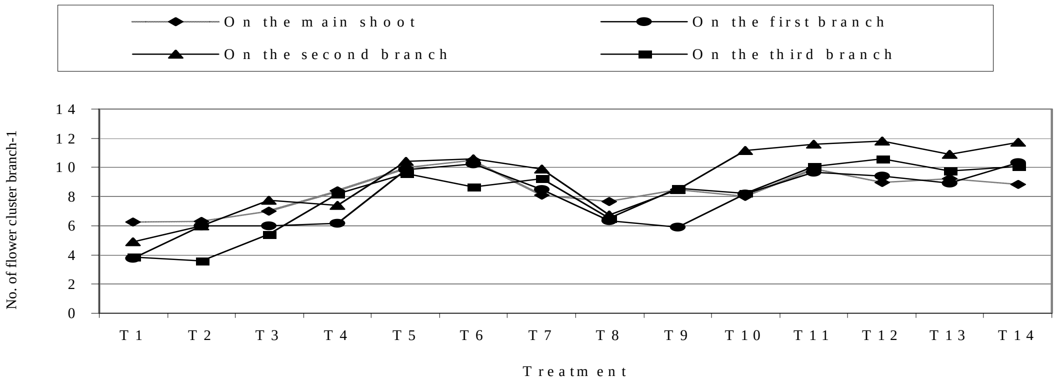

Fig. 2. Flower cluster dynamics on buckwheat.

T1 = Broadcast no$_{fert}$, T2 = Line sown no$_{fert}$, T3 = FYM, T4 = 20 kg N ha^{-1}, T5 = 40 kg N ha^{-1}, T6 = 60 kg N ha^{-1}, T7 = FYM + 40 kg N ha^{-1}, T8 = FYM + 20 kg N ha^{-1}, T9 = FYM + 40 kg N ha^{-1} + Weeding, T10 = 40 kg N ha^{-1} + Weeding, T11 = 40 kg N ha^{-1} + Irrigation, T12 = 40 kg N ha^{-1} + Irrigation + Weeding, T13 = FYM + 40 kg N ha^{-1} + Irrigation + Weeding, T14 = FYM + 40 kg N ha^{-1} + 2 Irrigation + Weeding

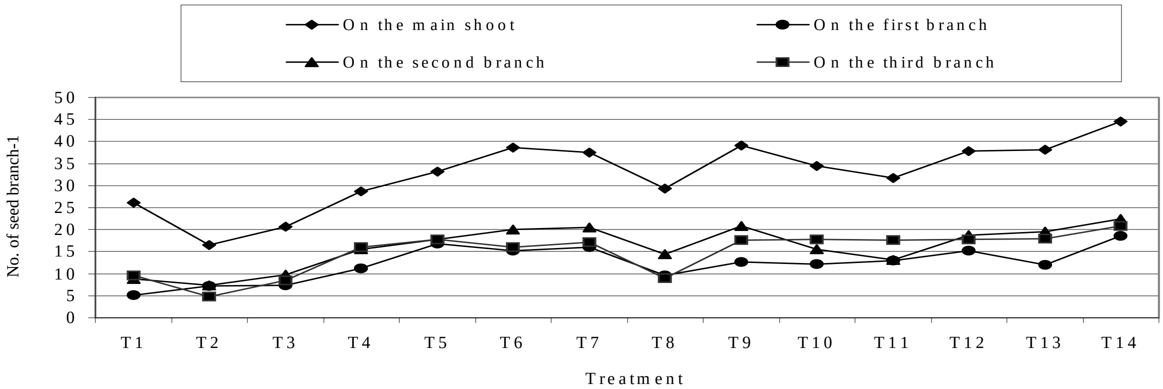

Fig. 3. Seed setting dynamics on buckwheat.

T1 = Broadcast no$_{fert}$, T2 = Line sown no$_{fert}$, T3 = FYM, T4 = 20 kg N ha^{-1}, T5 = 40 kg N ha^{-1}, T6 = 60 kg N ha^{-1}, T7 = FYM + 40 kg N ha^{-1}, T8 = FYM + 20 kg N ha^{-1}, T9= FYM + 40 kg N ha^{-1} + Weeding, T10 = 40 kg N ha^{-1} + Weeding, T11 = 40 kg N ha^{-1} + Irrigation, T12 = 40 kg N ha^{-1} + Irrigation + Weeding, T13 = FYM + 40 kg N ha^{-1} + Irrigation + Weeding, T14 = FYM + 40 kg N ha^{-1} + 2 Irrigation + Weeding

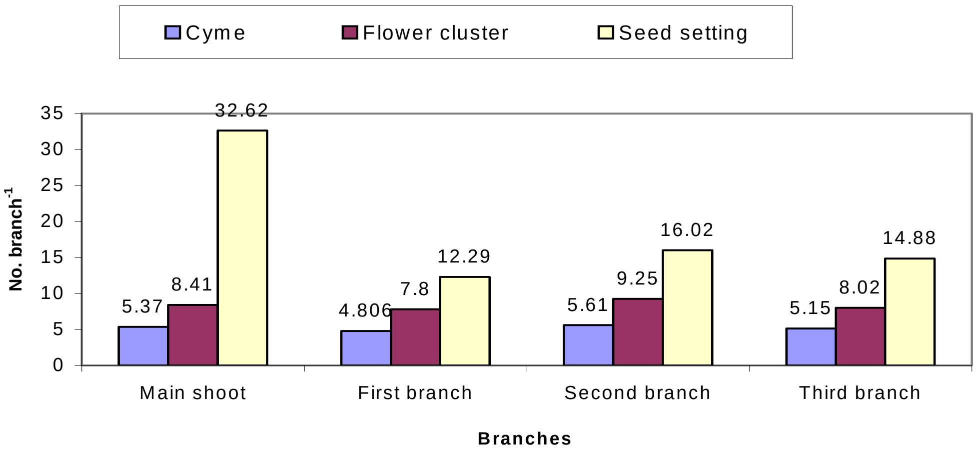

Fig. 4. Cyme, flower cluster and seed setting dynamics on buckwheat.

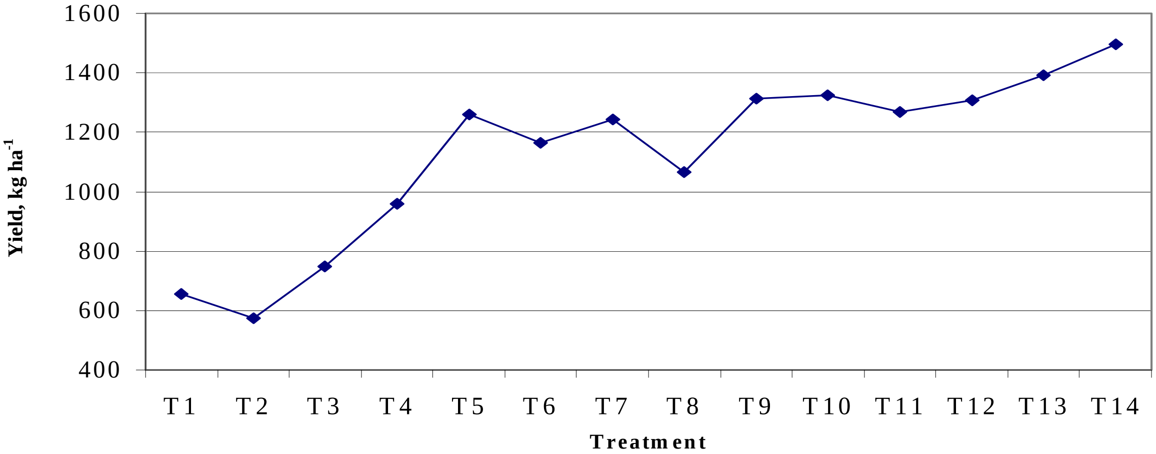

Fig. 5. Effect of different management practices on grain yield of buckwheat.

T1 = Broadcast no_{fert}, T2 = Line sown no_{fert}, T3 = FYM, T4 = 20 kg N ha^{-1}, T5 = 40 kg N ha^{-1}, T6 = 60 kg N ha^{-1}, T7 = FYM + 40 kg N ha^{-1}, T8 = FYM + 20 kg N ha^{-1}, T9 = FYM + 40 kg N ha^{-1} + Weeding, T10 = 40 kg N ha^{-1} + Weeding, T11 = 40 kg N ha^{-1} + Irrigation, T12 = 40 kg N ha^{-1} + Irrigation + Weeding, T13 = FYM + 40 kg N ha^{-1} + Irrigation + Weeding, T14 = FYM + 40 kg N ha^{-1} + 2 Irrigation + Weeding

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Effect of ABT-4 rooting powder on seed germination, seedling growth, chlorophyll content and yield parameters in buckwheat (*Fagopyrum esculentum*)

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Abstract

Buckwheat (*Fagopyrum esculentum* Moench.) is a pseudo cereal and traditional food crop in different parts of the world. It is endemic crop of China and cultivated in mountainous regions of Central and Western China. In Nepal cultivation of buckwheat is limited to hills because the hilly people have no other choice except maize, potato, amaranth, barley and finger millet. Buckwheat is inter-cropped with potato and also grown as a sole crop in hilly areas of Nepal. ABT-4 rooting powder, a new type of growth regulator has been used in the present investigation. ABT-4 rooting powder 5, 10, 15 and 20 ppm solutions were prepared as per the method of Wang, 1993. Healthy seeds of buckwheat were soaked and sown in earthen pots and fields. Concentration of 5, 10 and 15 ppm of ABT-4 rooting powder significantly increased percentage of seed germination, seedling growth (root and shoot length, seedling weight), chlorophyll contents (chlorophyll a, b and total chlorophyll) and yield parameters. ABT-4 of 15 ppm showed the most significant effect on all the parameters studied, however, 20 ppm ABT-4 rooting powder showed inhibitory effect on all parameters.

Key words: ABT-4, chlorophyll, growth regulator, germination, yield

Introduction

Buckwheat (*Fagopyrum esculentum*) is a unique traditional food crop in different parts of the world. This globally neglected pseudo cereal has been used for different purposes and has many features that are distinct from other crops. It is a part of stable diet in some part of China, Japan, Russia, Ukraine, Belorussia and hilly regions of India and Nepal and also some other countries of temperate zone of the world. It is cultivated in mountainous regions of central and western China (Vavilov, 1926). In Nepal buckwheat is cultivated in hilly regions since people have no other choice except maize, potato, amaranth, barley and finger millet to grow in their fields. Buckwheat is short duration crop, which matures within 60 to 90 days. It can be grown easily in low level of nutrients usually grown on the residual fertilizers from the previous crops. Weeding is not necessary due to broad leaves and fast growing plant. It covers weeds during its growth. Buckwheat has importance in terms of its adaptation, suitability to different cropping patterns and high nutritional value.

Recently, there has been a global realization of the increasingly important role of PGR in agriculture, horticulture and forestry for better growth of crops and their yield. ABT is a versatile plant growth regulator (PGR) recently developed by Wang (1993). There is a series of ABT, ABT-1 to ABT-9 having different functions ABT-4 is used for seed germination, seedling growth and crop yield in various crops. Prasad et al. (1997) reported significant effect of ABT-4 on broad bean and buckwheat. In the present investigation ABT-4 has been used for seed germination, seedling growth, chlorophyll content and yield parameters in buckwheat.

Materials and methods

The seeds of buckwheat (*Fagopyrum esculentum)* ecotype 9192 and 90151 were kindly provided by Buckwheat Research Project, Research Council for Applied Science and Technology (RECAST), Tribhuvan University. ABT rooting powder-4 was kindly provided by Professor Wang Tao, Director, ABT Research and Development Center the Chinese Academy of Forestry, Beijing, China and chemicals were provided by Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu. ABT rooting powder-4 was dissolved in 50 ml of 95% ethanol and solution was made 100 ml by adding distilled water. The solution was diluted separately to 5, 10, 15 and 20 ppm. The healthy seeds of *Fagopyrum esculentum* type 9192 a indeterminate and 90151 a determinate common type were selected and kept in doubled layer filter paper in petri dishes for seed germination in incubator at 30^0C. The seed germination and seedling growth in control and treated with ABT rooting powder-4 was recorded at different time period. The seeds of buckwheat of both ecotypes were selected and were soaked in 5, 10, 15 and 20 ppm ABT-4 for 6 h whereas for control set the seeds were soaked in same amount of distilled water and sown in earthen pots (locally known as *gamala*) and kept in natural sun light. For Cholorophyll contents the leaves from treated and control sets were harvested on day 10, 17, 24 and 31 after germination, Chlorophyll-a, Chlorophyll-b and total cholorophyll was estimated using Spectronic -20 Spectrophotometer using the method of Arnon (1949). For the yield parameters the seeds of both types were soaked in 5, 10, 15 and 20 ppm ABT-4 to 6 h and were sown in 2- × 2-m experimental plots, the seeds for control set were soaked in same amount of distilled water for 6 h and were sown in experimental plots. The plants from treated and control plots were harvested after well maturation for yield parameters viz. dry weight of plant, number of leaves and yields of grains plant^{-1}.

Results and discussion

Seed germination was recorded in treated and control sets at 24, 48 and 72 h from the incubator fixed at 30^oC. Treatment with 5 and 15 ppm ABT-4 increased the rate of seed germination significantly in both cultivars 9192 and 90151. Treatment with 15 ppm showed most significant result, which increased seed germination up to 25% (Table 1). On the other hand, ABT-4 with 20 ppm showed inhibitory effect on seed germination at different hours (Table 1). Prasad (2001) found similar result of ABT-4 on seed germination in some legumes.

Table 1. Effect of ATB-4 rooting powder on seed germination in buckwheat

Ecotype	ABT, ppm	Rate of germination, %		
		24 h	48 h	72 h
9192	0	40.0	60.0	80.0
	5	45.0	68.0	90.0
	10	50.0	74.0	97.0
	15	52.0	78.0	100
	20	35.0	52.0	68.0
90151	0	37.0	56.0	74.0
	5	42.0	62.0	80.0
	10	44.0	69.0	88.0
	15	47.0	75.0	96.0
	20	33.0	51.0	68.0

Seedling growth, root and shoot length in treated and control plants was recorded on day 3, 6 and 9 after germination. Treatment with 5, 10 and 15 ppm ABT-4 showed stimulatory effect on root and shoot length in both ecotypes of buckwheat. However 15 ppm ABT showed most significant result on root and shoot length of the seedlings on days 3, 6 and 9 which ranged between 12 to 18%, however 20 ppm ABT showed inhibitory effect on root and shoot length in both ecotype of buckwheat (Table 2). Prasad et al. (1997) found similar results on seed germination and seedling growth in broad bean. Chlorophyll a, b and total chlorophyll contents were estimated from the leaf samples of both ecotypes on day 10, 17, 24 and 31 after germination using Spectronic-20 by the method of Arnon (1949). The amount of chlorophyll expressed as mg g-^{1} fresh weight of leaf tissue following the formula.

Table 2. Effect of ATB-4 rooting powder on shoot and root length of seedling in buckwheat

Ecotype	ABT, ppm	Length of root and shoot at different days after germination, cm					
		3 day		6 day		9 day	
		Root	Shoot	Root	Shoot	Root	Shoot
9192	0	3.5	1.7	5.0	4.8	6.0	7.8
	5	4.0	2.2	5.4	5.3	6.4	8.4
	10	4.4	2.6	5.8	5.7	6.8	8.8
	15	4.8	2.8	6.0	5.8	7.2	9.2
	20	3.0	1.4	4.5	4.3	5.5	7.2
90151	0	3.2	1.5	4.4	4.2	5.8	7.5
	5	3.6	1.8	4.8	4.6	6.2	7.8
	10	4.0	2.3	5.3	4.9	6.6	8.4
	15	4.4	2.5	5.6	5.2	6.8	8.6
	20	2.8	1.2	4.1	4.0	5.4	7.1

Chlorophyll a: mg g^{-1} leaf tissue = [12.7 (D663)-2.69 (D 645)] × V/1000 ×W
Chlorophyll b: mg g^{-1} leaf tissue = [22.9 (D 645)-4.68 (D 663)] ×V/1000 ×W
Total chlorophyll: mg g^{-1} leaf tissue = D 652 ×1000/34.5 ×V/1000 ×W

In the above equation D represents the optical density, V represents the volume of acetone used and W is the fresh weight of leaf samples of the plants. Treatment with 5, 10 and 15 ppm ABT significantly increased chlorophyll contents (chlorophyll a and b between 10 to 15% on day 10, 17, 24 and 31 after germination), however, 20 ppm ABT showed inhibitory effect on chlorophyll contents (Table 3).

Table 3. Effect of ABT-4 rooting powder on cholorophyll contents (the data are mean of 3 replicates expressed as mg g^{-1} fresh weight of leaf sample of buckwheat)†

Ecotype	Days after germ.	Concentration of ABT-4 rooting powder									
		0 ppm		5 ppm		10 ppm		15 ppm		20 ppm	
		chl a	chl b	chl a	chl b	chl a	chl b	chl a	Chl b	chl a	chl b
9192	10	6.1	3.2	7.6	3.6	7.2	3.8	7.4	3.9	5.6	2.9
	17	7.2	4.3	8.1	4.8	8.4	5.1	8.7	5.3	6.5	3.8
	24	7.8	4.7	8.9	5.0	9.3	5.3	9.6	5.6	7.0	4.4
	31	6.5	3.6	7.6	3.9	7.9	4.2	8.1	4.5	8.1	3.3
90151	10	6.3	3.4	7.4	3.6	7.6	3.8	7.8	3.9	5.8	3.0
	17	7.5	4.5	8.5	4.8	8.8	5.0	9.0	5.3	6.7	4.1
	24	8.0	4.9	9.2	5.2	9.6	5.5	9.9	5.7	7.2	4.6
	31	6.6	3.8	7.9	4.2	8.3	4.5	8.6	4.7	6.0	3.5

† chl a = chlorophyll a, chl b = chlorophyll b, germ = germination.

The yield parameters in both ecotypes viz. dry weight per plant, number of leaves per plant and grain weight per plant were significantly increased with 5, 10 and 15 ppm of ABT (Table 4). On the other hand 20 ppm ABT showed adverse effect on the yield parameters of both ecotype of buckwheat (Table 4). Paudel (1995) reported similar effect of ABT on the yield parameters of buckwheat. Prasad (2001) reported that ABT-4 has significantly increased nodulation, nitrate reductase activity and crop yield in soybean, broad bean, pea and black gram.

Table 4. Effect of ABT-4 rooting powder on yield parameter of buckwheat (mean of 10 plants ± SD of 3 replicates)

Ecotype	ABT, ppm	Dry wt plant^{-1}, g	Leaves no. plant^{-1}	Grain yield plant^{-1}, g
9192	0	10.20±0.80	16.00±1.20	10.00±0.80
	5	12.40±1.00	17.40±1.50	11.00±0.85
	10	13.20 ±1.10	19.20±1.80	12.00±0.90
	15	14.00 ±1.12	22.00±1.90	12.50±1.00
	20	9.10 ±0.75	14.00±1.10	9.00±0.70
90151	0	10.30 ±0.80	16.20±1.20	10.20±0.80
	5	12.50 ±1.00	1760±1.50	11.30±0.85
	10	13.30 ±1.10	19.30±1.90	12.40±0.90
	15	14.20± 1.12	22.40±1.95	12.60±1.10
	20	9.20± 0.75	14.20±1.10	9.20±0.75

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Growth hormone enhanced cation mobilization in common buckwheat (*Fagopyrum esculentum* Moench.)

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Abstract

The study was carried out on the germinating seeds of buckwheat *(Fagopyrum esculentum* Moench.) at $\pm$ 25°C for a period of 48, 72 and 96 hrs to analyze the hormonal effects. The distribution pattern of Mg, Fe, Mn, Zn and Cu were analyzed separately. The mineral contents in buckwheat seeds were found in decreasing sequence as Mg > Fe > Mn > Zn > Cu. There is relatively larger amount of stored minerals in seeds, which were found translocated to the epicotyle during early periods of the germination. Growth promoters significantly affected normal pattern of mineral mobilization during germination. The growth promoters either increased or decreased the magnitude of translocation in both epicotyle and radicle regions. Most of the minerals were found to be mobilized towards the coleoptile than the radicle in effects of GA_3 and kinetin. GA_3 was found more active than kinetin for cation mobilization in the germinating seeds.

Key words: cation, germinating seed, growth hormone, minerals

Introduction

Buckwheat (*Fagopyrum esculentum* Moench.) is one of the cereal food crops, which is cultivated from low land to temperate regions of Nepal. In Nepal, buckwheat is unexploited crop (Baniya, 1990). They are generally cultivated in marginal land and less fertile soil conditions. Among four species of buckwheat *F. esculentum* and *F. tataricum* are cultivated species while *F. cymosum* and *F. megacarpum* remained in their wild state (Rajbhandari and Hatley, 1996). The *F. esculentum* is a herbaceous erect annual with diploid chromosome number (2n = 16). The cultivated species *F. esculentum* is known as common buckwheat or *mithephapar* in Nepali due to its palatable flavour where as *F. tataricum* is known as *titephapar* for its bitterness. Buckwheat has importance for its carbohydrate and protein value as well as for its richness in important dietary minerals like zinc, copper, magnesium, manganese and iron. Owing to rutin content, buckwheat is used for the people with cardiovascular disorders.

Studies on cation mobilization in Nepali common buckwheat are lacking. The present investigation was therefore conducted to know the distribution pattern of some major cations (Fe, Mg, Mn, Zn, Cu) in different organs during seed germination and to identify the role of plant growth regulators in germinating seeds.

Materials and methods

Seed source
The seeds of *F. esculentum* (Moench.) of indeterminate common ecotype of Nepali buckwheat were obtained from Dr Rajbhandari's collections.

Plant growth regulator (PGR)
Two plant growth regulators, gibberellin and cytokinin were used in the experiment. Gibberellic acid (GA_3) was supplied from Pharmaceutical Works, Polfa-Kutom, Poland and kinetin (6-furfurylaminopurine, $C_{10}H_9N_5O$, MW 215.22) was supplied from Loba-Chemie Wien Fishcambeno.

Preparation of stock solution

The stock solutions of GA_3 and kinetin were prepared following the methods described by Bajracharya and Gupta (1978).

Sample preparation

The sign of germination was taken into account as that of Bajracharya and Gupta (1978). Sampling was done for those seedlings, which exceeded 1-cm long coleoptile and radicle together. The length of coleoptile and radicle was measured at an interval of 48, 72 and 96 hrs. By using sharp stainless steel blade seedling parts were separated into coleoptile, seedbody and radicle. The obtained samples were hot air oven dried at 70°C to 80°C following Noggle and Fritz (1979). Then the samples were weighed and ground dry using mortar and pestle. The obtained powder of the samples was used for both ash and elemental analysis.

Determination of total cations (ash) and minerals

Percentage of total ash content in each sample was determined using the methods of Peach and Tracey (1956). Contents of Mg, Fe, Mn, Zn and Cu present in various ash samples of seedbody, coleoptile and radicle were analyzed by means of Atomic Absorption Spectrophotometer (AAS) (Perkin and Elmer, Mod2380, USA) at the Department of Standard and Quality Control, Balaju, Kathmandu. For AAS analysis, wet digestion method was applied as described by Inmgram (1962).

Statistical analysis

Level of significance was compared at 0.05 probability point. Least significant difference (LSD) analysis was carried out only for the significant cases in order to locate the effect relative to marginal means.

Results and discussion

Embryo included in a seed needs various nutritional factors, plant growth regulators (PGRs) as well as minerals for its proper growth and development until the establishment of a fully autotrophic habit. The mineral translocation into three distinct parts of the buckwheat seedlings ie coleoptile, radicle and seedbody were studied during germination periods of 48, 72 and 96 hrs. The amount of cations in 100 seeds of buckwheat (weight = 2.15 g) were in the decreasing sequence of Mg> Fe>Mn> Zn >Cu. The patterns of increment of ash in developing coleoptile and radicle as affected by different treatments were as follows: (a): GA3>Kin>Con in coleoptile and (b) GA3>Kin>Con in radicle.

Iron mobility was activated by GA_3 and kinetin in the sequence of GA_3>Kin>Con. However, it was not found to be statistically significant (Table 1). Such response showed independent translocation of Fe to developing seedling. The sequence of coleoptile was found same to the radicle. Fe mobility was found more in coleoptile than in radicle indicating various functions of iron in such part. The movement of iron from the seed to the growing axis is essential because of its involvement in the structural component of cytochrome and ferrodoxin (Price, 1968) and co-factor of several enzymes like cytochrome-6 oxidase (De Kock et al., 1960), Peptidyl-proline-hydrolase (Sadava and Chripeels, 1971) and nitrogenase (Allem, 1970).

Magnesium was present in the largest amount being associated with rapid mobilization at early period of germination. At 96 hrs of germination, kinetin and control (Con) treatment were found equal for the radicle. In the case of coleoptile it was, however, found linked to GA_3. Mobility was activated by kinetin and GA_3 in the sequence of GA_3>Kin>Con. Magnesium is essential for early translocation being the component of chlorophyll necessary for establishment of autotrophy of the plant as well as for ribosomal integrity (Bogoard, 1966; Nason and Moc Elory, 1963; Tempset et al., 1967). It was detected to be 1882.5 μ g ml^{-1} in 100 buckwheat seeds. GA_3 treatments affected Mg translocation in the sequence of GA_3>Kin>Con. GA_3 was effective than kinetin.

Seed content minerals

Fig.1 shows the seed content of different mineral in buckwheat seeds. The investigation related to minerals have been arranged from higher to lower content. Maximum content was found for Magnesium and minimum for copper among the determined minerals.

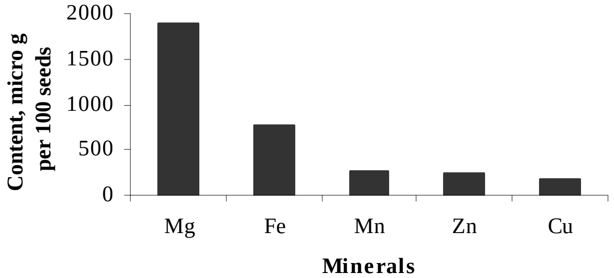

Fig. 1. Content of different cations present in buckwheat seeds (eq 100 seeds).

Table 1. Summary of analysis of variance

Variable	Coleoptile		Radicle		Seed body	
	Time	PGRs	Time	PGRs	Time	PGRs
Ash, %	LSD=2.77 *	LSD=2.77 *	NS	LSD=4.57 *	NS	NS
Fe	NS	NS	NS	NS	NS	NS
Mg	NS	NS	LSD=45.46	NS	LSD=32.1 *	LSD=32.1 *
Mn	NS	NS	NS	LSD=8.87 *	NS	NS
Zn	LSD=4.18 *	LSD=4.08 *	LSD=5.85 *	LSD.=5.85 *	LSD=11.31 *	LSD=11.31 *
Cu	LSD=0.40 *	LSD=0.40 *	LSD=6.16 *	NS	NS	NS

* Significant, NS, non-significant, LSD, Least significant difference.

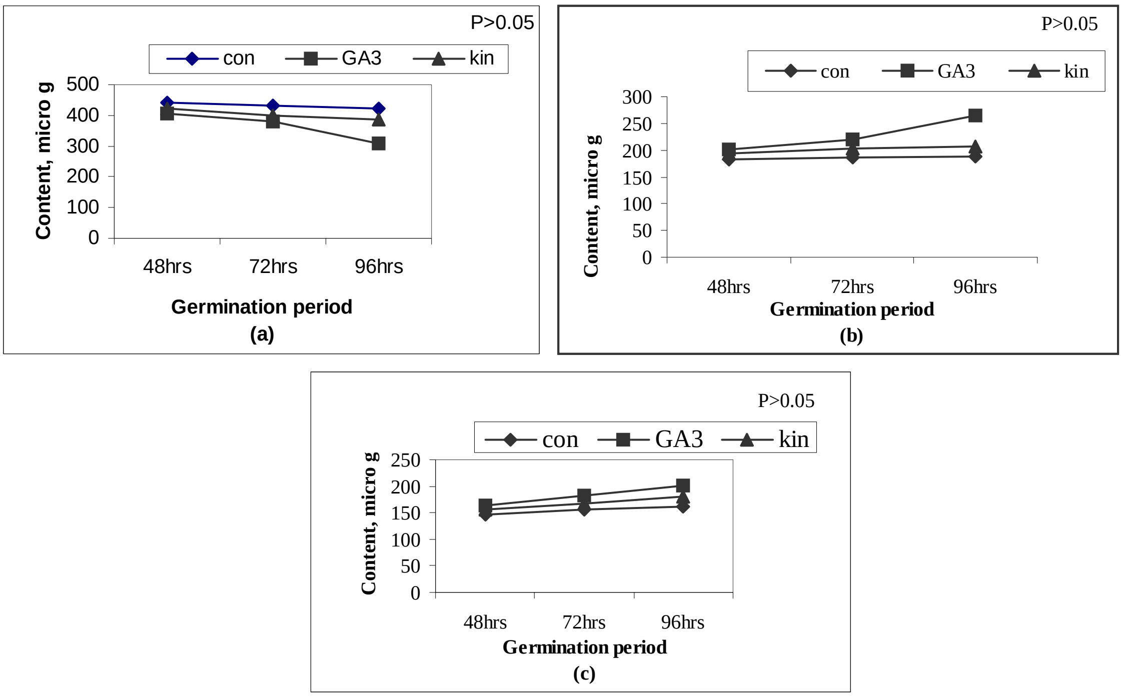

Fig. 2. Mobilization of Iron from (a) seed to developing, (b) coleoptile, (c) radicle during germination.

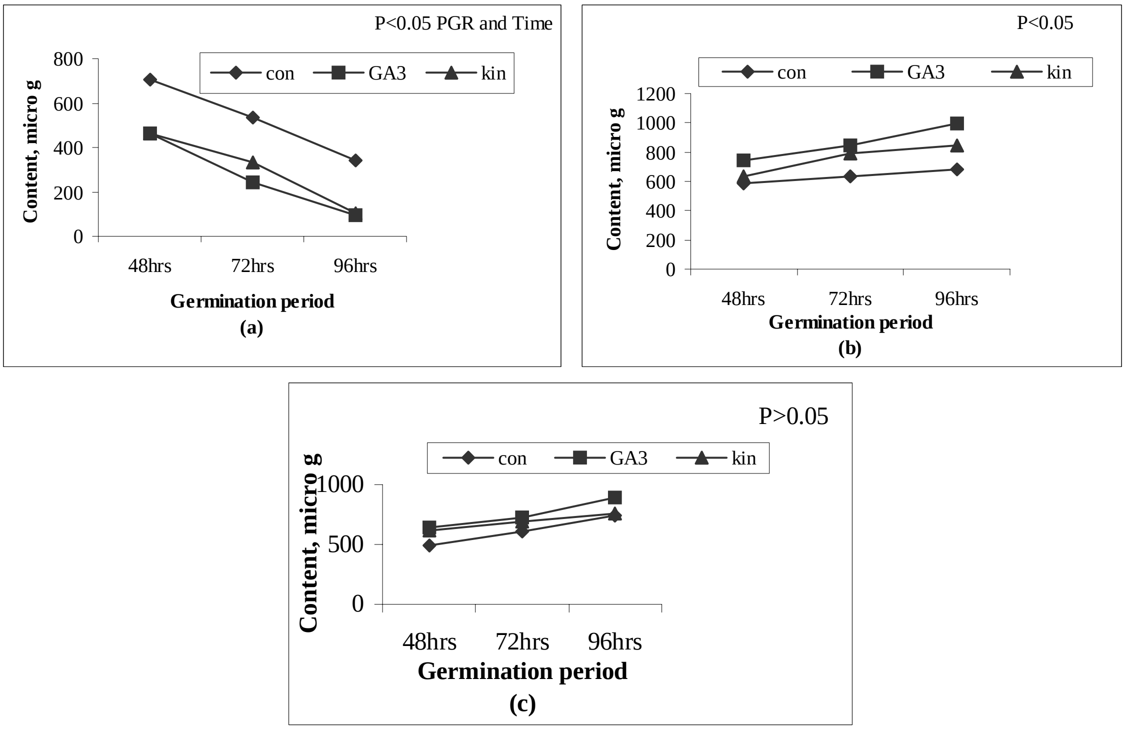

Fig. 3. Mobilization of Magnesium from (a) seed body, (b) coleoptile, (c) radicle during germination.

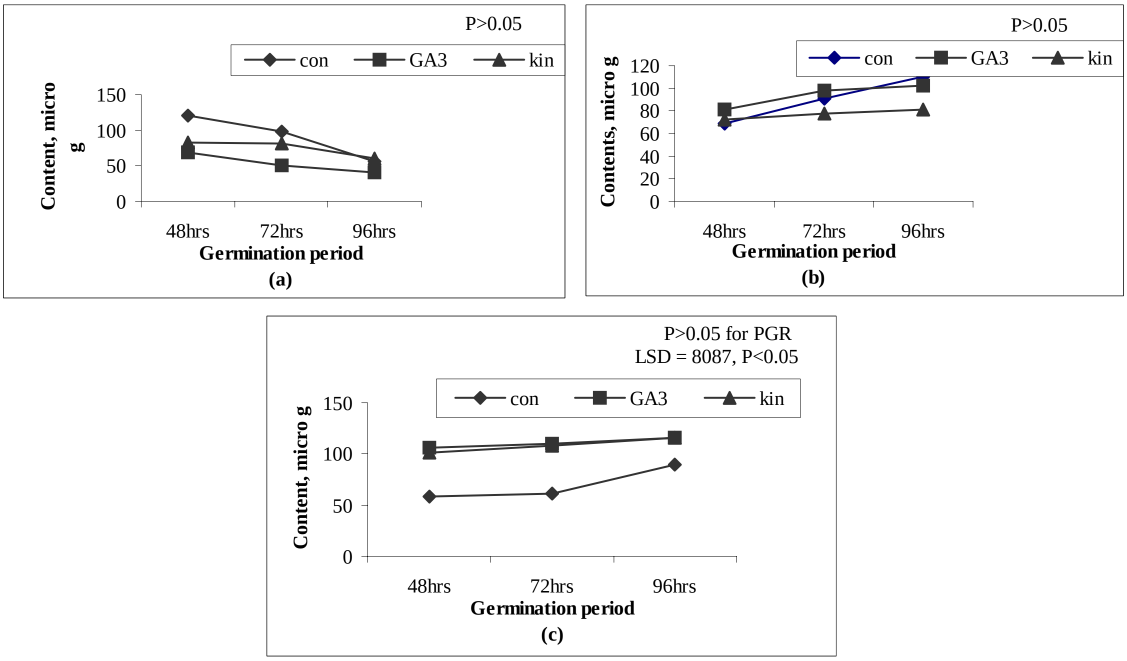

Fig. 4. Mobilization of Manganese from (a) seed to developing, (b) coleoptile, (c) radicle during germination.

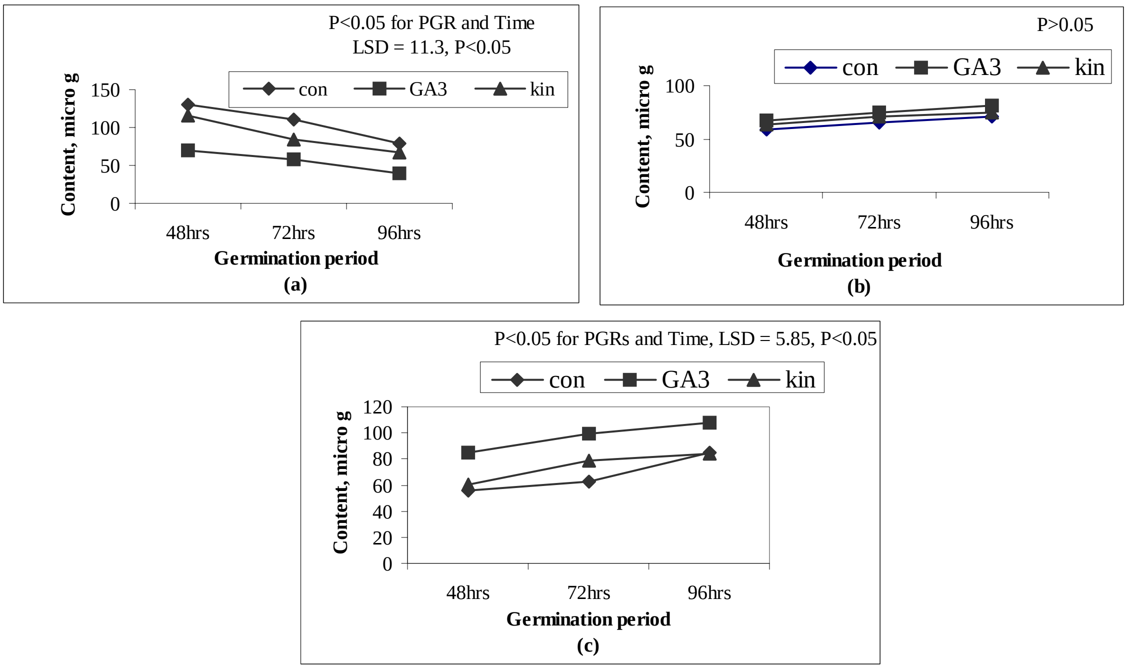

Fig. 5. Mobilization of Zinc from (a) seed to developing, (b) coleoptile, (c) radicle during germination.

Manganese followed iron for its concentration in buckwheat seeds (Fig. 1). Its distribution has been found rapid and the treatments had different effects. As noted at 96 hrs, GA_3 and kinetin were equal to mobilize manganese in developing radicle. More manganese was diverted towards the radicle than the coleoptile, which indicated that several metabolic activities required manganese in electron transport (Cheniae, 1970) and reduction in synthesis of t-RNA primoligodenylate (Walter and Mans, 1970). The sequence showed the mobility of manganese in coleoptile and radicle as GA_3> Kin>Con. More zinc was diverted toward the radicle than in coleoptile, thus carrying possible elaboration of such axis due to the fact that zinc is associated with auxin metabolism via tryptophan synthatase activity (Nason et al., 1951) and tryptamine metabolism (Takaki and Kushizaki, 1970)

Copper with 167.82 μg was detected in 100 germinated seed. During germination more copper diverted towards coleoptile than in radicle indicating terminal oxidation of cytochrome oxidase system (Nason and Mc Elory, 1963). Its mobility was under the influenced by both hormones.

Iron mobilization

A total of 775.82 µg iron was found in 100 seeds (Fig. 1). Its distribution pattern during germination is shown in Fig. 2. General mobilization has been found rapid for GA_3 than for control and kinetin treatment. The kinetin of Fe mobility is illustrated in Fig. 2.

Magnesium mobilization

Magnesium was detected to be 1882.5 µg in 100 seeds (Fig. 1). Its distribution during the germination was rapid from seeds to coleoptile and radicle. In control treatment the mobilization was slower than the PGRs. Although the visible effect of PGRs on the mobility of Mg was found as seed (Fig. 3). The data analysis showed seedbody depletion to be significant ($P<0.05$) for both the PGRs application and time incubation (Table 1).

Manganese mobilization

A total of 259.82 µg Manganese was detected in 100 seeds (Fig. 1). Its mobilization and distribution pattern is illustrated in Fig. 4. The treatment was been found variable in affecting Mn mobility. As summarized in Table 1 the mobility of Mn in radicles was significant ($P<0.05$) as affected by PGRs application. Although this cation was transported to coleoptile with associate decline in the seedbody, the mobility was not significant.

Zinc mobilization

A total of 242.98 µg Zinc content was detected in 100 seeds (Fig. 1) The pattern of its distribution is shown in Fig. 5. GA_3 was active in zinc mobilization in general. More zinc is diverted towards the radicles than the coleoptile. However, the analysis of data showed a significant effect of PGRs and germination time on Zn transport during germination ($P<0.05$) as summarized in Table 1.

Copper mobilization

A total of 168.82 µg copper was detected in 100 seeds (Fig. 1). Distribution pattern of Cu in seedling during germination has been illustrated in Fig. 6. More copper was diverted toward coleoptile than in radicle . The transport of copper to radicle was, however due to time effects as revealed by statistical analysis (Table 1).

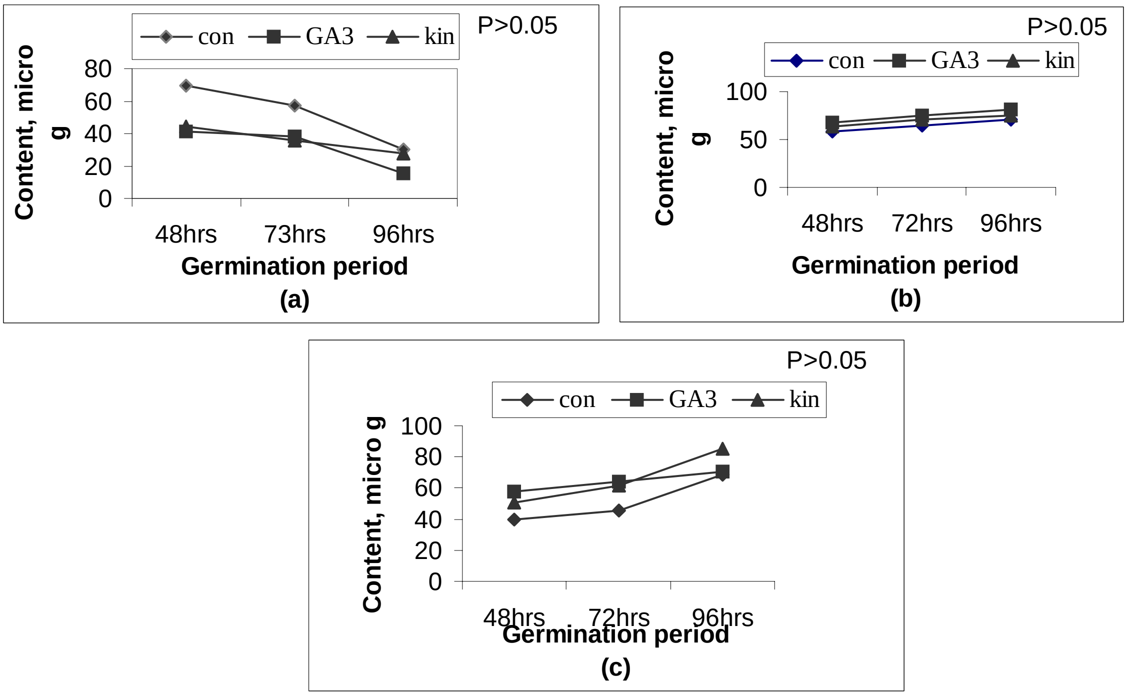

Fig. 6. Mobilization of Copper from (a) seed to developing, (b) coleoptile, (c) radicle during germination.

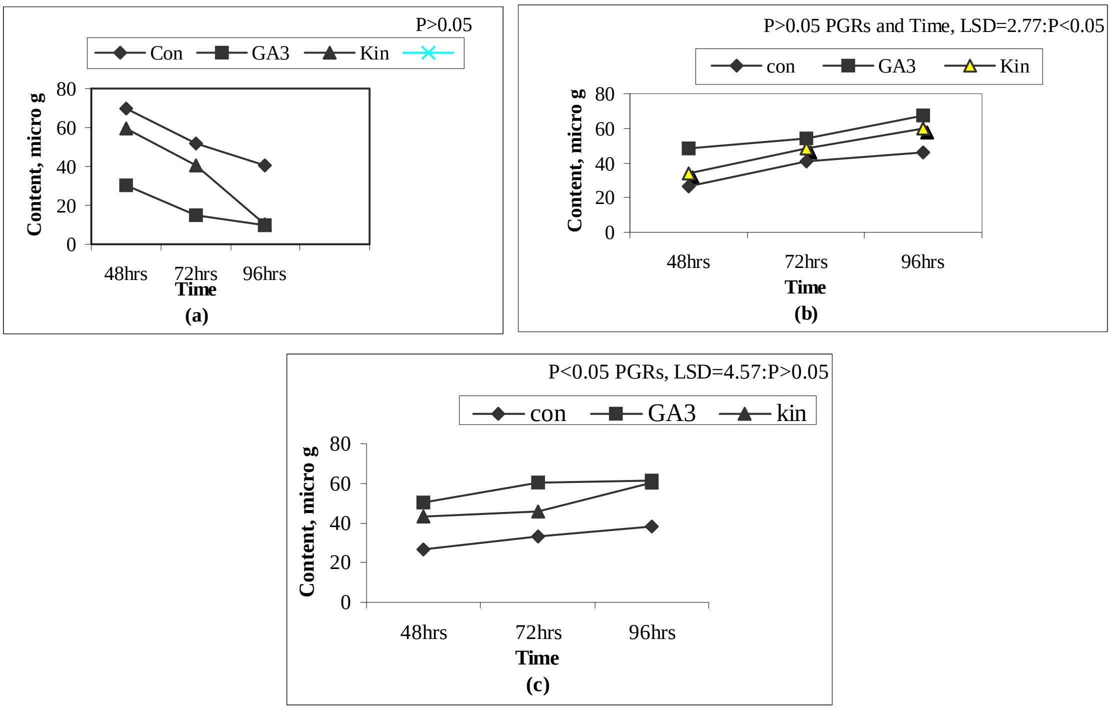

Fig. 7. Ash distribution in (a) seed body, (b) coleoptile and (c) radicle.

Ash content

Ash distribution in seedbody, coleoptile and radicle as affected by various treatments are shown in Fig. 6. At each level ie treatment and time, the losses of ash from the seed body was same for coleoptile and radicles. The percentage of ash content in the seed body was found decreasing with advancing time irrespective to the treatment (PGR such as GA3 and kinetin). Both PGRs decreased the ash content as time progressed. Application of GA3 was found with increasing ash content as compared to the application of kinetin.

However, There was variation among the hormonal effects. Radicle was found with more ash content than the coleoptile as the time progressed. The statistical Analysis showed a significant effect of PGRs on the mobility of ash (($P<0.05$) as given in Table 1.

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Pollination ecology of common buckwheat (*Fagopyrum esculentum*) in different agroecozones of Nepal with particular reference to the role of the Himalayan honeybee, *Apis cerana*

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Abstract

The agricultural crops grown in the mountain areas are showing considerable decline in productivity. The lack of visit by sufficient insect pollinators in the crop field is supposed to be one of the important factors for such a decline in productivity of the crops. For the production of better quality and yield of seeds, adequate pollination of crop is essential. Since most crops are completely or incapable of pollinating themselves, cross pollination of these flowers by the pollinating insects is indispensable. In Nepal, people living in the mountains regard special value to the buckwheat crops. It is because its input costs are very low, easy to grow even when other crops fail. It is adaptive to adverse climatic condition, well fitted in the sustainable farming system and helps to fulfill the precarious food needs of the hungry people. According to Rajbhandari and Hatley, 1991/1992 the yield of buckwheat crop is 600 to 800 kg ha^{-1}. This indicates that both the production and productivity of this crop needs to be elevated to keep pace with the growing demands of the population residing in the mountain and remote areas. In the present study, the potential of buckwheat crop through mobilization of honeybee colonies has been tried to explore expecting better pollination towards increased fertility and seed yield. The field experimentation will be done at RECAST, Tribhuvan University, Nepal.

Kew words: *Apis cerana*, buckwheat, pollination, yield

Introduction

The agricultural crops grown in the mountain areas are showing considerable decline in productivity. The lack of visit by sufficient insect pollinators in the crop field is supposed to be one of the important factors for such a decline in productivity of the crops. For the production of better quality and yield of seeds, adequate pollination of crop is essential. Since most crops are completely or incapable of pollinating themselves, cross pollination of these flowers by the pollinating insects is indispensable. In Nepal, people living in the mountains regard special value to the buckwheat crops. It is because its input costs are very low, easy to grow even when other crops fail. It is adaptive to adverse climatic condition, well fitted in the sustainable farming system and helps to fulfill the precarious food needs of the hungry people. In the mid hills and in the *Terai* region, buckwheat is regarded as an important catch, bonus, emergency or even cash crops (Baniya, 1993).

According to Rajbhandari and Hatley (1991/1992) the yield of buckwheat crop is 600 to 800 kg ha^{-1}. This indicates that both the production and productivity of this crop needs to be elevated to keep pace with the growing demands of the population residing in the mountain and remote areas.

In the present study, the potential of buckwheat crop through mobilization of honeybee colonies has been tried to explore expecting better pollination towards increased fertility and seed yield. The study and collection of pollinating insects were also done in some farms of lower Mustang (high land region), Kirtipur/ Kathmandu (mid land region) and Rampur/ Chitwan (low land region) in order to explore the pollinators of buckwheat crop. The field experimentation was carried out at RECAST/ Tribhuvan University, Kirtipur, Nepal.

Literature review

Pratap and Verma (1992) studied on lettuce crop using bee pollination. Tiwari and Singh (1983) and Verma (1990) studied the pollination of vegetable crops by insects. Similar studies were also undertaken by Verma and Pratap (1993) and they found that bee pollination increased the yield and enhanced the quality of seeds of vegetable crops. Kakizaki (1924); Jones and Rosa (1928) reported that the eggplant is neither self-pollinated nor wind pollinated but strictly insect pollinated. Pammel and King (1930) recorded bumble bees as most common pollinating insects on egg plant flowers but not honeybees. Similarly Sambandam (1964) ; Pal and Taller (1969) discussed the pollination of egg plant and they observed that 60 to 70% of fruit set attributed to insect pollination .

Report of the workers (Deodikan and Suryanarayana, 1972; 1973; 1977) gave support on the increase of seed yields of mustard crop by 30 to 22% because of bee pollination only. However, Free and Spencer - Booth (1963) studied bee pollination effects on the Indian mustard and reported 14% increase in the seed yield. Erickson et al. (1972) developed a method to differentiate between nectar and pollen collector foraging bees. For investigation of the weight of pollen loads of returning foragers, Frisch (1967) used carbondioxide to ansesthetize the sample of returning bees for pollen removing and weighing them easily.

Mattu and Verma (1980; 1983; 1984a, b, c) were of views that the heavier pollen loads carried by *Apis mellifera* compared to that carried by *Apis cerana* may be related to the larger size of body parts. Free (1970) and Kendall and Solomaon (1973) observed that the insects with smaller body parts carry little pollen compared to the larger hairy-bodied insects. Verma and Pratap (1993) showed that *Apis cerana* when visiting cauliflower and cabbage collected either pollen or nectar but never both on an individual foraging trip. Simailar observations were also recorded by Free (1960) for *Apis mellifera*.

Batra (1967) recorded 13 species of insect pollinators on eggplant during June to December in Ludhiana, India. Similarly Tanda and Mann (1985) reported honeybees, butterflies, bumblebees and syrphid flies on eggplant flowers in Punjab, India. Pratap and Verma (1992) observed three types of pollinating insects: *Bombus orientalis* , *Nomia* spp. and *A. cerana* in the fowering egg plant (*Solanum melongena*). To assess out the role of *A. cerana* and *A. mellifera* , Pratap and Verma (1992) studied the comparative foraging behavior on Indian mustard crop. They also observe distinct pattern of growth and development associated with the changes in the availability of floral resources in the Asian hive bee, *A. cerana*. The pollen morphological study of some Nepali bee plants was carried out by Manandhar et al. (1994).

ICIMOD (1993-1994) gave major focus on beekeeping research and development. The major focuses were on reviewing the state of arts of beekeeping, applied research and development programs including training activities. The major research undertaken were

- Design of modern straw beehive.
- Improvement of traditional wall hive
- Comparative performance of *A. cerana cerana* ecotypes of Jumla region and middle hills of Kathmandu valley.
- Insect pollinators diversity
- Pollen reference slide and pollen data bank
- Selection and queen rearing in *A. cerana* colonies
- Foraging competition between *A. cerana* and *A. mellifera* on *Brassica campestris*.

Baniya et al. (1992) studied on the characterization of Nepalese hill crops. In 1993 National Hill Crops Rresearch Programme under Nepal Agricultural Research Council felt the importance of buckwheat for mountain rural people. Real initiation were also undertaken to develop this crop by Rapid Rural Appraisal Trek , National Hill Crops Research Programme (1993) . A detail investigation on the exploitation of genetic yield of buckwheat farming was started by Rajbhandari et al. (1991; 1992; 1993) at RECAST, Tribhuvan University, Kirtipur. This research work is still being running at RECAST. The objectives of this research is to study the pollination and seed setting pattern as influenced by honeybee colonies and thereby to assess out exploitation of yield potential in the buckwheat crop.

Methodology

In the beginning, preparation and collection of required equipments were done. Personal communication was made with the local and international institutions and specialists for receiving relevant technical information, reports and journals. The field for carrying experiment at RECAST, Tribhuvan University, Kirtipur was arranged. The buckwheat seeds for sowing in the field were collected from the Mustang. A colony of cerana bees was collected. Special attention was given in the management of this colony to make it strong and healthy. In the month of Falgun (Feb-Mar), three colonies (having the strength of 4 frames) were made from this established mother colony.

Soil sampling

In the experimental field, the soil sample was collected by random method. Before collection, the field was divided into uniform segments, from which 20 spots per segments were selected. From each spot, samples were collected from the depths of 15 cm. All these samples were then mixed thoroughly and by quartering, the soil sample was reduced to one kg. After this, the soil sample was air dried and crushed to pass through 2 mm sieve. Then it was transferred into a labeled cotton bag for laboratory analysis. The analysis of the soil samples was done at the Soil Science Division NARC (Nepal Agricultural Research Council), Khumaltar.

The experimentation and collection

The experiment field was ploughed and made a firm and weed-free plot. Winnowing of buckwheat seeds were done. Only well-filled and bold seeds were selected for sowing. Then the following design was employed for layout planning and sowing:

i. Design: RCBD (Randomized Complete Block Design)
ii. Replication: Three
iii. Number of treatment: Three
   a) Without Insect Pollination (WIP)
   b) Bee Pollination (BP)
   c) Open Pollination (OP)
iv. Plot size: 5- × 5-m = 25 m^2
v. Plant Spacing: 25- × 5-cm. (row to row and plant to plant distances)
vi. Seed rate: 50 kg ha^{-1}.

About ½ *dokos* (12 to 15 kg) of well-decomposed and dried compost was applied to each of the plots. No irrigation was applied. The agro-meteorological data throughout the period of experimentation were recorded in the field.

The seed sowing was done by placing the seed in furrows at the depth of 1 to 2" in the rows. The sowed seed was then covered by harrowing the soil. The date of emergence of the plants in the field was noted. This was done when more than 75% of the seeds in each treatment and replication were found germinating. When the young plants developed ¾ leaves in each of the treatment and replication, the first inter-cultural operation was carried out. During this operation thinning of plants was done to maintain spacing of plant to plant (5 cm) and row to row (25 cm).

Before anthesis, the WIP and BP plots were caged by means of nylon nets. With the initiation of mass flowering, one *Apis cerana* colony (strength of five frames) was kept inside each cage of BP plots. To maintain the activities of the bee colony, each colony was given additional feeding for a week. The feeding was stopped when their foraging activities were increased on the buckwheat flower. The OP plots were grown open to permit natural pollinating insects visit the flowering buckwheat plants.

Different kinds of insects that visited the buckwheat flowers were collected in each OP plot. The field study to identify the diversity of insect pollinators of buckwheat flowers was also done in the Lower Mustang (High Mountain region) during the early month of Bhadra (Aug). Similar field study was also undertaken in Rampur/Chitwan (Terai region) during the month of late Mangsir (Dec) to early Poush (Dec/Jan). The collected insects were killed, pinned up and dried for longer preservation for diversity assessment. Some insects were also preserved in 75% alcohol for other biometric study.

When the flowering period was over, the bee colonies were removed from the BP plots. The harvesting of buckwheat plants were done when 75% of the kennels were physiologically mature in each plot. Before harvesting, 50 randomly selected plants were uprooted in each treatment and replication and the biometric measurements of those plants were done. The biometric measurement was done on such characters as plant height, stem diameter, number of nodes and branches per plant, number of flower and inflorescence per plant, number of seed per plant. After this the harvested kennels from each randomly selected plant were collected in separate cotton bags. Rest of the standing buckwheat crop in the OP and BP plots were harvested. After drying the harvested seeds for a week, the weights of the seeds collected from each random plant were taken out.

Preliminary findings

From the analytical report it is seen here that the texture of the soil is silty and slightly acidic in character (Table 1). The nitrogen, phosphorus and potassium are found in medium level with low amount of organic matter. Thus it was concluded that the soil is found to be generally non-fertile with the deficiency of major nutrients.

Table 1. Physical and Chemical composition of soils before sowing, RECAST, TU†

Sand, %	Clay, %	Silt, %	Tex	pH		Total N		P		K		Organic matter	
					Rating (Rat)	%	Rat	kg ha^{-1}	Rat	kg ha^{-1}	Rat	%	rat
30	53	17	silt	5.4	slightly acidic	0.16	med	83.19	med	273	med	2.01	low

† med, medium; Tex, texture.

Flowering in buckwheat is a continuous process due to its indeterminate growth habit. The nectar glands located at the base of the ovary and the bright colour of sepals attract different pollinators specially the common bees. When the bees gather or feed in the nectaries, they are easily charged with pollen. Thus they can effectively transfer pollen grains from one flower to another as they forage in the crop field. During the flowering period, variety of insects visiting the buckwheat flowers were observed. These insects included mostly Hymenoptera, Lepidoptera and Diptera. These insects foraging on buckwheat flowers are preserved for final identification.

The graphical representation of the pollination patterns of the Open, Control and Bee Pollination plots showed highest seed set in the BP and OP plots and the lowest seed set in the CP plot.

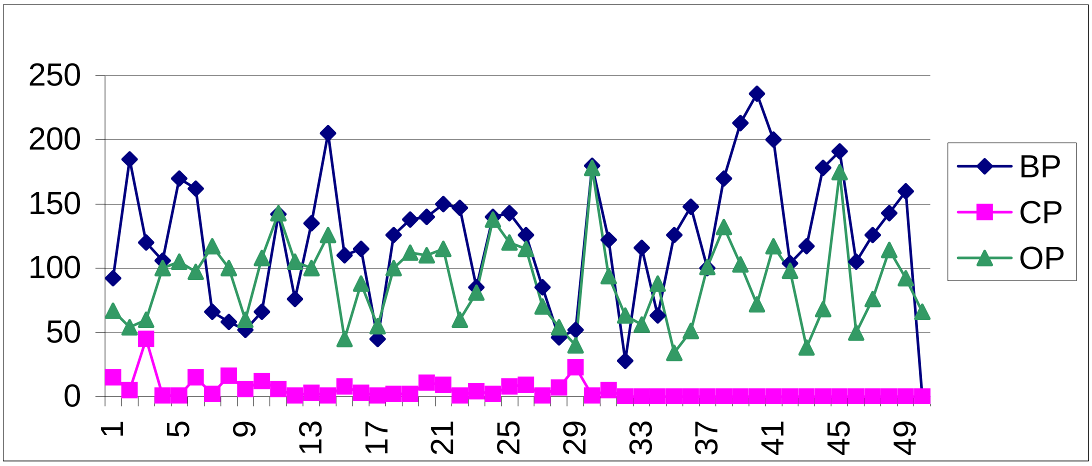

Fig.1 Buckwheat seed set in the open, control and bee pollinated plots RECAST, TU, Kirtipur, 2000.

Table 2. Quantitative and qualitative effects of *Apis cera*na pollination on buckwheat seeds

Parameter	Bee Pollination (BP)	Control Pollination (CP)	Open Pollination (OP)	Increase in %		
				BP and CP	**BP and OP**	**OP and CP**
Seed/plant	122.18±7.23	4.52± 1.11	90.22 ± 4.71	96.30054	26.158127	94.990024

The Table 2 describes about the quantitative and qualitative pollination effects on buckwheat crop. The control pollinated plot (CP) showed very few seed set (4.52+ 1.11). It may be due to the movement caused by person during the observation work and also due to wind movement inside the cage showing that wind also plays some role in the dispersal of buckwheat pollen. This finding was also supported by Marshall (1969). The seed set in the bee pollinated (BP) and open pollinated plots were found to be high i.e. 122.18+7.23 and 90.22 +4.71 respectively. Increase in seed set in the BP plots could be due to greater numbers of pollinators and also due to the superior pollinating efficiency of the *Apis cerana* honeybees. In the OP plots, due to wind movement and the visit of natural insect pollinators in the buckwheat flowers pollinated fewer flowers than in the BP plots. This resulted in the lower seed set in the OP plots. The number of seeds increased when compared between OP & CP, BP & OP and BP & CP were found to be 94%, 26% and 96% respectively.

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Prospects and possibilities of buckwheat development through biotechnology

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Summary

Genetic manipulation of buckwheat is very difficult due to its unique reproductive biology. *In vitro* techniques together with conventional breeding methods could be used to speed up the breeding program and overall improvement of buckwheat. Suggestion is made using plant cell and tissue culture techniques as means to overcome breeding barriers in buckwheat, a difficult crop not only in terms of conventional breeding but in terms of unconventional breeding as well. Success in some extent are reported in buckwheat improvement using biotechnological tools such as anther and ovule culture, callusing and somatic embryogenesis, interspecific hybrids using embryo rescue, protoplast isolation and somatic hybridization, genetic engineering. Major genetic problems are self-incompatibility due to dimorphic heterostylism, which is controlled by single gene; incomplete reproductive organ mainly in the female; failure of fertilization and seed collapse in the post zygotic stage. The problems encountered in the buckwheat development may be solved using the biotechnological tools especially by developing interspecific hybrids, transgenic plants and new populations. Achievements made at the international level on biotechnological research of buckwheat give scope to widen the research area on buckwheat in Nepal.

Key words: anther culture, callusing, embryo rescue interspecific hybrids, somatic hybridization

Introduction

Molecular breeding is supposed to be a helpful method for genetic manipulation of buckwheat. Conventional breeding techniques have not been successful in crossing common and tartary buckwheat (Morris, 1951; Adachi et al., 1989). Biotechnology including *in vitro* techniques together with conventional breeding methods could be used to speed up the breeding program and overall improvement of buckwheat. Many attempts have been made using different biotechnological tools to improve buckwheat. This paper is here to summarize the progress of biotechnological research in buckwheat. On the basis of the problems and biotechnological progress in buckwheat some opportunity and application of biotechnology for improvement of buckwheat are discussed.

Biotechnological research and development activities

Biotechnological researches are intensively carried out in most of important crop all over the world. Scientists involving in buckwheat improvement initiated biotechnological research sine last 20 years. Neskovic et al. (1986) suggested plant cell and tissue culture techniques as mean to overcome breeding barriers in buckwheat, which is a difficult crop not only in terms of conventional breeding but in terms of unconventional breeding as well (Lachmann, 1991). Biotechnology including tissue culture techniques is looked on as a promising tool that might help in genetic manipulation of buckwheat (Lachmann, 1991; Bohanec, 1995). Many progresses have been made in biotechnology including tissue culture. Some achievements made in biotechnological research are given below.

Callusing, Organogenesis, micropropagation

Plant regeneration of common buckwheat *in vitro* was reported from different explants: hypocotyls (Yamane, 1974; Takahata and Jumonji, 1985), cotyledons (Srejovic and Neskovic, 1981), immature inflorescence (Bohanec, 1987; Takahata, 1988). Different investigators (Srejovic and Neskovic, 1981;

Lacmann, 1991; Guo et al., 1992; Luthar and Marchett, 1994) have reported on regeneration of buckwheat plants from cultured cotyledons of hypocotyls. Hypocotyl segments of common buckwheat which is proved to be a source of high regeneration capacity were shown to regenerate via somatic embryogenesis and organogenesis (Lachmann, 1991). Callus formation was best on a medium supplemented with 2-5 mg 1^{-1} 2,4-D and 0-0.2 mg l^{-1} BA. Varieties with good callus formation were also superior in regeneration capacity. Some regenerants flower *in vitro* and some set seeds after transferring to soil. A modified MS medium supplemented with 2 mg l^{-1} NAA and 1 mg l^{-1} BA was most suitable for cell division and colony formation (Lachmann, 1991). *F. tataricum* showed higher plating efficiency than common buckwheat. Woo et al. (1997) reported of having reliable callus induction and plant regeneration system in *F. homotropicum*. Nair et al. (1999) reported that a medium containing BAP and IAA showed better regeneration efficiency than a medium with BAP and kinetin. A maximum regeneration frequency of 54.16% was obtained with 2 mg l^{-1} BAP and 0.2 mg l^{-1} IAA. Efficient rooting was observed when the healthy shoots were transferred to half MS medium supplemented with 0.5 mg/l Indole butyric acid. Frequency of shoot regeneration from callus in diploid and tetraploid buckwheat cultivars was very low on BAP and IAA containing media but was substantially improved when a phenyl urea derivative thidiazuron was substituted for BAP in the regeneration medium (Berbec and Doroszewska, 1999a). According to Srejovic and Neskovic, (1981) optimum shoot induction and regeneration was obtained on medium containing 10^{-6} M NAA and 10^{-5} M BAP. A combination of 2,4-D and ABA was used by Lachmann to regenerate shoots from hypocotyls. Bohanec (1986) also used a purine cytokinin (BAP and IAA) to induce shoots in buckwheat. Guo et al. (1992) reported that shoot regeneration rate in tetraploid buckwheat was substantially improved when TDZ, a phenyl urea derived cytokinin was added to the regeneration medium. Guo et al. (1992) did not find regenerants other than those with the parental chromosome number but Berbec and Doroszewska (1999a) found doubling of chromosome. Barbec et al. (1995) formed callus and regenerated shoots *in vitro* from hypocotyl and cotylendon explants. Media supplemented with 2,4-D were superior with respect to callus induction to IAA- and NAA-containing media. Low concentrations of 2,4-D with BAP and ABA were most effective for callus induction. Addition of ABA slightly improved the capacity of 2,4-D containing media to induce shoot formation. Best response to IAA and NAA-based media was recorded for tetraploid cultivar. Cotyledons were the better source of explants for Emka, hypocotyls for the diploid cultivars. Shoot induction was a relatively rare event in Barbec et al. (1995) study. Park et al. (1999) tested the ability of buckwheat to somatic embryogenesis and morphogenesis in young tissues of leaf and stem segments of Korean buckwheat cultivar. Rate of callus induction from leaf segments was 90 and 79% respectively in a MS media containing 2,4-D 1 mg and 3 mg l^{-1} while that from stem segments was 73 and 76% in MS media with same concentrations of 2,4-D. Rates of plant regeneration were 1.6 to 5.6% from leaf derived calli on hormone free MS medium. Ying (1989) obtained the complete plantlets from the young stem and leaf explants of *F. dibotrys*. Plant regeneration via callus of leaf and stem explants was reported by using different ecotypes of indigenous Nepalese buckwheat (Rajbhandari et al., 1995). Woo et al. (1998) demonstrated that whole plantlets were regenerated from the hypocotyl derived calli of cultivated buckwheat and wild buckwheat cultured on MS medium supplemented with 1 mg l^{-1} NAA and 1 mg l^{-1} BAP. Irrespective of the explant source callus formation was initiated from the surfaces of leaf and stem segments two weeks after inoculation. Somatic embryogenesis in tissue culture of buckwheat has been reported by Neskovic et al. (1987), Adachi et al. (1989), Lachmann (1990). Park et al. (1999) found higher callus induction rate than other studies reported by Neskovic et al. (1987), Berbec et al. (1995), Lukina and Rumyantseva (1998). FuXing et al. (1992) found the best medium for the callus induction containing 0.5-1.0 mg 1^{-1} 2,4-D from hypocotyls. On this medium the frequency was as high as 100%. When concentrations of 2,4-D were higher than 2.0 mg 1^{-1} both frequency of callus induction and growth of callus decreased. The regeneration frequencies could be 20-50%. IBA of 1.0 mg 1^{-1} was the most effective for rooting and root growth. The explants on the media with 0.5-1.0 mg 1^{-1} 2,4-D produced well-grown callus diameters of which were about 1.0 cm at the frequencies of 100%. When the concentrations of 2, 4-D were higher than 2.0 mg 1^{-1} the frequencies and callus growth decreased, the diameters of callus were less than 0.6 cm. TDZ alone could not induce any adventitious buds in callus derived from hypocotyl explants. When the callui were cultured on medium supplemented with 0.002 mg 1^{-1} TDZ in combination of 0.05 mg 1^{-1} IAA the frequency of bud formation increased to over 30%. On the medium with 1.0 IBA mg 1^{-1} the rooting frequency reached to 100% and the complete plantlets grew best. Yamane (1974) used auxins to induce the callus from seedlings of *F. esculentum*, only 2,4-D was effective and got the highest frequency of 73.3% (the 2,4-D concentration being 10.0 mg 1^{-1}). So the cytokinin activity of TDZ is much higher than that of BAP in induction of bud formation in callui of tetraploid buckwheat. The callus induced by 2,4-D is soft and translucent (Zhang et al., 1992). However, the callus induced by PUD swell like mushrooms at the end of the explants. It is dense and hard in quality. Either adding 2,4-D of low concentration to MS medium or setting PUD in MS medium for a certain period can produce an adventitious root. They found that by using PUD of different concentration there are different effects of different organ differentiation on the same explant. PUD of low concentration can promote the differentiation of adventitious roots. As the concentration goes higher, the growth of adventitious roots is decreased while the differentiation of adventitious bud is increased. Root is produced, as the proportion of auxin gets higher, while bud is produced, as the proportion of cytokinins gets higher. With mature cotyledons and immature embryos, shoot differentiation was easily obtained. The most efficient protocol was characterized by a sequential change of hormones leading to cell commitment, bud formation and eventually root production. Characters such as explant necrosis and bud formation are strongly influenced by genotype. Explant viability and shoot regeneration is supposed to be under genetic control. After 30 days of culture, more than 90% of the explants had developed at least some callus (Luther and Marchlti, 1994). Rajbhandari et al. (1995) found the maximum callus induction frequency in the culture media of MS+1 mg 1^{-1} of 2,4-D. Frequency of callus induction was higher from stem than leaf explant. The optimum media and plant growth hormone for differentiation and proliferation were MS+4 mg 1^{-1}BAP and MS + 0.2 mg 1^{-1} IAA+2 mg 1^{-1} BAP, respectively. Callus formation was initiated in 14 to 16 days after inoculation. The period from callus to plantlet regeneration was found to range from 50 to 70 days. The frequency of plantlet regeneration under the optimum media (MS+0.2 IAA+2.0 BAP) was found to range from 52 to 60% depending on genotype.

Anther and ovule culture

Neskovic et al. (1986) and Adachi et al. (1988) mentioned the potential of haploid plant induction by *in vitro* culture techniques for buckwheat genetic and breeding studies. Doubled haploid with expressed recessive genes and complete homozygosity can help to elucidate buckwheat genetic constitution and may be even more important in buckwheat than in some other spp since by conventional breeding techniques it is not possible to develop inbred lines because of the limited self pollination ability of buckwheat and the large inbreeding depression (Bohanec and Neskovic, 1991). Kong et al. (1992) succeeded in regenerating plant from anther culture. Adachi et al. (1988) and Berbec and Doroszewska (1998) have succeeded in regeneration of haploid plantlets by means of anther culture. Adachi et al. (1988) succeeded in inducing regeneration when the anthers were cultured on liquid B5 medium supplemented by 0.5 ppm NAA and 1.0 ppm BAP. Agar solidified media did not produce any response of anthers but both liquid medium and gellum-gum solidified medium showed relatively good results (Bohanec and Neskovic, 1991). High cytokinin concentrations were essential to achieve a response, media with no hormone or 2,4-D resulted by no development of anthers. Bohanec and Neskovic (1991) observed diploid, aneuploid or tetraploid number of chromosomes. They developed a method for selfing regenerated weaned plants to achieve at least a few seeds. These seeds were used in electrophoretic and isozyme tests, which showed some genotypic variability. Bohanec (1989) obtained diploid from anther *in vitro* culture. Berbec and Doroszewska (1999b) found that buckwheat plants grown *in vitro* were inferior to those grown in the greenhouse as a source of anthers for culture. Viable shoots were regenerated from anther when cultures were maintained in a modified MS liquid medium for more than 15 days. They reported that the maltose-containing medium was superior to those containing sucrose as source of carbon. Early transfer of callus to solidified medium result in rapid death of calli and in total lack of regeneration. Callus development and shoot regeneration was consistently the highest in the tetraploid cultivar. Shoots were produced by 10% of the calli of the tetraploid and 2.5% of the calli of the diploid. No haploid were found among regenerants derived from the diploid cultivars likewise the tetraploid cultivar yielded no diploid regenerants. According to Bohance et al. (1993) there is a strong tendency for endoduplication among the anther derived regenerants. Bohanec (1986) suggested that anthers could be obtained from plants growing *in vitro* but Bahanec et al. (1993) and Adachi et al. (1988) used anthers from *in vivo* grown plants. . Adhikari and Campbell (1998) reported the successful germination of pollen grains in an artificial medium. Some pollen remained viable for approximately 34 to 38 h in intact flowers. Adachi et al. (1988) got successful of 34.6% callus induction. The combination of 1.0 ppm NAA and 1.0 BAP were most suitable for the proliferation of calluses from anthers. Flower clusters under lower temperature before inoculation could increase callus inductivity. Effect of 24 hours treated at 5^0C was the best, inductivity of callus was 27.2% increased by 20.6% as compared with control without low temperature treatment. Dense calli emerged shoot easily. Transplant time of calli was very important for differentiation of shoot. Regeneration from anther occurs on induction medium within 30 days and rooting is achieved with application of indole -3 butyric acid (IBA) 0.5 mg 1^{-1} (Bohanec 1995). Several experiments resulted only in callus formation without regeneration. Only a part of regenerants exhibited haploid number, the rest being diploid, tetraploid or mixoploid.

Uchinomiya (1990, cited by Adachi, 1990) succeeded in ovule culture just three days after pollination. Ujihara et al. (1990) reported the successful buckwheat ovule culture. To overcome the post zygotic barriers ovule culture had facilitated the production of interspecific hybrids (Woo and Adachi, 1997; Wang and Campbell, 1998). Woo et al. (1990) suggest that ovule culture is an easy and effective tool for obtaining wide inter specific hybrids in the genus *Fagopyrum*. Ujihara et al. (1990) obtained successfully hybridized tetraploid wild buckwheat (*F. cymosum*, 2n =32) with tetraploid common buckwheat through ovule culture. Woo et al. (1995) found an average frequency of ovule production of 25% for all examined interspecific pollinations. The highest percentage of ovule formation (45% approximately) occurred in combination between *F. esculentum* (pin) and *F. cymosum*, the lowest 13% in combination between *F. esculentum* and *F. giganteum*. The influence of hormone concentration on ovule culture showed that MS medium without hormone produced more number of germinated hybrid embryos compare to the MS medium with 0.2 mg 1^{-1} IAA + 2 mg1^{-1} BA in ovule culture between *F. esculentum* and *F. cymosum*. The number of germinated embryos were increased with the increase of days after pollination. It reached the maximal at 5 days after pollination then decreased. Although attempts for the interspecific cross between *F. esculentum* and *F. tataricum* conducted by Morris (1951) and Samimy (1991), they could not obtain a hybrid seed. Hirose et al. (1995) mentioned the possibility of producing interspecific hybrid between the two species, through ovule and callus culture. Ovule culture experiments for haploidy induction were initiated to determine the possibility of inducing higher percentage of regenerants via gynogenesis than via androgenesis. Also speculated that gynogenetic regenerants will have less genetic aberrations than androgenetic (Bohanec, 1995).

Interspecific hybridization

Numerous attempts have been made to incorporate new traits into buckwheat through interspecific hybridization, but with limited success (Morris, 1951; Adachi et al., 1089; Samimy, 1991). Adachi (1990) induced the autotetraploid to diversify the genotypes by colchicine treatment. Samimy et al. (1996) successfully hybridized tartary buckwheat with common buckwheat both diploids, using the latter as male parent during bud pollination. This hybrid was produced by selecting common buckwheat plants that exhibited at loci of the isozymes phosphoglucomutase, shikimase dehydrogenase and alcohol dehydrogenase, alleles with similar mobility to those found in tartary and then transferring these alleles to a single plant through six generations of breeding. Ovule culture was used to rescue the 7-10 day-old embryos. On the rescue culture medium 41% of the hybrid embryos formed calli from which some cloned plant were produced. When tartary was crossed with the original genotype of common buckwheat only 22% of the hybrid embryos formed small calli and none differentiated. Flowers produced by the hybrid plants were of the same type (homomorphic) and size as those of tartary. The F_1 plants produced by Woo et al. (1999), whose objective was to introgress the self-compatible allele found in *F. homotropicum* into common buckwheat were partially fertile, late maturing and intermediate in some characters between the two parents. However, the rate of seed set was low. The cross *F. cymosum* by *F. pilus* produced seeds very readily even without embryo rescue. Morris (1951) that crosses between *F. esculenum* and *F. tataricum* resulted in immature embryos if *F. tataricum* was used as the female parent but no embryos developed if *F. esculentum* was used as the female parent. Nagatomo (1961, cited by Woo et al., 1999) was unsuccessful in developing crossed between *F. esculentum* and *F. cymosum* at the tetraploid level. Krotov and Dranenko (1975, cited by Woo et al., 1999) produced a new species *F. giganteum* from the hybrid buckwheat between tetraploid *F. tataricum* and *F. cymosum*. Wagatsuma and Un-no (1995) reported on the first fertile cross of diploid *F. esculentum* and *F. tartaricum*. Wang and Campbell (1998) reported on the first fertile cross of *F. homotropicum* and *F. esculentum* and further backcross to *F. esclentum*. Ujihara et al. (1990) successfully obtained sterile hybrid tetraploid buckwheat between common buckwheat and *F. cymosum*, through ovule culture. Suvarova et al. (1994) attempted hybrids between *F. cymosum* and *F. esculentum* but all plantlets died when transferred to soil. Hirose et al. (1993) produced similar hybrids through embryo rescue. This was accomplished using ovule culture and further back-crossing of the hybrids with common buckwheat have resulted in fertilized ovules which had to be rescued, with the resulting plants still being sterile. Campbell (1995) and Woo et al. (1997) reported self compatible interspecific hybrids from common buckwheat and *F. homotropicum*. Nair et al. (1999) produced interspecific hybrids between common buckwheat and *F. homotropicum* by cross-pollinating and embryo rescue. Campbell (1995) mentioned that, they also using conventional sexual hybridization at the diploid level have successfully hybridized *F. esculentum* Moench and *F. homotropicum* Ohnishi. Embryo culture was used to rescue the 18 to 20 day old embryos. The embryos grew into complete plants and were found to be fully fertile. This hybridization produced fertile progeny that were back crossed to *F. esculentum* to transfer the desirable traits of *F. homotropicum* to common buckwheat. Flowers produced by the hybrid plants were of the same type as those of *F. homotropicum* suggesting a simple dominant gene for homomorphism. Combinations between shorter style species as female parent and longer style ones as male parent is suggested to be interspecific cross -compatibility. Genotype of maternal plant, in the cultivated species *F. esculentum* has relatively high capacity to allow foreign pollen penetration (Woo et al., 1995). 20 hybrid plantlets were obtained from 280 pollinations by Woo et al. (1995). The maximal number of embryos were obtained in hormone free MS medium supplemented with 3% sucrose at 25^0C culture conditions. Rumyantseva et al. (1995) found that the best combinations of crosses were *F. esculentum* (short-styled, SS) × *F. cymosum* (long-styled, LS) and *F. esculentum* (SS) × *F. giganteum* (LS). The percent of embryo formation in the crosses *F. esculentum* × *D. cymosum* was about 46% whereas in the crosses *F.exculentum* × *F. giganteum* it was only 26%. Some lines of these hybrids had homostyle flowers typical for *F. tataricum*. The hybrids obtained were identified by different methods i.e. by DNA blot-hybridization, peroxidase isoenzyme patterns analysis and chromosome number study (Rumyantseva et al., 1995).

Protoplast culture and somatic hybridization

Rumyantseva and Lozovaya (1987) described the isolation and culture of protoplasts from common buckwheat. Adachi et al. (1989) and Gumerova (1991) was successful in plant regeneration from protoplasts in common buckwheat. Protoplasts isolated from hypocotyls of etiolated seedlings were able to regenerate callus (Lachmann, 1991). Lachmann (1991) produced cell colonies after protoplast fusion which however failed to continue growing. Employing a cold pretreatment prior fusion increased the fusion rates and most positively the survival rate even after elution with a high pH/Ca^{2+} solution. Mesophyll protoplasts were unsuitable for protoplast fusion. The high plating efficiency will be useful on the genetic transformation of buckwheat via protoplast fusion or direct DNA uptake if the regeneration capacity of protoplast-derived callus is increased. Zhang et al. (1992) received success in segregating and developing protoplasts of tartary buckwheat. Lachmann and Adachi (1990) reported the callus regeneration from tartary buckwheat protoplasts. They cultured the hypocotyl protoplasts on either solidified or liquid modified MS medium using a nurse culture technique. Application of protoplast regeneration from common buckwheat protoplasts and callus regeneration from tartary buckwheat protoplast fusion has failed because the resulting calli did not regenerate in the study of Adachi et al. (1989), Lachmann and Adachi (1991). Lachmann et al. (1994) found both fused and unfused hypocotyl protoplasts divided and formed colonies. Somatic hybridization, which offers a unique and simple way to transfer genes between sexually incompatible species, has been suggested as a means of overcoming breeding barriers in buckwheat (Neskovic et al., 1986).

Embryo rescue

A number of studies in relation to the potential of interspecific hybrids to over come cross incompatibility have used embryos or ovule culture system. As mentioned by Campbell (1995) successful hybridization of tartary buckwheat with common buckwheat at the diploid level has been accomplished using conventional breeding techniques to cross the two species and then grew the resulting ovules on media. Woo et al. (1999) used the embryo rescue to develop five hybrids between *F. cymosum* and other species: *F. esculentum, F. tataricum, F. homotropicum, F. pilus*. Hybrids embryos at the early heart stage, 5 and 7 days after pollination were used and cultured *in vitro* on MS media supplemented with IAA (0.2 mg l^{-1}) + BA (2 mg l^{-1}). Some calluses formed somatic embryos, which developed roots when sub cultured on hormone free MS media. The numbers of germinated embryos were found to increase with an increase from five to seven days after pollination. He mentioned the possibilities of transferring useful genes between *F. tataricum, F. homotropicum, F. cymosum, F. pilus* and self-pollinating buckwheat using *in vitro* methods. Wang and Campbell, (1999) studied the response of mature embryos to different methods of culturing. Culture of mature buckwheat embryos in test tubes on solid media can be replaced by culturing them in petri dishes with liquid media (Wang and Campbell, 1999). Culturing the embryos on tissue paper soaked by liquid media show good quality seedlings. After the embryos were transferred from beakers into the petri dishes seedlings were also found to grow better in 1/2 MS medium than in the tap water. Immersing embryos in liquid is not good for tissue culture. Suvarova et al. (1994) obtained interspecific hybrids in crossing combinations of *F. esculentum*× *F. cymosum* with the application of ovule culture. Hybrid plants possessed morphological traits similar to the paternal species, *F. cymosum* and were characterized by complete sterility. Plantlets, obtained from an older age embryos were marked by sufficiently high ability to live. Cytokinins in the compound promote callus formation from embryo (Suvarova and Kostrusin, 1992). With the increase of relative content of auxins in media decreased the frequency of callus tissue formation. A possibility of obtaining normal buckwheat plants from immature embryos starting from 4 days old was demonstrated by Suvarova and Kostrusin (1992) (Neskovic et al., 1987; Rumyantseva et al., 1989). First attempt of culturing of immature buckwheat embryos *in vitro* were taken by Paddubnaya - Arnoldy (cited by Suvarova and Kostrusin, 1992). The author was growing up 15 and 20 days old embryos on White's medium. Surikov (cited by Suvarova and Kostrusin, 1992) was able to get plants from the embryos of 10 and 15 days old and also from 6 days old ovaries. Rumyantseva et al. (1989) induced the callus from immature embryos of two species of buckwheat (*F. esculentum* and *F. tataricum*) and observed organogenesis and somatic embryogenesis *in vitro* cultures. Ovules not older than 6 days are considered best fit for *in vitro* culture; more matured ovules became necrotic in the medium (Suvarova et al., 1994). Some callus clones survived *in vitro* culture for several years but regeneration potential was found on only one of the six-day old embryo calli. Embryos could develop without callus formation. But since the embryo was premature, deviations from normal development were observed abnormal plantlets with different morphologic structures of sub mature roots and cotyledons or abnormal shoots (Suvarova et al., 1994).

In vitro fertilization

We did not find this technique applied in buckwheat. This may be due to successful in hybrid production through embryo rescue. *In vitro* pollination is proposed to produce the hybrids, which are otherwise difficult to produce through embryo rescue. Various methods are available for *in vitro* fertilization. Some may be more useful to produce interspecific hybrids in buckwheat.

Genetic diversity study

Diversity at morphological, biochemical and DNA level contribute the genetic basis for improvement. There are not much information about diversity at isozyme and DNA level of buckwheat.

Isozyme: The isozymes are being applied increasingly to the study of species re-sources, the prediction of heterosis, the identification of distant hybrid strain and the physiological researches. Huh and Huh (2000) detected the polymorphism in seven of the 13 loci studied (53.8%) in *F. esculentum*. Gene flow is reported to be high among population of this species. Large amount of genetic variability in buckwheat population is expected but common buckwheat did not show high allozyme variability in marginal populations (Huh and Huh, 2000; Campbell, 1976; Ohnishi, 1993). For *F. esculentum* ssp. *ancestralis,* nine of 21 loci studied (35%) showed detectable polymorphism (Ohnishi, 1998a). The average number of alleles per locus ranged from 1.10 to 1.55 among the populations. The average heterozyosity ranged from 0.010 to 0.134. Among the 20 loci of 13 enzymes, four loci were revealed to be polymorphism in tartary buckwheat (Ohnishi, 2000). Although natural populations of wild tartary buckwheat were self-pollinating the Pgm-2 and Adh loci were polymorphic, both at the species and the population level. High allozyme variability found in Sichuan by Ohnishi (1998) is used to indicate the original birthplace of tartary buckwheat. Bajracharya et al. (2001) used peroxidase, malate dehydrogenase and alcohol dehydrogenase to study the biochemical variability in Nepalese tartary buckwheat. Six out of eight loci showed polymorphisms in 32 landraces populations. SDS-PAGE analyses of buckwheat seed proteins revealed polymorphism in common buckwheat but not in tartary buckwheat (Nishiyama et al., 1991). Dolinsek (1980) demonstrated electrophoretic polymorphism of water-soluble protein of buckwheat seed. Bohanec and Neskovic (1991) used electrophoretic and isozyme techniques to test the homozygosity of anther-derived plants. Ohnishi (1998b) assayed isozyme diversity at 20 enzyme loci on natural populations of buckwheat wild relatives. On the basis of isozyme data he proposed that the wild ancestor of common buckwheat is *F. esculentum* ssp. *ancestralis* and of tartary buckwheat is *F. tataricum* ssp. *potanini* and the center of origin of buckwheat is northwestern corner of Yunnan Province, China. Hybridity of plantlets was determined using the isozyme by Samimy et al. (1996). The differences of the isozymograms among the common buckwheat varieties or among the tartary buckwheat varieties varied with organs (Yuanhui et al., 1992). The isozymograms of peroxidase varied greatly among the varieties both in the common and the tartary, while the isozymograms of esterase and cytochrome oxidase varied among the varieties only in certain organs. The similarity index of perennial and tartary buckwheats is 40.00 and the similarity index of tartary buckwheat and common buckwheat is 58.82 in the study of Gang et al. (1992) suggesting some relations between *F. gracilipes* var. *odontopteum* and tartary buckwheat, between perennial buckwheat and common buckwheat.

RAPD: Tsuji and Ohnishi (2000, 1998) and Bimb et al. (2000, 2001) used RAPD markers to access the genetic diversity in buckwheat. Tsuji and Ohnishi (1998) suggested the most probable candidate for the origin of cultivated and wild tartary buckwheat on the basis of RAPD markers. Samimy et al. (1996) used RAPD to determine the hybridity of the calli. Aii et al. (1999) cloned and characterized three RAPD markers, tightly linked to S^h gene (homomorphism gene designed by Woo et al., 1997) (Aii et al., 1998) and designed SCAR markers from RAPDs linked to the S^h gene in buckwheat. He mentioned that RAPD marker is usually dominant and useful for differentiating heterozygous from either homozygote (dominant or recessive). But the co-dominant nature of SCAR marker will facilitate MAS of the S^h gene in buckwheat breeding programs and will also be useful as genetic markers for high resolution mapping of the S locus region.

Marker assisted selection (MAS)

MAS are being increasingly used for crop improvement. Due to the limited genetic information about buckwheat, MAS are not applied. Aii et al. (1999) used the SCAR markers linked to S^h gene as tools for marker assisted selection introgression of self-compatibility into common buckwheat.

Genetic engineering

Buckwheat is very sensitive to *Agrobacterium,* (Neskovic et al., 1990) which could be used as a vector for genetic transformation. Inoculation with *A. rhizogenes* induced the development of hairy roots. In the experiments of Neskovic et al. (1990) about 90% of explants (cotyledon and hypocotyl segments) responded to the inoculation by forming transformed callus tissue. Tumour tissue cultured on hormone free media developed into large autonomous calli. A protocol for regeneration and genetic transformation of buckwheat using *Agrobacterium tumefacines* was established (Nair et al., 1999). Nair et al. (1999) mentioned the possibility of repressing the allergenic expression in buckwheat using antisense technology. The transgenic nature of the regenerated plants was confirmed by histochemical staining of the GUS gene by Nair et al. (1999). Milju-Djukic et al. (1992) reported the genetic transformation and regeneration of buckwheat using *A. tumefacines* strain as a vector.

Problems needs to be addressed

The research in buckwheat was started since 1973 (Baniya et al., 1993) in Nepal. What are the problems considered important during this time remained important still now. Because of high genetic diversity in Nepal it is supposed that there may be more chances to develop ideal plant suitable to different agroecological zones. Problems encountered by researchers and farmers are high seed abortion (Morris, 1991), self/cross incompatibility, self sterility, frost susceptible, low and unstable grain yield, dormancy, heterostylism, low vigor of inbred lines (Bohanec, 1995), tightly adhering husk which is hard to remove, low groat content, bitterness Campbell, 1995), indeterminate, photosensitive, genetic erosion, shattering etc. Narrowing the diversity is another major issues. Landraces which are popular will continue to be cultivated by farmers resulted in conservation of these genotypes. Wild and poor landraces of buckwheat are endanger. Many landraces and wild spp. have been exported elsewhere. Availability of genotypes for research and development may be the constraints in future. Farmers and scientists are interested in buckwheat development because of its growth period and nutrient contents. Due to inherent problems, common buckwheat is not well adapted to plant breeding. The transfer of valuable genetic traits such as self-fertility, frost tolerance and important agronomic characters such as grain yield have so far proved to be very difficult due to the cross incompatibility of common buckwheat. Major problems considered genetically important are self-incompatibility caused by dimorphic heterosylism and controlled by single gene, incomplete reproductive organ mainly in the female, failure of fertilization and seed collapse in the post zygotic stage. Major emphasis therefore should be given to develop the self-compatible flower, which open the door for genetic study and improvement. Breeding works based on the genetic information may be the best method for solving the problems faced by the farmers.

Practical applications of biotech

Biotechnology can be applied for the study of genetic diversity and development of genetic markers. Diversity at biochemical and DNA level is more reliable and PCR based markers is necessary for molecular breeding. Marker assisted selection will speed up the breeding works in buckwheat. Embryo rescue is suggested for development of F_1 hybrids between species within genus *Fagopyrum*. Achievements made on the regeneration of plants *in vitro* indicate the possibility of developing transgenic plants.

Opportunities

Nepal, where 15 spp. of buckwheat found (Baniya et al., 1999) is one of the centers of diversity for buckwheat (Baniaya et al., 1995). Buckwheat is grown in Nepal from 60 to 4200 m altitudinal range all over the country and all the year round. It is a minor food and cash crop in Nepal nevertheless, it is a staple and life-supporting crop in the remote food deficit areas, where buckwheat contributes about a third of food items. 507 accessions of buckwheat are collected and studied in Nepal (Dongol and Baniya, 1993). High yield variation between and within common and tartary buckwheat is observed. Particularly Himalayan region is very rich in buckwheat genetic resources due to its adaptation in diverse stress climatic conditions, unique crop to suit in different cropping patterns, high nutritious crop and as an emergency crop. Our ancestors developed the local varieties suitable to specific area. Hybridization and selection based on the genetic principles are not in use in Nepal. Therefore the expectation of what will be the genetic recombinants and selection response remained unanswered. Diversity assessments at biochemical and DNA level and buckwheat development on the basis of diversity are the potential areas. Breeding work should be carried out on the principle: local genes contribute more for the betterment of farmers than the introduced genes. Twelve biotechnological institutes in Nepal and 15 biotech experts in NARC (BP Regmi, NARC, Personal comm.) indicate the possibility of buckwheat development through biotechnology in Nepal.

Conclusion and future directions

Buckwheat is considered an important crop for the livelihood of marginal farmers in Nepal. Therefore scientific research works on buckwheat including *in situ* conservation should be emphasized. Conservation and variety development program of buckwheat should be carried out simultaneously. Varity development either by conventional or by unconventional method is the top most priority area. Diversity studies at morphological, biochemical and DNA level are the prerequisite for buckwheat improvement. The problems encountered in the buckwheat development may be solved using the biotechnological tools. Achievements made at the international level on biotechnological research of buckwheat encouraged the Nepalese scientists to involve in the improvement of the buckwheat through biotechnology.

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RAPD analysis for genetic variation in Nepalese Populations of wild buckwheat (*Fagopyrum cymosum* Meisn.) with reference to *in situ* conservation

a. **Genetic diversity among the populations of *F. cymosum* in Nepal and their genetic relationship**
b. **Monitoring of genetic variations in three populations of *F. cymosum* in Nepal**

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Abstract

Random amplified polymorphic DNA (RAPD) was used to assess genetic diversity of Nepalese populations of wild buckwheat (*Fagopyrum cymosum* Meisn.). Two experiments were performed. In the first experiment, genetic diversity in the populations collected in three regions in Nepal was studied, along with a few accessions from China and India. Formation of separate groups of Chinese and Nepalese populations in the dendrograms could be explained due to geographical variations. Within Nepalese populations, geographical variation was also observed dividing the populations into mid-western, western and central regions. Indian population was grouped with the population from mid-western Nepal. The second experiment was to monitor the changes of genetic variation in two years (1999 and 2000), in three selected populations. Changes in variation were observed in two populations (Sahartara and Boch) whereas no change was observed in one population (Juphal). On the basis of present data, it is suggested that *in situ* conservation of wild buckwheat should be undertaken on regional basis in Nepal. The significant change of genetic diversity over the years in two out of three populations would suggests need of more than two years of monitoring for understanding of population structure and genetic change of *F. cymosum* population over time.

Key words: *Fagopyrum cymosum*, genetic diversity, population structure, RAPD

Introduction

Fagopyrum spp. is widely observed plant in highlands of Nepal. Two species of buckwheat (*F. tataricum* Gaert. and *F. esculentum* Moench) are cultivated as a major summer crop in the mountainous area. They supply a significant portion of the food requirement especially in highlands above 2000m. Although maize has been gradually replacing to buckwheat due to taste preference and high yield, buckwheat still keeps significant position in the agricultural system in this area. Buckwheat is short growing and more sustainable crop than maize in infertile highlands (Bimb, 2000), while maize requires high input and is not adapted to whole part of this area. In addition to cultivated species, wild buckwheat, *F. cymosum* Meisn. is found in hilly and highland area (Ujihara and Matano, 1976). It grows in the sloping and terraced land along riversides, around the fields of buckwheat, millets and maize in hilly areas of Mustang and Dolpa districts, mostly in disturbed environments due to such as grazing by animals and erosion of lands (Fukuoka et al., 2000; Nakayama et al., 2001). Ujihara and Matano (1982) reported high level of genetic variation in Nepalese wild buckwheat based on geographical distribution and grain shape. Generally, wild relatives of crop plants are important genetic resources for the improvement of their related crops for disease resistance (Harlan, 1976; Stalker, 1980; Lenne and Wood, 1991) and other important traits. In common buckwheat, yield and fertility are the traits need to be improved. In this context, conservation of genetic diversity and evaluation of *Fagopyrum* species including wild species become important areas of work in conservation and utilization of *Fagopyrum* genetic diversity.

Field surveys were organized in 1999 and in 2000 to collect *Fagopyrum* species in Nepal. Since wild species, *F. cymosum* is allogamous perennial plant (Campbell, 1995; Ohinishi and Matsuoka, 1996), genetic basis of a population seems to be complicated and need to be studied in making action plan of conservation for this species. In the previous study, random amplified polymorphic DNA (RAPD) analysis was used to assess genetic diversity in eight populations of *F. cymosum* in two mountainous districts (Dolpa and Kaski) of Nepal along with two populations from China (Bimb et al., 2000). That study detected geographical variation which suggested that Nepalese populations were clearly different from the samples in China which was considered to be the origin of *F. cymosum* (Ohnishi, 1998). It is worthwhile to further investigate the genetic diversity of Nepalese populations in different parts of the country. With this background, in this study, two experiments were conducted.

a. Genetic diversity among the populations of *F. cymosum* in Nepal and their genetic relationship
b. Monitoring of genetic variations in three populations of *F. cymosum* in Nepal

In the first experiment genetic variation of Nepalese population together with the populations from China and India as reference were studied. Present study used three populations from China and one from India. This experiment provided a basis for geographical variation of the populations. Their genetic relationship is discussed based on their similarity in DNA level. Second experiment is to study annual change of the degree of genetic variation within a population. Genetic variation in three populations was estimated and their changes overtime were compared. Based on two year's study, the factors responsible for the change are discussed and plans for long term survey is presented.

Materials and methods

Plant material

The seeds were collected from a total of eleven populations of *F. cymosum* in Nepal. Seven populations (Dunai, Shahartara, Rasi, Ruma, Juphal, Dangiwada and Lhara) from Mid-western, three from Central (Boch, Imadol and Machhe Gaun), one from Western region (Lumle) of Nepal (Table 1 and Fig. 1). From each population, 29-30 seeds were randomly sampled. In experiment 1, all the populations were used together with two populations from Yunnan, China (Dali and Baoshan) and one each from Sichuan, China (Yuehua), and Ultar Pradesh, India (Duwali) as a reference. Seeds of the references were kindly provided by Prof. O. Ohnishi, Plant Germplasm Institute, Kyoto University, Japan. For three populations (Dangiwada, Dunai, Lhara and Imadol), the seeds collected in 1999 were used while in others those collected in 2000 were used in this experiment. In experiment 2, three populations (Juphal, Boch and Shahartara) where the seeds collected in both 1999 and 2000 were used. Two populations, Juphal and Shahartara were from Mid-western region, 20 km apart each other, while one population Boch was from Central region, which is more than 300 km apart from Juphal and Sahartara. Twentry individuals were used in each population.

Freshly harvested seeds were incubated at -23^{o}C for 10 days to break the dormancy. After the treatment with fungicide Benlate-T (Dupont) solution (5 mg ml^{-1}), 15-20 seeds were placed on the filter paper with Benlate solution in petri dish followed by incubation at 25^{o}C in dark. After 4 to 7 days, the germinated seeds were transferred to plastic pot and grown in a greenhouse until sampling for DNA extraction.

DNA extraction

Total DNA was extracted from fresh young leaves of 15-20 day old seedlings using the CTAB method (Murray and Thompson, 1980). Briefly, 0.32-0.42 g of fresh young leaves ground in liquid nitrogen were mixed with 800 μl of extraction buffer (2% cetyltrimethyl ammonium bromide, 0.1 M Tris-HC1 pH 8.0, 0.02 Mm EDTA, 1.4 M NaC1 and 0.3% 2-mercaptoethanol) followed by incubation at 55^{o}C for 60 minutes. After addition of 500 μl of chloroform-isoamylalcohol (24:1 v/v), the mixture was gently mixed for 25 minutes and centrifuged at 12000 rpm for 5 minutes. The upper aqueous layer was mixed with 80 μl of 10% CTAB solution (10% CTAB 0.7 M NaC1) and 500 μl of chloroform-isoamylalcohol (24:1 v/v) followed by mixing for 25 minutes. After centrifugation at 12000 rpm for 5 minutes, the supernatant was mixed with 800 μl of precipitation buffer (1% CTAB, 50 mM Tris-HC1 pH 8.0, 10 mM EDTA) and sit overnight for the precipitation of DNA. After centrifugation at 12000 rpm for 1 minute, pellet was dissolved in 250 μl of HS-TE (1 M NaC1, 10 mM Tris-HC1 pH 8.0, 1 mM EDTA and 20 ng of Rnase) and incubated for 12 hours at 42^{o}C. Then 250 μl of 2-propanol was added to precipitate DNA. After rinsing with 70% ethanol DNA was suspended in 50 μl of 0.1 x TE buffer (10 mM Tris-HC1 pH 8.0, 1 mM EDTA). The concentration of DNA was determined by using agarose gel electrophoresis against a known concentration of DNA.

RAPD analysis
Amplification reactions were performed in 10 μl reaction volumes consisting of 10mM Tris-HC1 pH 8.3, 2 mM $MgC1_2$, 0.2 mM dNTPs, 1 mM primer, 0.35 unit of Taq DNA polymerase (Perkin-Elmer) and 1 ng of total DNA as template. Ten 10meroligonucleotide that were selected in previous study (Bimb, 2000) were used (Table 2). PTC-100 thermocycler (MJ Research, USA) was programmed for 45 cycles of 1 min at 93.5^{0}C, 2 min at 36^{0}C, and 3 min at 72^{0}C for PCR. The amplification finished by incubating at 72^{0}C for 7 min, followed by 5^{0}C soak. Amplified products were separated in 1.4% agarose gel in 0.5 x TBE buffer. The gels were run for 2.5-3 h at 70 V, stained with ethidium bromide, and photographed on a UV-transilluminator.

Data analysis
For each individual, the presence (1) or absence (0) of each band was determined. The DICE coefficient that is defined as the proportion of shared bands to the sum of bands between two individuals was used for calculating the degree of similarity between them. The DICE coefficient of all pair-wise combinations was calculated for similarity of a population and that between two populations which are obtained based on the average of coefficient among individuals in the population and that between two populations, respectively. These data were further used for cluster analysis by the unweighted pair group method (UPMGA) and principal coordinate analysis (PCA) using computer software NTSYSpc ver. 2.02 h (Extra Software, NY). Tukey (HSD) test was conducted to test the difference of the average of DICE coefficient using computer program GLM of SAS (SAS Institute).

Results

Genetic diversity among the populations of F. cymosum in Nepal and their genetic relationship
RAPD analysis was conducted using 10 primers for 11 populations of *F. cymosum* in Nepal with reference populations from China and India. Twenty individuals from each population were used for the analysis while only 12 were available for the populations from Rasi population due to poor germination. Eighteen and 7 plants were used for the populations from Baoshan (Ynnan, China) and Duwali (Uttar Pradesh, India), respectively. A total of 105 DNA bands were detected among samples tested in this experiment. The number of bands per primer varied from 9 to 12 (Table 2) and primers P217, P232 and P270 gave the highest number of 7 polymorphic bands while primers P209 gave the lowest 2 bands. A total of 46 polymorphic bands were scored for stastical analysis.

To compare the degree of diversity of the populations, the average of DICE coefficient among the individuals in a population was calculated (Table 3). The average ranged from 0.85 for Yuehua (Sichuan, China) to 0.96 for Duwali (Uttar Pradesh, India). Among Nepalese population, the average ranged from 0.89 for Dangiwada (Mid-western) and Lhara (Mid-western) to 0.94 for Boch (Central), Rasi (Mid-western) and Sahartara (Mid-western). The differences in average of DICE coefficient were not significant in all the populations except two references, Yuehua (Sichuan, China), and Duwali (Uttar Pradesh, India) according to the Tukey (HSD) test at 5% level. The average of DICE coefficient in a population was lager than those between populations in all cases (Table 3). Cluster analysis resulted in a dendrogram dividing the populations into three major groups (Fig. 2). The first group comprised of the populations from Nepal. The second and third group comprised of the two populations from Yunnan, China (Dali and Baoshan) and one from Sichuan, China (Yuehua), respectively. Among Nepalese populations, the populations from the same area had similarity each other than those from the other area. The similar result was obtained by principal coordinate analysis (Fig. 3a). The population Duwali from Uttar Pradesh, India was grouped together with the populations from Mid-western Nepal.

Monitoring of genetic variations in four populations of F. cymosum in Nepal

Degree of genetic variation and its annual change were analyzed in three populations of *F. cymosum* in Nepal using 46 RAPD bands obtained by 10 primers. Averages of DICE coefficient in a population was compared between the seeds collected in 1999 and 2000 (Table 4). Significant increase in averages of DICE coefficient was observed in two populations except Juphal population according to the Tukey (HSD) test. In terms of relative levels of genetic variation among three populations, Juphal population was higher than other two both in 1999 and 2000 while the other two had same level both years. Although degree of annual changes in a population was different among populations, the cluster analysis grouped the samples collected in different years from the same populations together (Fig. 4). The similar result was obtained by principle coordinate analysis (Fig. 5).

Discussion

Fagopyrum is important species in agriculture of highland area in Nepal and genetic diversity of its wild relative *F. cymosum* need to be conserved for improvement of this crop species. *In situ* conservation has an advantage for heterogeneous field populations such as wild species (Vaughan and Chang, 1992), while natural condition involves changes, which includes loss of diversity (Smithon and Lenne, 1996; Lenne and Wood 1999). Hence, genetic diversity and its change of a population need to be studied to enhance understanding of genetic aspect of the populations for *in situ* conservation. Level of genetic variation and its change and genetic relationship among population are important information to choose the population for *in situ* conservation. The present study analyzed genetic variation within and among populations of wild buckwheat *F. cymosum* in Nepal using RAPD makers. Annual change of genetic diversity also analyzed in several populations.

Genetic diversity among the populations of F. cymosum in Nepal and their genetic relationship

A total of eleven populations from western, mid-western and central regions of Nepal were analyzed along with the populations from China and India. The level of diversity of the populations was almost similar range (Table 3) although the size of the population was different among populations (data not shown). Effective population size that is relevant to genetic diversity is not equal to actual plant number in a population (Barrett and Kohn, 1991). Many factors such as temporal fluctuation in number, nonrandom mating and age-and-size structure associated with effective population size. The survey for effective population size is important to understand population structure. Based on the cluster analysis and principal coordinate analysis, populations used in this study were classified into three major groups (Fig. 2 and 3a). The first major group included all the populations from Nepal and the one from India (Duwali). The second major group was formed with the populations from Yunnan province of south China (Dali and Baoshan). The third is the outstanding population from Sichuan province of China. Yunnan or/and estern Tibet has been suggested to be the centre of origin of tetraploid *F.cymosum* (Yasui and Ohnishi, 1998; Yamane and Ohnishi, 2001). Higher level of genetic variation in Chinese *F. cymosum* in the present study is consistent with this hypothesis. Present results also suggest that Nepalese populations are different from Chinese populations used in this study. The sample from the eastern Tibet was not included in the present study due to unavailability of seeds. Future study with samples from eastern Tibet, Bhutan and Nepal will further highlight the genetic relationship among them and genetic diversity of *F. cymosum* in this area. Based on the RAPD data, some level of geographic differentiation could be noticed among the Nepalese populations (Fig. 2 and 3b). The populations from Mid-western region of Nepal were grouped into one sub-group. The second sub-group included three populations from Central region (Boch, Imadol and Machhe Gaun) and the third is Lumle population from Western region of Nepal (Fig. 3b). This indicates that *in situ* conservation should be undertaken on regional basis in Nepal.

Table 1. Populations of *Fagopyrum cymosum* used in this study

Country/Regi on	District/ Province	Village/Location (Population name)	Code No.	Altitude, m	Sampling year
Nepal, Mid-western	Dolpa	Juphal	1	2410	1999/2000
Nepal, Mid-western	Dolpa	Dangiwada	3	2260	1999
Nepal, Mid-western	Dolpa	Dunai	6	2050	1999
Nepal, Mid-western	Dolpa	Rasi	7	2900	2000
Nepal, Mid-western	Dolpa	Sahartara	8	2303	1999/2000
Nepal, Mid-western	Dolpa	Lhara	9	2820	1999
Nepal, Mid-western	Dolpa	Ruma	25	2370	2000
Nepal, Western	Kaski	Lumle	23	1675	2000
Nepal, Central	Dolakha	Boch	4	2230	1999/2000
Nepal, Central	Lalitpur	Imadol	26	1360	1999
Nepal, Central	Kathmandu	Machhe Gaun	27	1410	2000
India	Uttar	Duwali (18643)*	InUt	-	-
China	Pradesh	Dali (C9748)*	ChY	-	-
China	Yunnan Yunnan	Baoshan(99-10-24-4)*	ChBo	-	-
China	Sichuan	Yuehua (C9911)*	ChSi	-	-

* Seeds provided by Prof. O Ohnishi, Plant Germplasm Institute, Kyoto University, Japan and their accession number is indicated.

Table 2. Primers used in this study

Primer	Sequence (5'---------3')	Size range of scored bands, bp	Bands observed	Bands scored
P41	GAGTGCGCAG	700-1400	9	3
P141	GTGATCGCAG	360-1700	9	3
P189	TGGGTCCCTC	1200-2100	11	3
P202	CGCAGACTTG	500-1700	9	3
P205	GCCGTGAAGT	800-2100	11	5
P209	GGCGTCGGGG	600-2900	10	2
P217	GGGTTGCCGT	360-1900	11	7
P222	GTCACCCGGA	700-1700	11	6
P232	GCGCATTAGA	700-1600	12	7
P270	AGCCAGTTTC	400-2700	12	7
	Total		105	46

Table 3. Average of DICE coefficient for within and among populations of *Fagopyrum cymosum* from Nepal, China and India†

Population	Region/Country	Juphal	Dangiwada	Dunai	Rasi	Sahartara	Lhara	Ruma	Lumle	Boch	Imadol	Machhe Gaun	Duwali	Dali	Baoshan	Yuehua	
Juphal	Mid-western	0.91±0.05	def														
Dangiwada	Mid-western	0.83±0.06	0.89±0.08	f													
Dunai	Mid-western	0.85±0.04	0.87±0.06	0.94±0.04	bc												
Rasi	Mid-western	0.89±0.04	0.86±0.07	0.89±0.04	0.93±0.05	bcd											
Sahartara	Mid-western	0.89±0.04	0.84±0.07	0.87±0.04	0.91±0.04	0.94±0.04	b										
Lhara	Mid-western	0.82±0.04	0.85±0.06	0.85±0.04	0.85±0.04	0.84±0.05	0.89±0.07	ef									
Ruma	Mid-western	0.87±0.04	0.82±0.07	0.84±0.05	0.89±0.04	0.89±0.03	0.84±0.05	0.93±0.04	bcd								
Lumle	Western	0.77±0.05	0.72±0.08	0.75±0.05	0.79±0.05	0.80±0.05	0.76±0.05	0.81±0.05	0.91±0.05	def							
Boch	Central	0.83±0.04	0.79±0.06	0.79±0.05	0.82±0.04	0.83±0.04	0.79±0.04	0.82±0.04	0.75±0.05	0.94±0.04	b						
Imadole	Central	0.81±0.05	0.76±0.07	0.76±0.05	0.82±0.05	0.83±0.04	0.79±0.05	0.84±0.05	0.81±0.05	0.82±0.03	0.92±0.05	cd					
Machhe Gaun	Central	0.81±0.05	0.77±0.08	0.77±0.05	0.82±0.05	0.81±0.04	0.79±0.05	0.83±0.05	0.77±0.06	0.85±0.04	0.84±0.04	0.92±0.05	bcd				
Duwali	Uttar Pradesh	0.86±0.04	0.81±0.06	0.83±0.03	0.84±0.05	0.88±0.03	0.83±0.06	0.88±0.03	0.79±0.04	0.84±0.04	0.78±0.04	0.82±0.05	0.96±0.03	a			
Dali	Yunnan, China	0.52±0.05	0.52±0.05	0.05±0.05	0.53±0.05	0.53±0.05	0.54±0.05	0.54±0.06	0.51±0.05	0.61±0.06	0.56±0.05	0.56±0.05	0.52±0.05	0.91±0.05	cde		
Baoshan	Yunnan, China	0.52±0.04	0.52±0.05	0.52±0.05	0.55±0.04	0.55±0.04	0.51±0.06	0.55±0.05	0.59±0.05	0.61±0.05	0.57±0.05	0.55±0.05	0.51±0.04	0.78±0.06	0.91±0.05	cde	
Yuehua	Sichuan, China	0.39±0.05	0.33±0.07	0.30±0.05	0.37±0.04	0.36±0.06	0.35±0.05	0.39±0.05	0.42±0.05	0.42±0.05	0.40±0.05	0.42±0.05	0.39±0.06	0.52±0.07	0.52±0.06	0.85±0.08	g

† Standard deviation is indicated with ± following average. The data followed by same letters are not significantly different according to the Tukey (HSD) test.

Table 4. Average of DICE coefficient for the samples collected in 1999 and 2000 in three populations of *Fagopyrum cymosum* in Nepal†

Population	Region	1999	2000
Juphal	Mid-western	0.90 ±0.06[a]	0.91 ±0.05[a]
Sahartara	Mid-western	0.92 ±0.06[b]	0.94 ±0.04[c]
Boch	Central	0.92 ±0.04[b]	0.94 ±0.04[c]

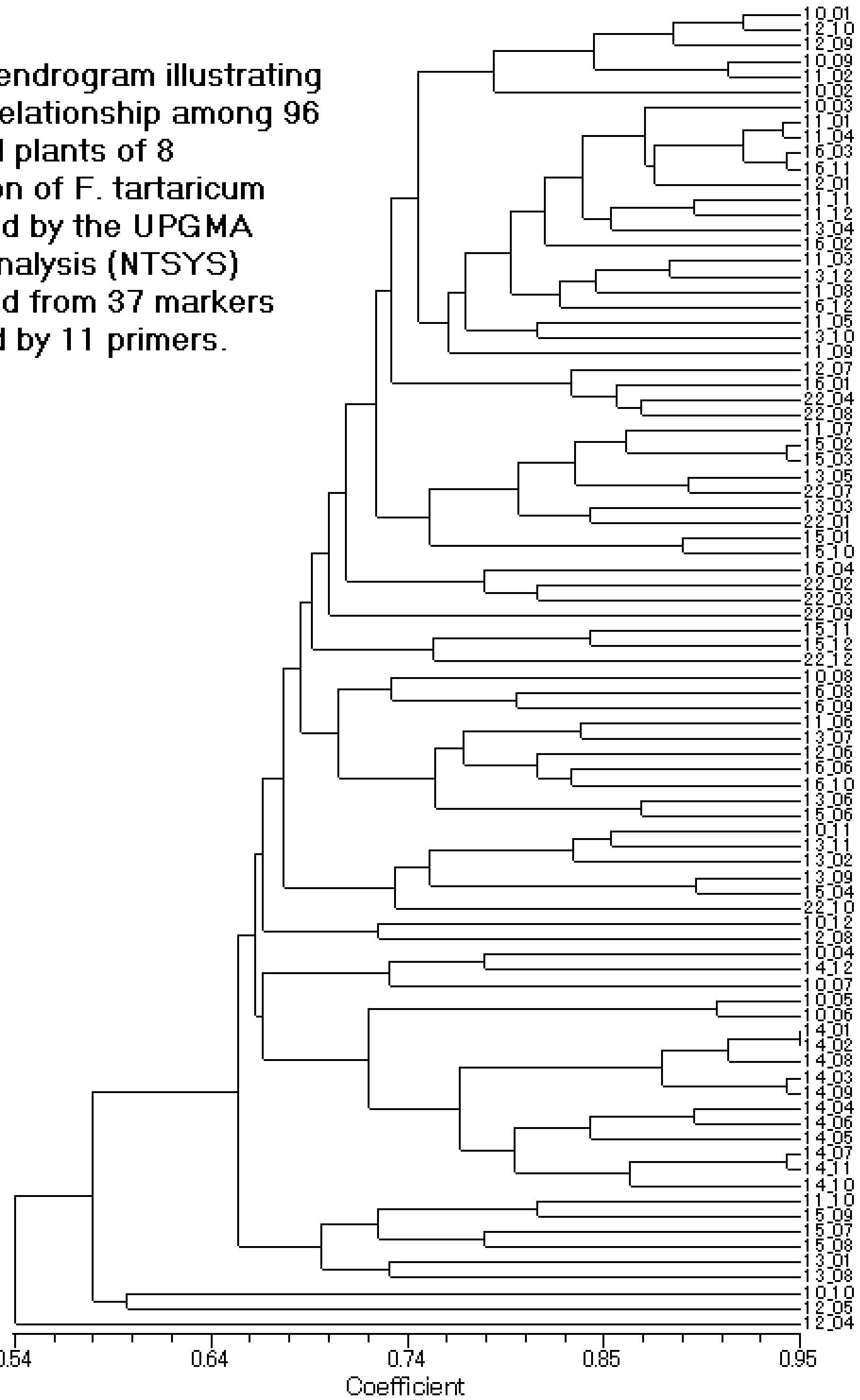
† Standard deviation is indicated with ± following average. The data followed by same letters are not significantly different according to the Tukey (HSD) test.

Monitoring of genetic variations in three populations of F. cymosum in Nepal

Three populations, two from Mid-western region (Juphal and Sahartara), One from Central region (Boch), were analyzed to monitor the genetic variation over a period of on year (1999 and 2000). In the present study, significant difference of genetic diversity was observed between years of collection for Sahartara, and Boch populations while Juphal was not significant. Both in Sahartara and Boch population genetic diversity was significantly lower in 2000 than in 1999 (Table 4). The reason of the changes is unclear. Since *F. cymosum* is allogamous perennial plant (Campbell, 1995) and grows mostly in disturbed environments due to grazing or erosion of lands, not a few factors may be responsible for this change. The result of cluster analysis (Fig 4 and 5) indicated that similarity of the samples collected in different years from the same population were higher than those from different populations even between the sites in the same district. This may suggest that the genetic change short term in a population is smaller than genetic difference among populations. Though the results give us some indication of some variation over the years, monitoring genetic variation over time in *F. cymosum* would need more than two years of study. As mentioned above, population structure including age-and-size structure and reproductive manner should also be investigated in each population. Additionally, environmental and socio-economic information should be integrated with genetic diversity data to reach in certain conclusions.

Wild relatives may represent the most extensive basic variation ever accumulated in a crop species and thus be needed in the future crop improvement programmes. Several of the benefits derived from wild relatives of crops have been well documented (Oldfield, 1989; Prescott-Allen and Prescott-Allen, 1983). In addition, many possibilities currently exist for extended wide hybridization and rebuilding genomes (Tanksley and McCouch, 1997). Therefore, future work should focus on the analysis in gene level for all the species in the genus *Fagopyrum* available in Nepal, and identifying useful genes in wild/weedy species for varietal improvement. Survey and collections of *Fagopyrum* species should be enhanced especially in eastern hills to understand genetic diversity and genetic diversity of wild buckwheat more clearly.

Fig. 1. Dendrogram illustrating genetic relationship among 96 individual plants of 8 population of F. tartaricum generated by the UPGMA cluster analysis (NTSYS) calculated from 37 markers produced by 11 primers.



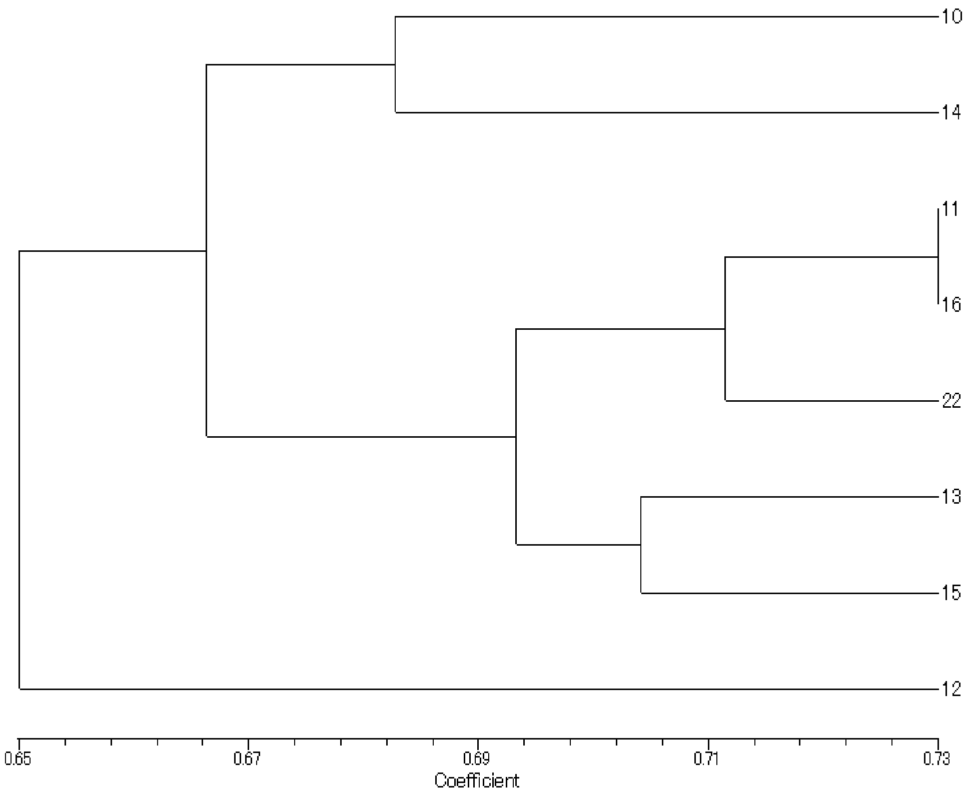


Fig. 2. Dendrogram illustrating genetic relationships among 8 populations of *F. tartaricum* generated by the UPGMA cluster analysis (NTSYS) calculated from Table 3 for similarity coefficient.

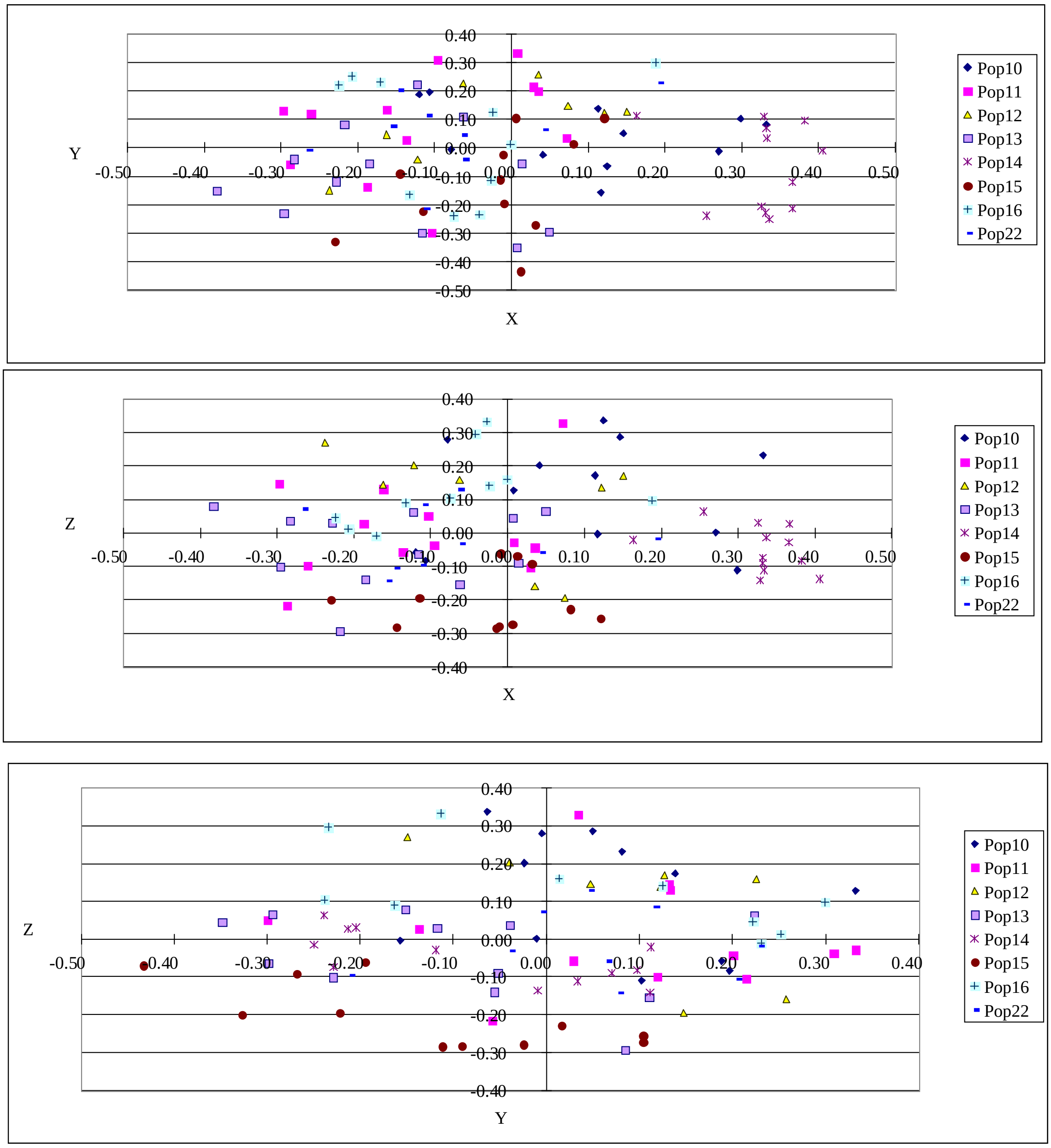


Fig. 3. Plot figures generated by principal coordinate analysis for 96 individuals of 8 populations of F.

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Genetic diversity in Nepalese populations of *Fagopyrum tataricum* revealed by RAPD assays

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Abstract

Random amplified polymorphic DNA (RAPD) was used to assess genetic diversity in eight populations (96 individuals) of cultivated *tite* buckwheat (*Fagopyrum tataricum*) sampled from three mountainous districts of Nepal. This study includes 37 polymorphic markers (46.25%) from the total of 80 bands. Genetic variability was estimated using similarity coefficient. Three groups were formed in dendrogram. These groups could not be explained due to geographical distance between them. On the basis of genetic data, *in situ* conservation strategies were suggested.

Key words: *Fagopyrum tataricum*, genetic diversity, poligonaceae, RAPD

Introduction

Buckwheat (*Fagopyrum* spp.) is a major summer crop in Nepal that supplies a major portion of the food requirement in high hills (above 6000 ft). The common buckwheat (*F. esculentum*) is referred to as *mithe* buckwheat while tartary buckwheat (*F. tataricum*) is called *tite* buckwheat. *F. tataricum* is mainly self-pollinated with greenish to white flowers and is mostly cultivated in high hills under irrigated condition in Mustang area and rain-fed condition in Dolpa area for local consumption (Bimb, 2000). *F. tataricum* is a rich source of rutin that is a medicinal agent for the treatment of vascular disorder and has been found to be higher in genotypes from Nepal (Kitabayashi et al., 1995). Yield of *F. tataricum* is higher than *F. esculentum* (Bimb, 2000). Since the area of production is declining and new crops are replacing *F. tataricum*, many landraces may disappear in near future. Thus collection and conservation of *F. tataricum* genetic resources are the urgent priorities. To date this species is maintained by farming communities in the mountains where the crop is adapted under low input requirements (Bimb, 2000). Hence, population genetic divergence or the extent to which the populations of *F. tataricum* differ genetically from one another is a crucial variable in planning for their *in-situ* conservation. In this regard, field surveys were organized in 1999 to identify and collect *Fagopyrum* spp. at Dolpa and Dolakha areas where *F. tataricum* is common (Table 1) (Fukuoka et al., 2000). Collected samples were brought to National Institute of Agrobiological Resources (NIAR), Tsukuba, Japan for the study of variation at DNA levels.

Random amplified polymorphic DNA (RAPD) techniques (Williams et al., 1990) have been used to characterize genetic diversity in populations. This assay is a technique that is sensitive, quick to perform and can be applied to a large number of samples. Furthermore, RAPD analysis does not demand isolation of large quantities of DNA and yet has the ability to span a high number of loci along the genome (Lynch and Milligan, 1994). This technique is a variant of PCR, in which a decamer oligonucleotide primer of arbitrary sequence is allowed to anneal at a relatively low temperature, priming the amplification of DNA fragments distributed at-random throughout the genome. The random primer used in this technique can effectively 'scan' a genome for inverted priming sites that are close enough to amplify the intervening sequences. The resulting RAPD polymorphism is of direct relevance to population genetics because it arises from one or a combination of the following: (1) nucleotide changes that prevent amplification through the introduction of a mismatch at the priming site, (2) deletion of priming site, (3) insertions that render the priming site too distant to support amplification cascades and (4) insertions or deletions that change the sites of amplification (Williams et al., 1990). Due to functionality-control in the evolution of gene families, the influence of ecological changes on the complexity and dynamics of RADP-detected repetitive DNA is particularly challenging (Devos and Gale, 1992; Nei, 1973; 1978; 1988; Hedrick, 1982). These attributes, coupled with reproducibility of strong bands in specific primer-temple combinations and locus specificity (Williams et al., 1990; Rejiseberg, 1996; Bustos et al., 1998) make RAPD very suitable for molecular population genetic analysis.

In this paper, we quantify within and between population genetic variation of *F. tataricum* using RAPD assays. This information will be useful in evaluating the significance of different populations repositories of genetic diversity in *F. tataricum*. Thus, the major objectives of this study are (1) to quantify the amount and distribution of genetic diversity within and among sub populations using genetic diversity measures and (2) to make conservation recommendations based on genetic data.

Materials and methods

Population samples

The locations of the *F. tataricum* populations where seeds were collected for this study are shown in Table 1. In each population 29-30 seeds were randomly sampled across their range of distribution. Seeds were grown in a greenhouse at the NIAR, Tsukuba, Japan to produce leaf materials for DNA extraction. Some of the populations did not germinate at all.

Table 1. Eight populations of *tite* buckwheat (*F. tataricum*) used in this study from different districts of Nepal

Accession No.	District	Village	Altitude, m	Date†
10	Dolpa	Dangiwada	2100	II
11	Dolpa	Vyasgad	2200	II
12	Dolpa	Sahartara	2407	II
13	Dolpa	Dhupichaur	2031	II
14	Dolakha	Boch	2232	II
15	Dolpa	Rasi	2880	I
16	Mustang	Samda	2656	I
22	Dolpa	Dunai	2010	I

† I, the first field survey in Sept 1999; II, the second field survey during 12-16 Nov 1999.

Table 2. Sequences of eleven 10-mer RAPD primers used in the analysis

Primer	Sequence (5---3)	Size range of scored loci, bp	Bands scored	Total bands observed	Remarks
P41	gagTgCgCAg	700-1400	3	6	Rice genome
P141	gTgATCgCAg	600-1700	2	7	Operon Tech
P189	TgggTCCCTC	1200-2100	2	6	Operon Tech
P202	CgCAgACTTg	1520-	1	7	TAG 91:654-667.'95. Lentil
P205	gCCgTgAAgT	800-2100	3	9	TAG 91:654-667.'95. Lentil
P209	ggCgTCgggg	600-1300	4	5	TAG 91:654-667.'95. Lentil
P217	gggTTgCCgT	700-1900	4	8	TAG 85:937-945.'93 Vicia faba
P222	gTCACCCggA	700-1700	4	9	TAG 85:937-945.'93 Vicia faba
P232	gCgCATTAgA	700-1600	4	9	Bio/Tec 10:686-690, conifer
P270	AgCCAgTTTC	400-2700	6	7	TAG 85:190-196.'92 Brassica
P292	CAAACggCAC	400-2000	4	7	TAG 86:788-794.'95 Alfalfa
		Total	37	80	

Extraction of DNA

Total DNA was extracted from fresh young leaves of 15-20 day-old seedling of 12-20 individuals from each population using the CTAB method following the method of Murray and Thompson (1980) with minor modifications. Fresh young leaves (0.25-0.4 g) were ground in liquid nitrogen using a previously chilled mortal and pestle. The grindate was added to 800 ml of extraction buffer [2% (w/v) CTAB (Cetyltrimethyle ammoniumbromide), 0.1 M Tris-HC1 buffer (pH 8.0), 0.02 M EDTA (pH 8.0), 1.4 M NaC1]. 2-mercaptoethanol (final concentration 0.3%) was added to 2CTAB before use.

The mixture was transferred to leveled 1.5 ml microtube and incubated in a water bath at 55^{o}C for 60 minutes. The homogenate was mixed with 500 µl of 24:1 chloroform:isoamylalcohol (v/v) and mixed gently in a rotator for 25 minutes. Following centrifugation at 14000 rpm for 5 minutes, the upper aqueous layer was transferred to a fresh labeled 1.5 ml microtube and 75 µl 10% CTAB (10% CTAB, 0.7 M NaC1) solution was added along with 500 µl of 24:1 chloroform:isoamylolcohol (v/v). The mixture was allowed to mix gently in a rotator for 20 minutes. Following centrifugation at 14000 rpm for 5 minutes the supernatant was carefully transferred using cut -pipette into a fresh labeled 1.5 ml microtube in which 800 µl of precipitation buffer [1% CTAB, 50 mM Tris HC1 (pH 8.0), 10 mM EDTA] was added and allowed to sit overnight for the precipitation of DNA. Following centrifugation at 14000 rpm for 1 minute, the supernatant was discarded and pillet was retained in the bottom of microtube. In the DNA pillet, 250 ml of HS-TE (1 M NaC1, 10 mM Tris-HC1 (pH 8.0), 1 mM EDTA) containing 10 µl of Rnase (Sigma R5125, 10 mg ml^{-1} Rnase) was added and incubated for digestion for 24-36 hours at 42^{o}C. When all the DNA was dissolved, equal volume (250 µl) of isopropanol was dispensed and gently but thoroughly mixed. Following brief centrifugation, the DNA pillet was retained and supernatant was discarded. The precipitated DNA was added with 1 ml 70% ethanol and mixed the solution with several inversions and then allowed to stand for 15 minutes. Following brief centrifugation, the supernatant was carefully discarded. The DNA was allowed to dry for 30 minutes by overlaying sheet of Saran Wrap onto the uncapped microtubes. The DNA was suspended in 50 µl of 0.1 TE buffer (10 mM Tris-HC1 (pH 8.0), 1 mM EDTA (pH 8.0) and stored in a refrigerator at 4^{o}C for further use. The purity and quality of DNA was determined using 0.8% agarose gel electrophoresis against a known concentration of unrestricted lambda DNA. Standard 5 ng ml^{-1} DNA working solutions were formulated for each sample in 0.1 TE. For PCR, standards 5 ng ml^{-1} DNA working solutions were further diluted in 0.1 TE to make 0.5 ng ml^{-1} concentration.

PCR condition

Amplification reactions were performed in 10.2 µl reaction volumes, with 5.4 µl sterile water (dd H_2O), 1 µl 10 x PCR reaction buffer (Perkin-Elmer), 0.8 µl of 25 mM $MgC1_2$ (Perkin-Elmer), l 0.2 µl of 10 mM of dNTPs, 0.5 µl of 20 mM Primer, 0.3 µl (1 U) of Taq DNA polymerase (Perkin Elmer), and 2 µl of genomic DNA template (0.5 ng µl^{-1}). One drop of mineral oil (Sigma) was overlayed in each reaction mixture. PCR reactions were performed on a PTC-100 thermocycler (MJ Research, Inc., USA) programmed for 45 cycles of 1 min at 93.5^{0}C for denaturation, 2 min at 36^{o}C for annealing and 3 min at 72^{o}C for extension. The amplifications finished with incubation at 72^{o}C for 7 min, followed by a 5^{o}C soak for 3 min until recovery.

Reproducibility tests on RAPD bands

The amplification reactions were first performed using representative DNA sample from each population as template DNA in the primer-screening program to identify informative primers. These primers then were used to study each genotype individually. The DNA bulks from each population were used to screen over 75 candidate RAPD primers. This enabled the identification of 11 consistently reproducible polymorphic primers (Table 2) that supported screening of up to 37 bands which were used to analyze all the sub-populations.

Agarose gel electrophoresis

Amplified products were separated in 1.4% agarose gels (Takara Biomedicals) in 1 X TAE [Tris, Acetic Acid anhydride and 0.5 M EDTA (pH 8.0)] buffer. The gels were run for 2.5-3 h at 70V, stained with ethidium bromide (10 mg ml^{-1}) and photographed on a uv-transilluminator. To determine RAPD profiles, the size of each band was inferred by comparison with a 1kb ladder of lambda DNA digested with PstI (Providencia stuartii-164) as a molecular weight marker (M). Only the amplified products that consistently appeared in two replications were scored as presence (1) or absence (0) for further analysis. Bands that were not clear were scored as 3 in the data matrix.

Data analysis

Bands observed by RAPD analysis were assigned a letter in relation to their migration within the gel. Bands with the highest molecular weight were assigned 'a', 'b' and so on in the alphabetical order until the bands of lower molecular weight was assigned. Due to unclear genetic interpretation of RAPD bands, we chose analytical methods that minimized the number of genetic assumptions. It was assumed that bands of the same molecular weight in different individuals were identical in nucleic acid sequence. For each individual, the presence or absence of each band was determined and designated (1), presence, or (0) absence.

Measuring genetic diversity

The similarity index was calculated as follows:
Similarity index = 2 Nij/(Ni+Nj) where i and j are sample, Nij is the number of shared bands; Ni and Nj are total number of bands of sample i and j. The index was calculated for all pair-wise comparisons and was used to construct a dendrogram by the UPGMA using computer software NTSYS 2.0. Similarity index within and between population were calculated based on the similarity coefficient matrix with NTSYS.

Results

Eleven primers (10-mer) were selected, after assaying 75, to amplify total DNA from samples of eight populations of *F. tataricum.* The selection of each primer was based, after several trials, on its suitable amplification of DNA from all the test samples. The selected primers amplified a total of 80 DNA products (Table 2). The total number of amplified bands per primer varied from 5 (P209) to 9 (P205, P222, P232). Primer P270 gave the highest number of 6 polymorphic bands and primer P202 gave the lowest of 1 polymorphic band out of a total of each 7 bands. A total of 37 polymorphic bands were used in scoring. The level of polymorphism shown by each primer was variable for the different populations. The size range of scored bands appeared differently for different primers. Primer P270 gave size range of 400-2700 bp where as primer P 202 gave one polymorphic band of 1520 bp for scoring.

A data matrix of DICE similarity coefficient was generated from the RAPD results. The coefficient was used to produce a cluster using the unweighted pair group method (UPMGA). The data derived from the analysis of similarity were used to construct a dendrogram (Fig. 1). Although the dendrogram presents not a clear-cut separation of the groups of individuals in the populations *F. tataricum* included in this study, however they may be broadly separated into three groups at 0.66 similarity coefficient. The first group associated with the samples from the populations 12. The second group comprised of population 14 with 10 and the third group included samples from the population 11, 13, 15, 16 and 22. The similarity coefficients of inter and intra populations are shown in Table 3. The intra population similarity coefficient ranged from 0.71 for population 12 to 0.83 for population 14. The dendrogram produced from the data of Table 2 also divides the populations into three main groups (Fig. 2) The relationships were further shown in Table 4 that presents the similarity coefficient of a population relative to the rest of populations. The range of similarity coefficient falls between 0.65 for population 12 to 0.69 for population 16. The standard deviations between and within populations were also estimated. The average intra-population standard deviation of population 14 was the lowest (0.101) where as population 12 possessed the highest value of 0.203 (Table 5). The cluster formation by principal coordinate analysis also showed mainly three groups of populations (Fig. 3).

Table 3. Average similarity coefficients for inter and intra populations of *F. tataricum*

Pop	10	11	12	13	14	15	16	22
10	0.75							
11	0.70	0.80						
12	0.66	0.69	0.71					
13	0.65	0.71	0.66	0.77				
14	0.69	0.67	0.63	0.66	0.83			
15	0.66	0.71	0.63	0.71	0.70	0.80		
16	0.69	0.73	0.67	0.71	0.66	0.68	0.79	
22	0.67	0.73	0.65	0.70	0.66	0.68	0.71	0.77

Table 4. Average similarity coefficient of a population compared with 7 other populations of *F. tataricum*

Pop	10	11	12	13	14	15	16	22
Av. Coeff.	0.75	0.80	0.71	0.77	0.83	0.80	0.79	0.77
Av. Coeff. of 7 populations	0.67	0.66	0.65	0.68	0.67	0.68	0.69	0.68

Table 5. Analysis of standard deviations to show inter and intra populations variations among 8 opulations of *F. tataricum*

Pop	10	11	12	13	14	15	16	22
10	0.085							
11	0.083	0.072						
12	0.068	0.072	0.097					
13	0.077	0.067	0.093	0.064				
14	0.082	0.068	0.098	0.071	0.063			
15	0.087	0.052	0.074	0.075	0.051	0.097		
16	0.079	0.078	0.092	0.079	0.063	0.080	0.122	
22	0.087	0.060	0.103	0.074	0.080	0.081	0.082	0.142

Discussion

Pilot experiments with various decamer-primers showed that no specific DNA segments were amplified from total buckwheat DNA using the RAPD assay conditions as described for soybean DNA (Williams et al., 1990). However, decreasing DNA template concentration (at 0.5 ng μl^{-1}), maintaining thermal profile at 93.5^{o}C for denaturation of template DNA and increasing concentration of Taq polymerase at 0.3%, amplification of discrete buckwheat DNA fragments was achieved. The reason for the lack of success in using the ‘soybean conditions’ is not clear, but it might be due to differences in purity between the various template and primer preparations or alternatively, to differences in the thermal profile generated by the respective PCR machine (Hoelzel, 1990). Once the proper conditions were established, ‘finger prints’ were reproducibly generated with different batches of genomic DNA. Eight populations of *F. tataricum* under study were collected from different mountainous regions of Nepal. There is an indication that geographical variation is not observed for genetic diversity in tartary buckwheat. Table 3 shows that population 14 is least and population 12 is highly diversified group, which is also supported by the standard deviation values for these populations. Population 14 is also associated with pop 10. Population 14 is 100 km east of Kathmandu and far from Dolpa district where as Sahartara is in Dolpa district enroute to Tibet. Rest of the populations lie within similar group within Dolpa and Mustang area (neighbor of Dolpa district). Therefore, on the basis of genetic data available, it can be suggested that populations 12 with most diversed population at Sahartara in Dolpa district and population 14 with least diversified but may posses different genetic information at Boch in Dolakha district should be given priority for *in situ* conservation of *F. tataricum* in Nepal. The results from the analysis are an empirical demonstration of the potential power and applicability of PCR-based technology for studies of the genetic diversity of buckwheat.

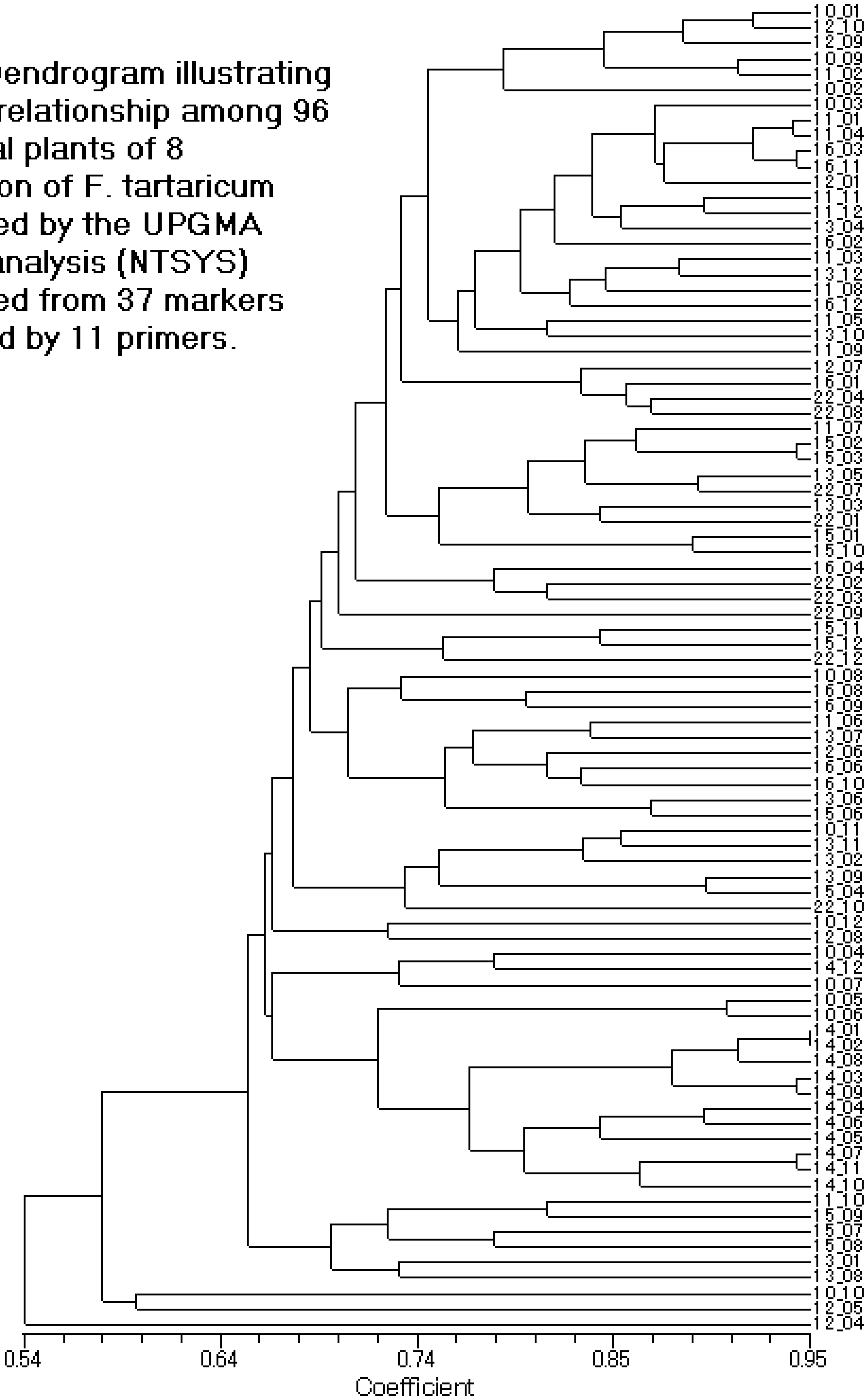

Fig. 1. Dendrogram illustrating genetic relationship among 96 individual plants of 8 population of F. tartaricum generated by the UPGMA cluster analysis (NTSYS) calculated from 37 markers produced by 11 primers.

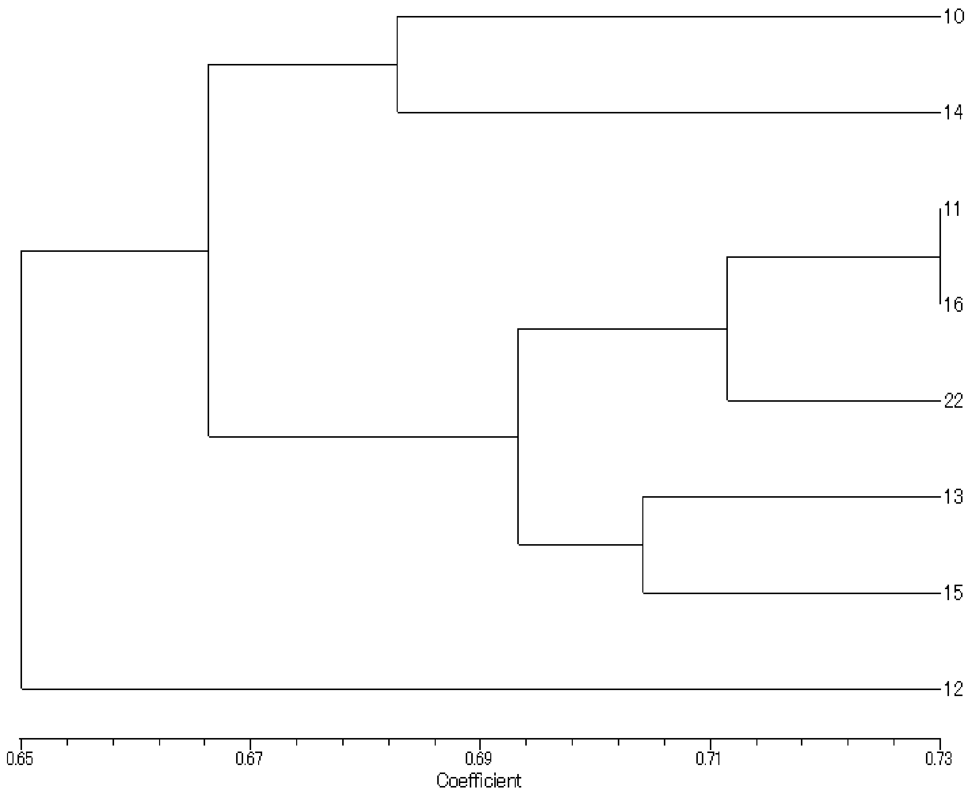

Fig. 2. Dendrogram illustrating genetic relationships among 8 populations of *F. tartaricum* generated by the UPGMA cluster analysis (NTSYS) calculated from Table 3 for similarity coefficient.

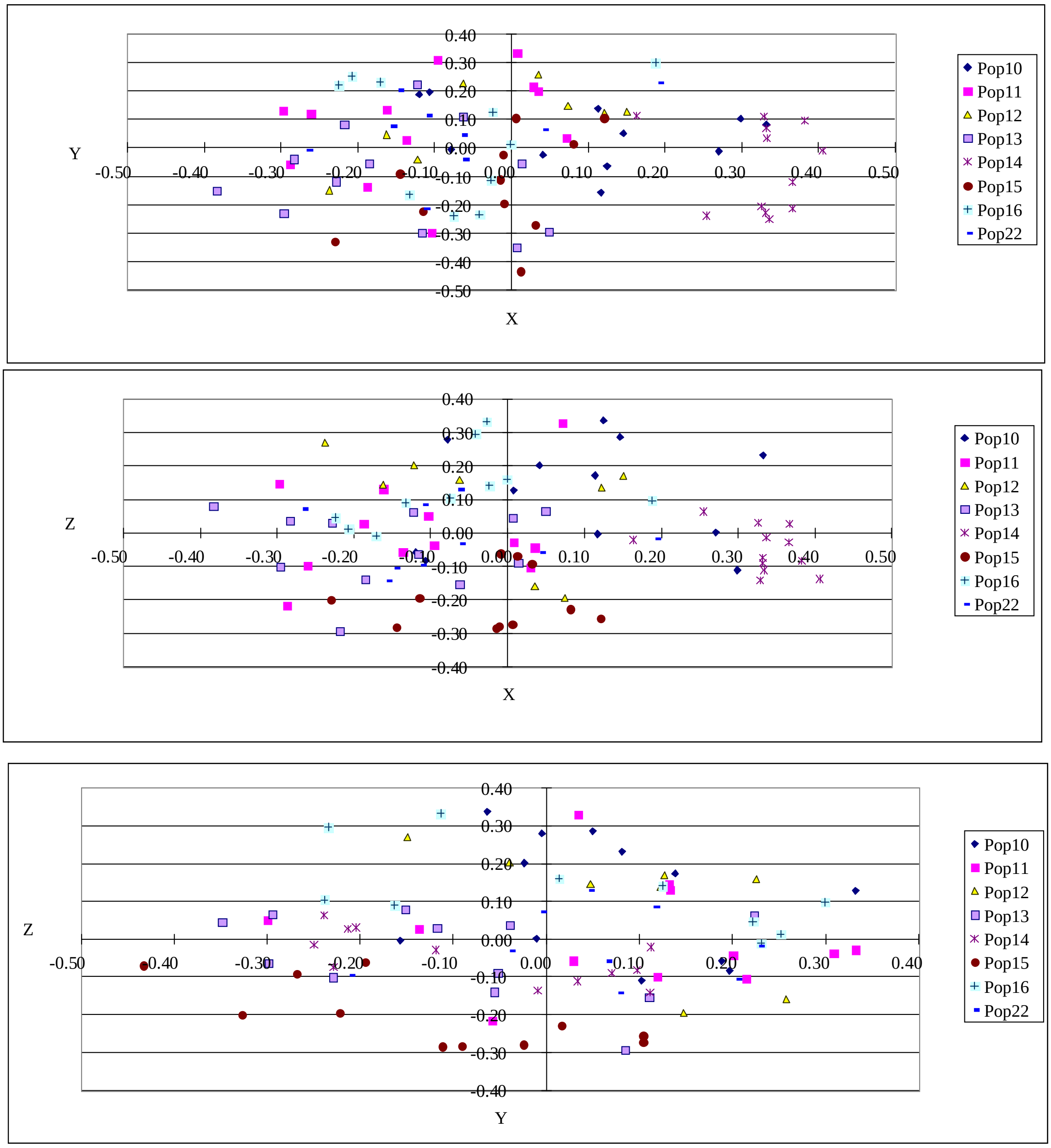

Fig. 3. Plot figures generated by principal coordinate analysis for 96 individuals of 8 populations of F.

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Allozyme variation in tartary buckwheat (*Fagopyrum tataricum* Gaertn.): A preliminary study in landraces from Jumla

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Abstract

Thirty-two landrace populations of *tite* buckwheat (*Fagopyrum tataricum* Gaertn.) from Urthu and Ghodasain villages of Jumla, Nepal were studied to investigate genetic diversity for allozyme variability. This study was based in three enzyme systems: peroxidase (Prx), malate dehydrogenase (Mdh) and alcohol dehydrogenase (Adh) by using horizontal starch gel electrophoresis. Diversity was measured for individual locus at various levels among the landrace populations. The studied enzyme systems revealed eight loci and 18 alleles including null alleles. Six of eight loci (75%) showed polymorphism. The percentage of polymorphic loci per population was 40.77%. Adh and Prx-4 were found with highest total genetic diversity 0.449 and 0.430 respectively. Allele frequency data revealed a low to moderate degree of population genetic diversity.

Key words*: Fagopyrum tataricum*, isozyme analysis, Jumla, landrace

Introduction

Buckwheat is an important crop in high mountainous regions of Nepal. *Mithe* (*Fagopyrum esculentum* Meisn.) and tartary (*Fagopyrum tataricum* Gaertn. ssp. *tataricum*) buckwheat are two common types grown extensively in mountainous regions. Tartary is a cold resistant and short duration easy crop with well adaptation in marginal lands, harsh climates and under low input conditions (Rana and Sharma, 2000). The crop fits well into various cropping systems and land types that are in use in high mountainous regions of the country (Baniya et al., 2000). It is a stable food crop supplying a major portion of the food requirement for the livelihood of the people in and above 6000 ft (Bimb et al., 2000). Local food of buckwheat are thick bread, *chapati*, thick porridge (d*hindo*), vegetables and pickles. Medicinal value of buckwheat has also been reported. Wild buckwheat populations (*F. tataricum* ssp. *potanini* and *F. cymosum* Meisn.) grow as natural populations. *F. cymosum* Meisn. is the most common wild buckwheat growing in sloppy and terraced lands of Nepal and is believed to be the ancestor of cultivated tartary buckwheat (Ohnishi and Matsuoka, 1996). Ghodasain (2450 masl) and Urthu Chautara (2380 masl) are two major sites identified with large cultivation of buckwheat in Jumla. Landraces have been grown and maintained by the farmers in these villages from generation to generation for their many desirable traits and for grains and green vegetables. Besides, the natural population of tartary buckwheat as wild has also been explored in Jumla.

Allozyme, single gene markers have been widely used as a reliable measure for detecting genetic diversity among populations of crop species at different levels (Brown and Clegg, 1983; Hamrick and Godt, 1997). Many studies on allozyme and RAPD marker variability in landraces and wild populations of buckwheat from different zones of the world have been carried to reveal genetic variation and origin of cultivated common and tartary buckwheat (Ohnishi, 1998; Tsuji and Ohnishi, 1998; Tsuji and Ohnishi, 2000; Bimb et al., 2000; Rana and Sharma, 2000; Huh and Huh, 2000). Present study is therefore aimed to estimate allozyme variability among the populations of bitter buckwheat landraces maintained by the farmers of Jumla.

Materials and methods

Collection sites

Ghodasain (2450 masl) and Urthu Chautara (2380 masl) were two villages identified as major buckwheat growing sites in Jumla (Rana et al., 2000). These sites are characterized by farming systems and land types e.g. *Gadkule* (irrigated land by snow melted *Tila* river), *Pakhobari* (marginal upland far away from homestead), *Lekh* (land situated at high altitudes far from villages), *Gharbari* (upland around homestead with kitchen garden) and orchard (Poudel et al., 1998). Two species common (*mithe)* and tartary (*tite)* buckwheat are cultivated. The area and yield of tartary type is higher than that of common type and its cultivation is associated with medium to poor farming households of ethnic group Chhetry (Rana et al., 2000). In total 32 households were randomly sampled and surveyed in two villages for the collection of seed samples. The collections consisted only the tartary the type of buckwheat.

Plant materials

A total of 32 buckwheat populations collected from two sites were studied for isozyme variation by using horizontal starch gel electrophoresis. Ten seeds of each population were used to ascertain the level of allozyme variability in these populations. Each collection from a farmer's field managed by a farmer is taken as a population.

Extraction of enzyme from seedling tissue

Enzymes were extracted from plumules of three day old seedlings grown in controlled condition of 20^{o}C in darkness. Plumules of seedlings of each population were cut into small pieces and crushed individually in pre-chilled cavity block with 3-4 drops of chilled extraction buffer of sodium ascorbate, pH 7.5 (GEVES, 1993). The crude extracts were absorbed with paper wicks (3- × 1.1-mm Whatman paper no. 3) and used for gel electrophoresis.

Electrophoresis run and enzyme detection

A horizontal starch gel (12.5%) was used to estimate allozyme variation. The composition of gel and electrode buffer systems used to assay three enzyme systems: peroxidase (Prx), malate dehydrogenase (Mdh) and alcohol dehydrogenase (Adh) is given in Table 1.

The gels were run for about 16 hrs at a constant watt of 4 at a temperature of 4^{o}C. After completion of gel run, each gel was then cut into three horizontal slices. Each slice was stained independently for a specific enzyme system. The names and the recipes for staining of Prx, Mdh and Adh were as suggested by Shields et al. (1983). Enzymes were separated into respective loci and discrete bands sequentially with respect to the migrating distances from origin. Each band as an allele of respective loci was scored as 1 for presence and 0 for absence. The enzyme banding patterns as zymograms were interpreted on the basis of migration distances traveled by each isozyme.

Data analyses

Isozyme band data was analysed for genetic diversity parameters such as frequency of alleles, alleles per locus, alleles per polymorphic locus (A and Ap), percentage of polymorphic loci (P) and heterozygosity (H). The total genetic diversity for species was analysed according to the method suggested by Nei (1973) using the GENESTAT statistical package. Genetic diversity within populations (Hs), Genetic diversity between populations (Dst) and the coefficient of gene differentiation (Gst) were also calculated to reveal the proportion of total genetic variation. Likewise, on the binary data of the scored bands, unweighted pair group method (UPGMA) cluster analysis was used to study genetic relatedness drawing a dendrogram employing NTSYS package (Rolf, 1993). Based on the combinations of the scored alleles (bands), different zymograms were constructed diagrammatically with respect to the enzyme systems.

Table 1. Composition of buffer systems used for gel and tank to run starch gel electrophoresis

Enzyme	Tank buffer	pH	Gel buffer
Peroxidase (Prx)	**0.05 M L-Histidine = 7.758 g** 0.024 M Citric acid H_2O = 5.044 g pH adjusted to 5.0 with citric acid Make up volume to 1 l with distilled water (DW)	**5.0**	**0.004 M L-Histidine** 0.002 M Citric acid H_2O Made by diluting 25 ml of electrode buffer to 300 ml with DW
Malate dehydrogenase (Mdh)	**0.065 M L-Histidine = 10 g** 0.007 M Citric acid, H_2O = 1.47 g pH adjusted to 6.5 with citric acid Make up volume to 1 l with DW	**6.5**	**0.016 M L-Histidine** 0.002 M Citric acid H_2O Made by diluting 75 ml of electrode buffer to 300 ml with DW
Alcohol dehydrogenase (Adh)	**0.400 M Tris Base = 48.46 g** 0.105 M Citric acid H_2O = 22.06 g pH adjusted to 8.0 with citric acid Make up volume to 1 l with DW Use without dilution	**8.0**	**0.180 M Tris = 10.90 g** 0.100 M L-Histidine = 7.758 g pH adjusted to 8.0 with HCl Make up volume to 0.50 l with DW Use by diluting 15 ml of the above stock to 300 ml with DW

Results

A total of 32 populations of buckwheat comprising 10 individual plants of each population were assayed for three enzyme systems to estimate the genetic diversity at various levels. Peroxidase and malate dehydrogenase generated 4 to 6 distinct bands at four and three activity zones respectively, while alcohol dehydrogenase produced one zone of activity (Fig. 1). In total 8 loci and 18 alleles including respective null alleles were resolved for three enzyme systems in 32 populations of buckwheat from two sites. Six of 8 loci assayed (75%) showed polymorphism based on the number of alleles detected and the frequencies of alleles scoring less than 0.95 (data not shown). The number of allele per locus (*A*) was low, ranging from 1 to 2 with 1.44 as mean across the populations (Table 2). Populations 5 and 13 from *Urthu chautara* showed the highest number of alleles per locus (A = 1.88). Likewise allele per polymorphic locus (*Ap*) was 2 across the populations except the population 32 from *Ghodasain*. The percentage of polymorphic loci varied from population to population, ranging from 0 to 88.0% with a mean of 40.77% (Table 2). The gene diversity value as heterozygosity (H) averaged over all loci and population was 0.17, ranging from 0 to 0.33 with higher diversities in the populations 5 and 13 from Urthu Chautara (P = 88% and H = 0.32). Least diversity 0.04 was observed in population 17 from Urthu Chautara. Population 32 from Ghodasain showed no gene diversity (Table 2). Most of the populations from Urthu Chautara were found genetically variable (H = 0.04 to 0.33) and populations from Ghodasain were relatively low variable (H = 0.06 to 0.29) (Table 2). In general, all the studied populations showed similar levels of genetic variation based on mean gene diversity (0.17) and alleles per locus (1.44).

Table 2. Summary of diversity data for isozyme traits in tartary buckwheat by landrace populations (the estimates of average number of alleles per locus (A), number of alleles per polymorphic locus (Ap), heterozygosity (H), and percentage of polymorphic loci at 95% (P) are based on 8 isozyme loci)

SN	Population	Collection site	Land type	Ap	A	H	P
1	Population 1	Urthu	*Khet* land:	2.0	1.50	0.20	50.00
2	Population 2	Urthu	*Gadkule* = 4 %	2.3	2.00	0.32	75.00
3	Population 3	Urthu	*Bari* land:	2.3	2.00	0.32	75.00
4	Population 4	Urthu	*Pakhobari* = 45%	2.0	1.13	0.06	13.00
5	Population 5	Urthu	*Lekh* = 45%	2.0	1.88	0.32	88.00
6	Population 6	Urthu	*Gharbari* = 1%	2.0	1.75	0.33	75.00
7	Population 7	Urthu	Orchard = 5%	2.0	1.13	0.06	13.00
8	Population 8	Urthu		2.0	1.63	0.26	63.00

9	Population 9	Urthu		2.2	1.75	0.24	63.00
10	Population 10	Urthu		2.0	1.63	0.30	63.00
11	Population 11	Urthu		2.0	1.50	0.20	50.00
12	Population 12	Urthu		2.0	1.50	0.22	50.00
13	Population 13	Urthu		2.0	1.88	0.32	88.00
14	Population 14	Urthu		2.0	1.13	0.06	13.00
15	Population 15	Urthu		2.0	1.13	0.06	13.00
16	Population 16	Urthu		2.0	1.38	0.12	38.00
17	Population 17	Urthu		2.0	1.13	0.04	13.00
18	Population 18	Ghodasain	*Khet* land:	2.0	1.13	0.06	13.00
19	Population 19	Ghodasain	*Gadkule* = 20%	2.0	1.13	0.06	13.00
20	Population 20	Ghodasain	*Bari* land:	2.0	1.63	0.22	63.00
21	Population 21	Ghodasain	*Pakhobari* = 45%	2.0	1.50	0.18	50.00
22	Population 22	Ghodasain	*Gharbari* = 5%	2.0	1.25	0.12	25.00
23	Population 23	Ghodasain	Orchard = 30%	2.0	1.25	0.10	25.00
24	Population 24	Ghodasain		2.0	1.25	0.10	25.00
25	Population 25	Ghodasain		2.0	1.50	0.20	50.00
26	Population 26	Ghodasain		2.0	1.20	0.10	20.00
27	Population 27	Ghodasain		2.0	1.20	0.08	20.00
28	Population 28	Ghodasain		2.0	1.20	0.10	20.00
29	Population 29	Ghodasain		2.0	1.80	0.29	80.00
30	Population 30	Ghodasain		2.0	1.60	0.22	60.00
31	Population 31	Ghodasain		2.0	1.20	0.10	20.00
32	Population 32	Ghodasain		0.0	1.00	0.00	00.00
	Mean			1.96	1.43	0.17	40.77
	SD			0.367	0.295	0.103	26.667

The distribution of genetic variation at various levels for each locus is summarized in Table 3. The average total genetic diversity (Ht) across all 32 populations was 0.293 and the range was 0.098 to 0.449. Loci Prx2, Prx3, Prx4 and Adh exhibited marked diversity, while the rest had values that were below the mean. The mean intra population diversity (Hs) was 0.184 with a range of 0.073 to 0.376. The values were above the average except Prx1, Prx4, Mdh2 and Mdh3. The measure of inter population diversity (Dst) was in the average of 0.109, ranging from 0.026 to 0.249. The mean relative coefficient of gene differentiation (Gst) was on average 0.227 with a range of 0.130 to 0.402. This indicated that the inter population component of diversity accounted 22.7% of the total genetic diversity, while 77.3% of the total was due to intra population component. Among the populations studied, Adh locus showed the highest total genetic diversity (Ht = 0.449) followed by Prx4 (Ht = 0.430) with an average of 0.293 for 8 allozymes. The highest genetic distance (0.249) and the highest gene differentiation (0.402) was revealed for Prx4 (Table 3).

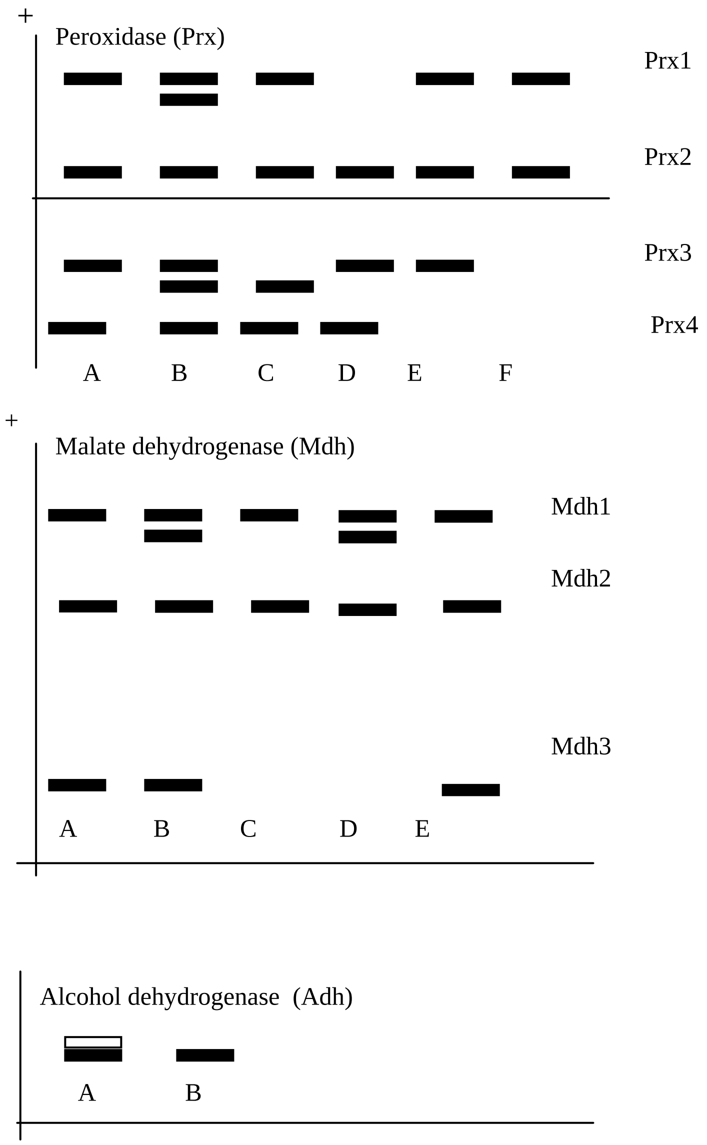

Fig. 1. Zymograms observed in tartary buckwheat landrace populations for 3 enzymes systems.

Table 3. Genetic diversity and differentiation among 30 landrace populations of tartary buckwheat for 8 isozyme loci (1999)†

Isozyme locus	Ht	Hs	Dst	Gst
Prx1	0.234	0.154	0.080	0.180
Prx2	0.319	0.187	0.132	0.283
Prx3	0.314	0.196	0.119	0.231
Prx4	0.430	0.182	0.249	0.402
Mdh1	0.287	0.201	0.087	0.172
Mdh2	0.209	0.099	0.110	0.220
Mdh3	0.098	0.073	0.026	0.130
Adh1	0.449	0.376	0.073	0.199
Mean	0.293	0.184	0.109	0.227
SE	0.046	0.031	0.026	0.057

† Ht = total genetic diversity, Hs = mean genetic diversity within populations, Dst = mean genetic diversity among populations and Gst = coefficient of gene differentiation.

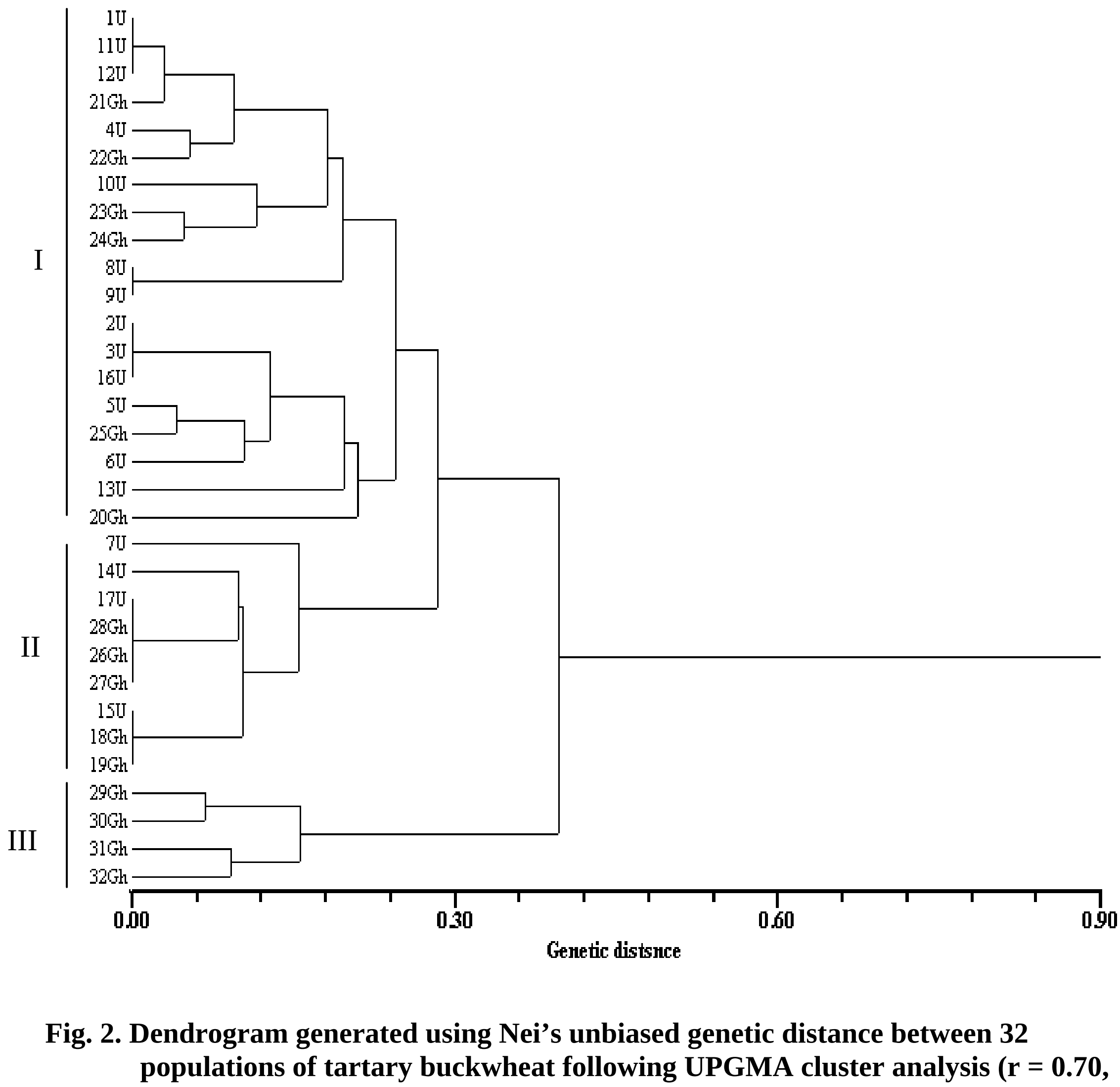

Fig. 2. Dendrogram generated using Nei's unbiased genetic distance between 32 populations of tartary buckwheat following UPGMA cluster analysis (r = 0.70, P<0.01).

The result of UPGMA cluster analysis in the form of a dendrogram illustrating relationships among 32 populations is presented in Fig. 2. Clustering of the populations on the basis of Nei's genetic distances revealed three distinct clusters. The largest of these clusters as I included 19 populations of which 13 were from Urthu Chautara and 6 from Ghodasain. The next cluster II comprised 5 populations from Ghodasain and 4 from Urthu Chautara. The cluster III included 4 populations from

Ghodasain. It showed the existence of genetic differentiation among the populations of two different agro environments with few exceptions. Ghodasain represents the mixed land type with *gadkule* (*khet* land type) and *pakhobari* (*Bari* land type) while Urthu Chautara is dominated with *pakhobari* and *lekh* (only *Bari* land type) (Paudel et al., 1998).

Discussion

Preliminary data revealed low to moderate level of genetic diversity among and within 32 landrace populations of cultivated tartary buckwheat in Jumla. Intra population diversity was higher than inter population diversity. This was exhibited by the Gst value (0.227), which indicates that only 22.7% of the total genetic diversity is attributed for inter population variability and the rest (77.3%) is for intra population diversity. Cultivated tartary buckwheat, although an autogamous plant has shown with high genetic variation within the populations. The observed values for A, Ap, and H were found similar to that of Korean and Chinese common buckwheat (Ohnishi, 1993; Huh and Huh, 2000). These landrace populations are found polymorphic to each other and found varied conspicuously for studied allozymes. Tsuji and Ohnishi (1998) and Bimb et al. (2000) have also observed variability in allozyme and RAPD markers in cultivated landraces of buckwheat, which were less variable than natural populations of wild species of buckwheat. This indicates that these landrace populations are the valuable resources possessing high genetic variability and are adapted to local agroclimatic and edaphic conditions. The observed variation in populations could be due to the farmers practices of seed exchange, continuous cultivation of buckwheat, antiquity of agriculture, variations in growing environments and gene flow from wild species of buckwheat (Huh and Huh, 2000; Ohnishi, 2000). Besides, holding of many landraces by a single farmer, local seed storage practices, growing different populations in adjoining fields etc are some traditional practices prevalent in Jumla, which could also be the factors for the allozyme variability.

The results of this study show allozyme is one of the useful measures in detecting population variation and relationship of cultivated tartary buckwheat landraces. Using UPGMA cluster analysis of allozyme data, three distinct groups among the studied buckwheat populations from two sites in Jumla were determined and it exhibited location specific demarcation among the populations of two sites. A further detail study with many polymorphic enzyme systems is suggested to assess landrace variability of buckwheat.

Conclusions

The study exhibited the existence of on farm diversity in tartary buckwheat in Jumla. The natural and human selection for their specific needs together with traditional practices have helped in creating and maintaining the diversity. Selection practice is an important tool in relation to germplasm improvement. Hence, the phenotypic selection in a diverse population could help the germplasm improvement of tartary buckwheat.

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Buckwheat variety improvement in Nepal: Overview and future prospect

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Abstract

Genus *Fagopyrum* consists of two cultivated buckwheat species viz. *mithe* (common) (*F. esculentum*) and *tite* (tartary) (*F. tartaricum*). Both species are under cultivation since time immemorial in Nepal. Buckwheat is one of the mandatory crops of Hill Crops Research Program (HCRP) and is an important staple food crop in high hills. *Tite* buckwheat is more important in higher elevation. Under varietal improvement work on buckwheat a number of activities have been carried out by HCRP, Kabre. Separate sets of *mithe* and *tite* buckwheat experiments are being tested. Observation nurseries have been tested in two-row plot^{-1} basis while Initial Evaluation Trial (IET) and Coordinated Varietal Trial (CVT) in lattice design. Seven activities viz. National Observation Nursery (NON) (*mithe* and *tite*), IET (*Mithe* and *tite*), CVT (*Mithe* and *tite*) and Farmer Field Trial (FFT) (*mithe*) are carried out under varietal improvement work. This paper consists of the finding of Agriculture Research Station, Jumla (2350 masl), Agriculture Botany Dicision, Khumaltar (1350 masl) and HCRP, Kabre (1740 masl) in 1999 and 2001. In advance observation nursery, AccNo. 481, CBBP-03, IR-13, AccNo. 6529 were promising in *mithe* genotypes while AccNo. 5170, AccNo. 7529, AccNo. 2193 and sample No. 6-1 were superior genotypes in *tite* at Kabre, Jumla and Khumaltar. Genotypes GF-5139 (1255 kg ha^{-1}), DARZA (1204 kg ha^{-1}) and local *mithe* (1148 kg ha^{-1}) were found promising in *mithe* while genotypes MY-2-27-1 (1423 kg ha^{-1}), AccNo. 2227-1 (1317 kg ha^{-1}) and local *tite* (1265 kg ha^{-1}) were high yielding in *tite* under IET. In CVT (*mithe)*, local *mithe* (645 kg ha^{-1}), GF-5274 (614 kg ha^{-1}), GF-5099 (575 kg ha^{-1}) and in CVT (*tite)*, AccNo. 2223 (1055 kg ha^{-1}), GF-212 (1010 kg ha^{-1}), AccNo. 2230, (964 kg ha^{-1}) AccNo. 2227 (964 kg ha^{-1}) were promising at Kabre and Jumla. In FFT, GF-5274 (1309 kg ha^{-1}), IR-13 (1188 kg ha^{-1}) and GF-5283 (1036 kg ha^{-1}) were superior in mid hills. Diversed yield potential of these genotypes indicates the possibility of developing high yielding varieties suitable to different sites.

Key words: common buckwheat, tartary buckwheat, variety, yield

Introduction

Buckwheat (*Fagopyrum* spp.) is an important crop in the high hills of Nepal. Both cultivated species of buckwheat viz. *F. tataricum* Geartn and *F. esculentum* Moench have been found cultivated in Nepal since time immemorial. Tartariy buckwheat is more common in higher elevation as summer crop and is sporadic in mid hills across the country and grown as autumn and/or spring crop. The common buckwheat is a summer crop in high hill, autumn and spring crop in mid hill and winter crop in *Terai*.

There is no available statistics on the exact area of buckwheat cultivation in Nepal. However, according to LRMP 1985, the area and productivity of buckwheat is 43000 ha and 540 kg ha^{-1} respectively. Though there is no authentic data available nevertheless interaction with the old farmers and direct observation reveal that the area under buckwheat in mid hills is decreasing. Recently the area under buckwheat in *Terai* especially in Jhapa and Chitwan is increasing but fluctuates with its price, which is affected by Indian market.

Tsuji et al. (1999) reported that southern China, especially Yunnan and Sichuan provinces is the center of diversity of *Fagopyrum* species, which supports Dr CG Campbell (1976), who reported that buckwheat is originated in temperate eastern Asia.

Materials and methods

The materials and methods common to all trials are as follows:

1. Spacing : Row to row 25 cm
Plant to plant continuous
2. Fertilizer : 30:30:0 kg NPK ha^{-1} or
5 t compost or FYM ha^{-1}, these doses of fertilizer was applied at HCRP, Kabre and ABD, Khumaltar
However, at ARS Jumla 15:0:0 NPK kg ha^{-1} fertilizer was applied in CVT (*tite*)
3. Seed rate : 50 kg ha^{-1}
4. Management: Rainfed
5. Sowing time: As local farmer's practice

Table 1. The specific methods of experiment†

Experiment	Locations	Design	Rep	No. of Trt	Plot size	Date of sowing	
						1999/2000	2000/2001
CVT *Mithe*	HCRP Kabre ARS, Jumla	Sq.Lattice	3	9	3x2=6m^2	1-09-1999 21-7-1999	2057/5/20 2057/4/12
CVT *Tite*	HCRP Kabre ARS, Jumla	Sq.Lattice	3	9	3x2=6m^2	3-09-1999 22-07-1999	2057/5/13 2057/4/11
IET *Mithe*	HCRP Kabre ARS, Jumla	Rect.Lattice	3	12	2x2=4m^2	5-09-1999 21-09-1999	2057/5/20 2057/4/12
IET *Tite*	HCRP Kabre ARS, Jumla	Rect.Lattice	3	12	2x2=4m^2	5-09-1999 22-07-1999	2057/5/19 2057/4/11
NON *Mithe*	HCRP Kabre, ABD, Khumaltar ARS, Jumla	Rod to Row	None	40	2x0.5=1m^2	5-09-1999 15-09-1999 21-07-1999	2057/5/20 2057/5/22 2057/4/12
NON *Tite*	HCRP Kabre, ABD, Khumaltar ARS, Jumla	Rod to Row	None	40	2x0.5=1m^2	5-09-1999 15-09-1999 21-07-1999	2057/5/19 2057/5/22 2057/4/11
FFT *Mithe*	HCRP Kabre,	Single Rep	Many	6 set	3x2=6m^2		2057/5/20

† Rep, replication; No., Number; CVT, coordinated varietal trial; IET, initial evaluation trial; HCRP, hill crop research program; ARS, agriculture research station; ABD, agriculture botany division; NON, national observation nursery; FFT, farmer field trial.

Buckwheat National Observation Nursery (NON-Mithe) 1999/2000-2000/01

In National Observation Nursery (NON-*mithe*) a total of forty genotypes including IR-13 and local check were tested at HCRP, Kabre, ABD, Khumaltar and ARS, Jumla during 1999/2000 and 2000/01. But the data were analyzed from Kabre and ABD Khumaltar only.

Table 2 reveals that tested genotypes showed significant difference in most parameters for locations and year indicating that same genotype expressed differently in different year within location for various parameters. There was also significant variation in different characters between location for the same year. The 1000-grain weight and grain yield of the tested genotype ranges from 15.7 to 30.4 g and 577 to 1700 kg ha^{-1} respectively and both parameters were found statistically significant (Table 2).

Table 2. Summary of buckwheat National Observation Nursery (NON-*Mithe*) set at HCRP, Kabre and ABD, Khumaltar during 99/2000-2000/01†

Trt	Cultivar	HD 75%	MD 75%	Plant plot^{-1}	PlHt, cm	Br plant^{-1}	Fl cluster plant^{-1}	1000-gr wt, g	GY kg ha^{-1}
1	Local check	37	72	222	83.4	4.5	6.4	26.4	993
2	AccNo.481	37	72	195	85.4	4.6	12.2	25.8	1700
3	CBBP-01	36	70	225	88.3	3.8	6.9	27.0	1063
4	AccNo.497	36	69	228	88.6	3.9	5.9	25.1	1337
5	AccNo.293	34	72	243	79.9	4.4	7.5	25.5	1012
6	Sample lot A	36	69	199	86.3	4.5	8.4	24.2	1182
7	Sample lot B	35	71	238	81.3	4.4	6.3	25.8	1122
8	GF-2181	34	70	298	81.2	3.5	5.8	24.9	1162
9	GF-5251	34	70	272	80.0	4.6	7.3	26.2	1154
10	Acc2248	37	69	239	86.9	3.6	7.9	24.7	1106
11	IR-13 (Chk)	35	68	284	91.1	5.0	7.5	25.3	979
12	CollSR-02	35	68	275	90.3	3.7	7.7	25.9	1307
13	Acc1012	34	73	265	85.3	4.2	8.2	24.7	1152
14	AIBL-T	37	69	306	90.3	3.8	8.0	24.4	1237
15	CollFE-22	36	70	239	89.6	4.5	8.1	24.2	1441
16	AIBL-d	34	71	287	93.4	4.8	7.6	25.3	1114
17	BoxFE-1	35	71	361	90.3	5.1	9.4	23.9	1433
18	AIBL-4	36	72	320	87.7	5.1	9.1	24.1	1236
19	AIBL-8	36	72	298	87.5	4.2	7.8	23.2	1174
20	Acc6529	35	74	330	90.4	5.0	7.4	23.8	1474
21	Local check	34	70	230	90.8	3.9	7.3	27.3	1129
22	Dhankuta Pop	35	70	285	87.0	3.6	7.5	26.5	1303
23	9251	36	72	398	90.1	4.8	9.9	25.0	1369
24	Acc4995	38	73	269	92.2	3.6	6.7	26.6	1348
25	Acc2288	34	70	232	83.6	4.0	5.8	26.5	1244
26	Acc2244	36	73	379	84.0	3.8	7.6	25.4	1459
27	Mithe Phapar	36	72	344	79.3	4.4	7.6	25.9	1259
28	CBBP-02	36	71	237	84.5	4.3	7.0	29.8	1434
29	CBBP-03	36	70	311	80.5	2.7	5.7	30.1	1599
30	CBBP-04	37	69	241	80.9	3.2	8.3	30.4	1338
31	IR-13	38	69	297	87.7	3.8	6.1	27.1	1522
32	CBBP-05	36	68	237	75.6	3.5	5.4	28.5	1125
33	CBBP-06	35	67	265	83.3	3.6	6.2	27.7	1286
34	PL-30	37	71	296	93.2	4.2	9.5	19.7	577
35	Pl-15	37	74	316	94.8	5.8	8.4	24.0	683
36	Coll9147	37	73	329	96.1	4.9	9.4	24.6	1016
37	Coll9228	36	68	302	86.4	5.0	5.9	25.3	768
38	CollPl-39	35	72	328	95.0	5.9	8.1	20.5	873
39	CollPl-32	36	72	329	93.5	5.2	6.5	22.1	655
40	CollPl-21	36	71	353	97.5	4.7	5.5	22.0	1219
Mean		35.8	70.8	282.3	87.36	4.32	7.47	25.45	1189.8
CV, %		31.44	9.47	67.0	16.76	60.99	60.26	12.78	36.72
SD		11.27	6.70	189.2	14.65	2.63	4.5	3.25	436.93
Minimum		34	68	195	75	3.2	5.4	19.7	577
Maximum		38	74	398	97.5	5.9	12.2	30.4	1700
SE		0.89	0.53	14.95	1.15	0.2	0.35	0.25	34.57
F (treatment)		NS	NS	NS	*	NS	NS	**	**
F (location)		**	**	**	**	**	**	**	**
F (year)		**	**	**	**	**	3.63	**	**
LSD at 5%		13.92	4.96	159.3	11.9	2.75		2.70	466.66

† Trt, Treatment; HD, Heading days; MD, Maturity days; PlHt, Plant height; Br, Branch; Fl, Flower; gr wt, Grain weight; GY, Grain yield; CV, coefficient of variance; SD, standard deviation; LSD, least significance difference; NS, non significant; *, significant at 5% and **, significant at 1%.

Table 3. Selected genotypes of non-*mithe* at three locations during 99/2000-2000/01†

Location	1999/2000				2000/2001			
	Trt	Genotype	Days to maturity	Grain yield kg ha^{-1}	Trt	Genotype	Days to maturity	Grain yield kg ha^{-1}
HCRP, Kabre	20	Acc 6529	78	2120	2	Acc 481	68	2069
	13	Acc 1012	80	2073	20	Acc 6529	68	1805
	17	Box FE-1	70	2023	8	GF-2181	64	1662
	14	AIBL-7	71	1974	15	Coll FE-	61	1600
	26	Acc 2244	68	1935	30	22	60	1542
	22	Acc 9251	71	1910	29	CBBP-04	63	1426
						CBBP-03		
ABD, Khumaltar	4	Acc 497	80	1930	28	CBBP-02	67	1485
	31	IR-13	85	1920	25	Acc 2288	69	1453
	29	CBBP-03	80	1900	15	CollFE-	68	1418
	23	9251	81	1770	26	22	73	1346
	40	CollPL-21	84	1720	29	Acc2244	65	1255
						ABBP-03		
ARS, Jumla	9	GF-5251	71	600	5	Acc293	82	526
	37	Coll9228	84	350	39	CollPI-32	82	498
	40	CollPL-21	84	350	22	Dhankuta	81	478
	31	IR-13	65	320	2	pop	81	460
	33	CBBP-06	67	320	24	Acc481	82	434
	34	CBBP-05	68	310	20	Acc4995	83	411
						Acc6529		

† Refer to Table 1 and 2 for full description.

Buckwheat National Observation Nursery (NON-tite) during 1999/2000-2000/01

In buckwheat National Observation Nursery (*Tite*), a total of thirty four genotypes including Kabre *tite* and local *tite* check were tested at three locations ie HCRP Kabre, Agric. Botany Division Khumaltar and ARS Jumla.

Grain yield

Mean grain yield was 819.8 kg ha^{-1} across location over two years. Though grain yield of tested genotypes ranges from 510 to 1092 kg ha^{-1} yet the difference were not statistically significant, which could be due to poor precision.

Phenology and other agronomic traits

The highest 1000-grain weight was obtained in AccNo.6709 (19.9 g) and lowest was obtained in FT-25-2-2 (13.6 g) and the difference was statistically significant. Tested genotypes did not vary significantly within year and locations in many parameters like days to flowering, days to maturity, plant height (Table 4).

Table 4. Yield and other parameters of buckwheat genotypes tested under National Observation Nursery (NON-*tite*) (Mean of Kabre and Khumaltar for 1999/2000- 2000/2001)†

Trt	Cultivar	HD	MD	Plant Ht, cm	Pl stand $plot^{-1}$	Branch $plant^{-1}$	Fl cluster $plant^{-1}$	1000-gr wt, g	GY, kg ha^{-1}
1	Kabre *tite*	44	77	57.8	242	5.0	9.3	15.3	551
2	Sample5-1	45	75	67.1	244	3.0	9.8	16.0	803
3	Sample5-3	44	76	66.9	214	2.8	10.5	15.7	644
4	Sample6-1	44	77	68.1	214	3.2	8.7	16.9	991
5	Sample8	44	76	74.9	196	3.4	8.7	15.1	651

Table 4. Continued…

Trt	Cultivar	HD	MD	Plant	Pl stand	Branc	Fl	1000-	GY,
6	Sample9	45	75	69.2	210	3.7	9.9	17.1	946
7	Sample9-5	46	75	64.5	278	3.3	10.4	15.7	834
8	Local *tite*	46	75	67.9	306	3.1	9.1	15.5	761
9	Acc0491-2	44	77	75.3	321	3.2	8.3	15.6	991
10	Acc2201-1	44	76	81.4	446	3.2	9.4	16.2	880
11	Acc2203	45	76	78.3	305	3.1	10.6	15.3	965
12	Acc2199-2	45	77	68.4	273	2.9	11.3	15.3	945
13	Acc2227-1	44	77	68.6	291	3.7	9.6	15.3	876
14	Acc7529	45	74	70.4	361	2.8	7.1	15.9	1040
15	Acc5170	46	78	74.7	374	2.9	10.1	14.9	1092
16	Kabre *tite*	46	75	69.4	211	3.0	7.3	14.1	783
17	FT-22-1	46	76	70.7	333	2.9	10.4	16.2	936
18	FT-25-2-1	45	75	71.1	319	3.0	9.2	16.2	831
19	FT-25-2-2	45	77	73.9	260	3.1	8.8	13.6	816
20	FT-25-2-3	45	77	75.0	300	3.1	8.0	13.9	838
21	MY-3-4-1	46	76	78.3	261	2.8	9.2	15.1	842
22	MY-2-33-1	46	77	75.1	265	3.8	8.4	13.9	846
23	MY-2-27-1	46	76	69.4	297	3.2	9.4	16.7	894
24	MY-2-2	46	72	65.2	294	2.5	9.6	14.9	902
25	Local *tite*	45	74	62.5	245	2.5	8.1	15.2	843
26	YDR-27-FT-19-4	45	73	67.8	286	3.1	8.6	14.1	644
27	Coll9104	47	73	66.2	347	3.2	8.1	15.1	813
28	Acc2193	46	74	69.8	378	3.7	8.1	17.5	1015
29	Acc6709	47	72	63.7	191	3.3	9.7	19.9	719
30	Acc6575	46	72	66.2	224	3.9	8.1	18.4	567
31	Acc2182	44	76	71.4	300	4.4	8.7	17.1	783
32	Acc6506	47	78	61.6	390	3.4	8.5	14.8	695
33	Acc2179	47	74	58.0	216	3.5	10.8	17.5	704
34	FT-7-MY-18	45	72	63.9	322	3.1	8.9	14.2	510
Mean		45.34	75.4	69.19	286.6	3.28	9.16	15.75	819.8
CV, %		17.84	10.52	20.62	50.04	32.74	29.13	21.2	45.77
SD		8.09	7.93	14.26	143.46	1.07	2.66	3.33	375.2
Minimum		34.0	61.0	39.4	44	0.8	4.0	8.7	102
Maximum		61.0	91.0	113.8	772.0	10.0	17.4	25.40	1653
SE Mean		0.69	0.68	1.23	12.34	0.09	0.22	0.28	32.17
F (treatment)		NS	NS	NS	NS	NS	NS	**	NS
F (location)		NS	**	**	**	NS	NS	**	**
F (year)		NS	**	*	**	NS	NS	**	**
LSD at 5%		13.03	6.17	20.24	187.42	1.52	4.03	2.31	511.3

† Refer to Table 1 and 2 for full description.

Buckwheat Initial Evaluation Trial (IET-mithe) in 99/2000-2000/01

The experiment consisting of twelve genotypes including IR-13 and local *mithe* as checks was conducted at HCRP Kabre and ARS Jumla.

Grain yield: The mean grain yield was 1006 kg ha^{-1} across locations and years. The genotype GF-5139 produced highest (1255 kg ha^{-1}) grain yield followed by Darza (1204 kg ha^{-1}) and local *mithe* (1148 kg ha^{-1}) (Table 6). All tested genotypes were statistically at par. However, different genotypes performed differently across locations indicating genotype environment interaction.

Table 5. Selected genotypes of NON *tite* at three locations during 1999/2000-2000/01†

	1999/2000				2000/2001			
Location	**Trt**	**Genotype**	**75% days maturity**	**GY, kg ha^{-1}**	**Trt**	**Genotype**	**75% days maturity**	**GY, kg ha^{-1}**
HCRP, Kabre	18	FT-25-2-1	90	1090	4	Sample6-1	73	1422
	31	Acc2182	89	1084	13	Acc2227-1	77	1394
	20	FT-25-2-3	88	1070	15	Acc5170	77	1338
	33	Acc2179	81	1057	12	Acc2199-2	77	1335
	21	MY-3-4-1	83	1015	6	Sample9	72	1223
ABD, Khumaltar	19	FT-25-2-2	83	1653	16	Kabre *tite*	68	1289
	28	Acc2193	77	1631	2	Sample5-1	68	1180
	14	Acc7529	77	1609	11	Acc2203	70	1180
	20	FT-25-2-3	83	1495	28	Acc2193	68	1163
	21	MY-3-4-1	83	1446	15	Acc5170	68	1152
	23	MY-2-27-1	83	1423	9	Acc0491-2	70	1096
ARS, Jumla	9	Acc49-2	79	910	23	MY-2-27-1	79	2634
	4	Sample6-1	84	870	18	FT-25-2-1	80	2440
	7	Sample9-5	87	770	20	FT-25-2-3	82	2151
	31	Acc2182	85	750	22	MY-2-33-1	84	2122
	32	Acc6506	85	690	28	Acc2193	79	1957
	28	Acc6704	84	680	2	Sample5-1	80	1931

† Refer to Table 1 and 2 for full description.

Table 6. Yield and other parameters of buckwheat (IET-*Mithe*) (Mean of Kabre and ARS, Jumla during 1999/2000-2000/2001)†

Trt	**Cultivar**	**HD**	**MD**	**PlHt, cm**	**Pl stand plot^{-1}**	**Branch plant^{-1}**	**Fl cluster plant^{-1}**	**1000-gr wt, g**	**GY, kg ha^{-1}**
1	GF-198	30	62	97.8	315	3.9	5.7	26.3	886
2	GF-5122	28	62	84.1	335	3.7	4.9	24.3	1054
3	GF-5282	28	60	88.8	279	4.0	5.6	25.4	953
4	GF-4959	31	64	94.4	331	5.1	5.8	24.3	897
5	GF-5139	28	59	81.5	261	4.2	5.4	25.3	1255
6	Acc2244	29	60	93.9	339	4.5	5.6	23.6	892
7	No85613	28	62	90.9	272	4.6	4.9	26.5	1041
8	BoxFE-1	32	67	101.3	414	4.8	8.2	22.2	838
9	Acc2237	29	61	94.6	381	4.9	5.3	22.9	947
10	DARZA	28	61	87.5	363	4.3	4.9	24.3	1204
11	IR-13	28	59	85.9	332	4.7	5.2	24.6	960
12	Local *mithe*	29	60	83.2	332	4.1	5.7	23.7	1148
Mean		28.8	61.5	90.8	329.5	4.4	5.6	24.5	1006.2
CV, %		6.89	5.83	11.82	29.9	57.9	45.6	7.08	44.23
F, Genotype (G)		**	NS	**	NS	NS	NS	**	NS
F, Year (Y)		**	*	**	**	**	**	**	**
LSD at 5%		1.45	7.22	9.7	112.5	1.47	3.03	1.43	337.03

† Refer to Table 1 and 2 for full description.

Phenology: Mean days to flowering and maturity were 29 and 62 respectively. Though Genotypes did not differed significantly for maturity, however GF-5139 and IR-13 were found earlier (59 days) as compare to the other tested lines. Moreover, consistency was not observed for days to heading and maturity within genotypes tested for the same location in different years.

Other agronomic traits: Significant difference was observed in 1000-grain weight among genotypes. Genotype 85613 produced highest 1000-grain weight (26.5 g) followed by GF-198 (26.3 g) and GF-5139 (25.3 g) respectively. Tested genotypes were at par for parameters like plant height, number branches plant^{-1} and flower cluster (Table 6).

Table 7. Location wise average grain yield of IET-*mithe* during 1999/200-2000/01†

Trt	Cultivar	Grain yield, kg ha^{-1}					
		1999/2000			2000/2001		
		Kabre	Jumla	Mean	Kabre	Jumla‡	Mean
1	GF-198	330	-	330	1442	341	892
2	GF-5122	598	-	598	1510	191	850.5
3	GF-5282	593	-	593	1313	146	729.5
4	GF-4959	497	-	497	1298	339	818.5
5	GF-5139	1000	-	1000	1509	267	888
6	Acc2244	533	-	533	1252	307	779.5
7	85613	477	-	477	1605	180	892.5
8	BoxFE-1	438	-	438	1238	245	741.5
9	Acc2237	588	-	588	1307	341	824
10	DARZA	708	-	708	1700	179	939.5
11	IR-13	759	-	759	1163	269	716
12	Local *mithe*	723	-	723	1573	364	968.5
Mean		628.2	-		1409.2	264	836.6
CV, %		47.6	-		25.54	45.32	
F-test		NS	-		NS	NS	
LSD at 5%		376.5	-		425.12	195.83	

† Refer to Table 1 and 2 for full description. ‡ Sterility recorded 50-68% at Jumla.

Buckwheat Initial Evaluation Trial IET-tite 1999/200-2000/01

The experiment consisting of 9 genotypes including local *tite* as a check was conducted at HCRP Kabre and ARS Jumla but the data was not received from Jumla in the year 1999/2000.

Table 8. Yield and other parameters of Buckwheat genotypes (IET-*Tite*) (average of HCRP, Kabre and ARS, Jumla for 1999/2000-2000/2001)†

Trt	Cultivar	HD	MD	PlHt, cm	Pl stand	Branch	Fl cluster	1000-gr wt, g	GY, kg ha^{-1}
1	GF-5234	44	80	101.8	215	5.4	19.6	13.0	1154
2	Acc2227-1	44	73	93.6	194	4.7	18.3	15.0	1317
3	MY-2-27-1	44	74	97.9	224	4.7	17.3	14.9	1423
4	Sample5-1	44	75	97.7	225	4.4	16.8	15.9	1162
5	Sample6-1	44	75	96.9	191	4.4	17.1	15.2	1170
6	Sample7	44	79	97.4	189	3.7	18.6	15.6	1174
7	Sample8	43	77	101.1	204	3.7	17.5	14.8	1111
8	Sample9-7	43	76	100.1	173	4.1	18.3	15.3	828
9	Local *tite*	45	74	100.8	172	4.6	19.4	16.1	1265
Mean		43.8	75.9	98.6	198.7	4.4	18.1	15.1	1178.2
CV, %		12.6	7.0	11.2	25.6	17.5	24.9	7.4	24.5
F, Genotype (G)		NS	NS	NS	NS	NS	NS	NS	NS
F, Year (Y)		**	**	**	**	NS	**	NS	**
LSD at 5%		2.39	8.17	12.0	75.8	1.8	2.06	2.32	392.91

† Refer to Table 1 and 2 for full description.

Yield: The mean grain yield over location in two years was 1178 kg ha^{-1}. The genotype MY-2-27-1 produced highest (1423 kg ha^{-1}) grain yield followed by AccNo2227-1 (1317 kg ha^{-1}) and local *tite*

(1265 kg ha^{-1}). However, the yield difference among the genotypes was not significant. The yield data reveals that the genotype AccNo2227-1 (2052 kg ha^{-1}) was highest at Jumla and same genotype was one of the low (1219 kg ha^{-1}) yielders at Kabre. Genotype sample 6-1 was the highest (1574 kg ha^{-1}) yielder at Kabre and the lowest (914 kg ha^{-1}) at Jumla, indicating that there is genotype, environment interaction (Table 9). Therefore, location specific varieties should be developed for each location.

Phenology and other agronomy traits: Mean days to flowering and maturity was 44 and 75 days respectively. Genotype MY-2-27-1 and local *tite* were found earlier in maturity (74 days) as compared to other tested genotypes but the difference was not significant. Besides, plant height, plant stand, number of branch plant^{-1}, number flower cluster plant^{-1} and 1000-grain weight were also non-significant (Table 8).

Table 9. Location wise average grain yield of IET-*tite* during 1999/200-2000/01†

Trt	Cultivar	Grain yield, kg ha^{-1}					
		1999/2000			2000/2001		
		Kabre	Jumla	Mean	Kabre	Jumla	Mean
1	GF-5234	894	421	657.5	1079	1750	1414
2	Acc2227-1	998	413	705.5	1219	2052	1635
3	MY-2-27-1	1131	510	820.5	1512	1916	1714
4	Sample5-1	1082	347	714.5	1087	1397	1242
5	Sample6-1	1096	433	764.5	1574	914	1244
6	Sample7	1127	395	761	1023	1620	1221
7	Sample8	980	423	701.5	1325	1561	1243
8	Sample9-7	480	328	404	1094	1258	1176
9	Local *tite*	965	435	700	1532	1601	1566
Mean		1003	412	707.5	1271.7	1563	1417.8
CV, %		28.24	22.75		45.1	29.06	
F-test		NS	NS		NS	*	
LSD at 5%		172.73	182.66		1100	643.5	
LSD at 1%		375.74	132.57		1507.0	881.7	

† Refer to Table 1 and 2 for full description.

Coordinated Varietal Trial (CVT-mithe) 99/2000-2000/01)

The experiment consisting of nine genotypes including IR-13 (standard check) and local check was conducted at HCRP Kabre and ARS Jumla. A short description of experimental result is given bellow.

Grain yield: Mean grain yield was 552 kg ha^{-1}. Local *mithe* produced the highest (645 kg ha^{-1}) grain yield followed by GF-5274 (614 kg ha^{-1}) and GF-5099 (575 kg ha^{-1}) respectively across locations and years. Though the grain yield of tested genotypes were non-significant however, at HCRP Kabre genotype GF-5099 produced the highest (1395 kg ha^{-1}) grain yield followed by GF-5063 (1361 kg ha^{-1}) and GF-5194 (1317 kg ha^{-1}). In Jumla, grain yield was very poor which could be due to high sterility (30-57%) may be caused by cold injury (Table 11).

Phenology: Average maturity day ranges from 62 to 67 with highly significant genotype interaction. Genotype GF5289 produced the highest 1000-grain weight, which ranged from 21.7 g to 25.2 g (Table 11).

Other agronomic traits: Mean plant height was 74 cm. Local *mithe* was found tallest (82.5 cm) among the tested genotypes. Clear G × E interactions were not observed in plant height though the height of tested genotypes at Kabre and Jumla ranges from 94 to 106 cm and 53 to 76 cm respectively.

Coordinated Varietal Trial (CVT-tite) 99/2000-2000/01)

The experiment consisting of nine genotypes including Kabre *tite* and local *tite* as checks was conducted at HCRP Kabre and ARS Jumla. Short descriptions of the results of both locations are given bellow.

Table 10. Yield and other parameter of buckwheat genotypes (CVT-*Mithe*). Mean of Kabre and Jumla during 1999/2000-2000/01†

Trt	Cultivar	HD	MD	PlHt, cm	Pl stand	Banch	Flower cluster	1000-gr wt, g	GY, kg ha^{-1}
1	GF-5289	27	63	75.5	184	4.3	5.8	25.2	549
2	GF-5099	27	65	76.0	167	4.6	6.1	23.6	575
3	GF-5006	28	68	77.0	182	3.5	6.1	22.2	560
4	GF-5063	27	64	73.7	177	4.2	5.6	23.0	466
5	85603	28	65	72.2	180	4.5	6.1	24.1	550
6	GF-5274	25	65	73.6	177	3.9	6.0	24.6	614
7	GF-5194	27	63	64.8	172	3.6	5.5	24.7	499
8	IR-13	28	62	70.6	189	4.2	5.9	21.7	521
9	Local *mithe*	27	67	82.5	189	4.2	7.5	23.5	645
Mean		26.9	64.4	74.0	179.5	4.1	6.1	23.7	552
CV, %		13.4	8.2	11.6	25.02	47.4	17.8	5.7	39.7
F, Genotype (G)		NS	**	NS	NS	NS	NS	*	NS
F, Year		**	**	**	**	**	**	*	**
LSD at 5%		2.57	1.44	10.4	47.9	2.25	1.7	1.63	198.03

† Refer to Table 1 and 2 for full description.

Table 11. Location wise average grain yield of CVT-*mithe* during 1999/200-2000/01†

Trt	Cultivar	Grain yield, kg ha^{-1}					
		1999/2000			2000/2001		
		Kabre	Jumla	Mean	Kabre	Jumla	Mean
1	GF-5289	428	-	428	1129	210	670
2	GF-5099	355	-	355	1395	195	795
3	GF-5006	371	-	371	1256	242	749
4	GF-5063	142	-	142	1361	219	790
5	85603	360	-	360	1199	239	719
6	GF-5274	473	-	473	1307	205	756
7	GF-5194	246	-	246	1317	185	751
8	IR-13	340	-	340	1240	163	702
9	Local *mithe*	447	-	447	1118	529	823
Mean		353.6	-		1258	243.4	750.6
CV, %		87.0	-		18.74	48.8	72.55
F-test		NS	-		NS	**	

† Refer to Table 1 and 2 for full description.

Grain yield: Mean grain yield of all genotypes during two years was 924 kg ha^{-1}. Genotype AccNo2223 produced the highest grain yield (1055 kg ha^{-1}) followed by the genotype GF-212 (1010 kg ha^{-1}) and AccNo2230 (964 kg ha^{-1}) across locations and years, however, the difference was not significant. While considering the location specific performance, genotype GF-212 (1428 kg ha^{-1}) and AccNo2230 (1196 kg ha^{-1}) produced the highest grain yield at Kabre and Jumla respectively (Table 13). Yield difference was not observed significant between genotypes for the same year. However, yield difference was observed significant between year for the same genotype.

Table 12. Yield and other parameter of buckwheat genotypes (CVT-*Tite*). (Mean of Kabre and Jumla during 1999/2000-2000/2001)†

Trt	Cultivar	HD	MD	PlHt, cm	Pl stand m^{-2}	Branch $plant^{-1}$	Fl cluster $plant^{-1}$	1000-gr wt, g	GY, kg ha^{-1}
1	GF-216	45	81	96.9	146	5.3	17.2	16.1	934
2	GF-212	44	79	94.3	160	4.2	17.0	14.8	1010
3	Acc2223	44	80	85.7	158	4.2	16.5	15.4	1055
4	Acc2230	45	81	91.2	151	4.8	15.2	14.4	964
5	Acc2227	48	79	92.2	159	5.4	15.1	14.7	964
6	Acc2234	46	81	87.5	152	4.8	17.2	14.0	884
7	Acc481-1	45	80	92.2	144	4.8	16.8	13.6	855
8	Kabre *tite*	44	81	97.7	153	5.0	19.9	14.7	909
9	Local *tite*	45	81	87.8	170	4.4	16.3	15.8	844
Mean		45	80.2	91.8	155.2	4.8	16.7	14.8	924.3
CV, %		9.8	7.7	8.1	10.9	20.0	24.6	5.0	23.0
Genotype (G)		NS	NS	NS	NS	NS	NS	**	NS
F, Year		**	**	**	*	**	**	NS	*
LSD at 5%		3.8	3.04	7.66	34.4	1.54	2.71	1.07	514.33

† Refer to Table 1 and 2 for full description.

Phenology: There was no significant difference in days to flowering and maturity among genotypes tested for the same year. However, same genotypes interact differently between the years for these parameters. Nevertheless, days to flowering and maturity ranged from 44 to 48 and 79 to 81 respectively (Table 13).

Other agronomic traits: The variation in other parameters like plant height, plant stand, branches $plant^{-1}$ and flower cluster $plant^{-1}$ were not significant (Table 14). The genotype GF-216 produced highest 1000-grain weight (16.1 g) followed by local *tite* (15.8 g) but they were at par and differed significantly with most of the genotype tested. Genotype AccNo481-1 produced the lowest 1000-grain weight (13.6 g) (Table 13).

Table 13. Location wise average grain yield of CVT-*tite* during 1999/200-2000/01†

Trt	Cultivar	Grain yield, kg ha^{-1}					
		1999/2000			2000/2001		
		Kabre	Jumla	Mean	Kabre	Jumla	Mean
1	GF-216	477	802	639	1344	1114	1229
2	GF-212	964	852	908	1428	794	1112
3	Acc2223	846	1186	1015	1406	884	1095
4	Acc2230	434	847	641	1157	1196	1288
5	Acc2227	672	709	690	1285	1188	1237
6	Acc2234	925	869	897	976	767	872
7	Acc481-1	643	645	644	1163	964	1063
8	Kabre *tite*	1067	682	874	379	1109	744
9	Local *tite*	863	969	916	787	783	772
Mean		765.6	839.9	803.8	1101.7	986.46	1046
CV, %		69.4	32.73	52.4	57.3	34.74	48.43
F-test		NS	NS		NS	NS	

† Refer to Table 1 and 2 for full description.

Farmers Field Trial (Mithe) at HCRP, Kabre during 2000/01

FFT-*Mithe* set consists of five genotypes including local check. In this experiment 5 sets were planted at outreach research (OR) site Mati and one set at HCRP Kabre. Statistically all tested genotypes were at par (Table 15) nevertheless because of low precision (high CV) the highest (1309.4 kg ha^{-1}) yielding genotype GF-5274 should be again tested with high precision to conform its superiority in FFT.

Table 14. Yield and other parameters buckwheat (FFT-*Mithe*) at HCRP Kabre and HCRP outreach research (OR) site (Mean of five locations) 2000/01†

Trt	Cultivar	HD	MD	PlHt, cm	Pl stand	Branch	Flower cluster	GY, kg ha^{-1}
1	GF-5283	32	65	77.5	79	3.9	15.8	1035.6
2	GF-5099	32	64	77.3	118	3.9	15.4	899.9
3	GF-5274	33	57	76.2	89	3.5	13.9	1309.4
4	IR-13	31	65	75.6	116	3.8	17.0	976.3
5	Local *mithe*	30	64	72.8	111	4.8	15.5	1188.1
Mean		31.43	63.25	75.9	102.6	4.0	15.6	1081.9
CV, %		3.79	14.17	19.59	49.3	46.09	39.5	29.12
F-test		**	NS	NS	*	NS	NS	NS
LSD at 5%		0.93	10.81	9.87	39.12	1.25	3.5	346.1
LSD at 1%		1.26	14.7	13.47	41.88	1.7	4.8	472.09

† Refer to Table 1 and 2 for full description.

Importance

Buckwheat is a very important crop in hilly areas of Nepal. Being a short duration crop (70-90 days to mature), it is usually grown as a catch crop in mid hills. Farmers being unable to transplant finger millet (*Eleusine coracana*) in maize/millet system where they plant buckwheat. The buckwheat is successfully grown in poor soil where other crops can not thrive. Moreover, tartary buckwheat can also be taken under moisture stress condition. Therefore *tite* buckwheat also follows rice under low level of irrigation facility where wheat can not be grown. It is a less labor and input-demanding crop. It is easy to plough buckwheat field as it makes the soil more friable. Buckwheat is planted as a (alternate) catch crop if millet is failed in maize/ millet system.

In higher mountains such as in Manang Mustang and Dolpa buckwheat is a summer crop and a staple food of the people. Baniya et al. (2000) reported that potato, barley (naked or hulled) pea/wheat, or mustard follow buckwheat under 2-3 years crop rotation in upper Mustang (3500-4000 masl) and only one crop is taken in one year in this area. *Tite* buckwheat is grown in higher elevation than common buckwheat. In higher elevation above 3500 m the time for crop growth is extended and buckwheat is adopted mainly in such specific and tight cropping sequences. The crop can also be successfully grown under harsh condition of soil and temperature without external inputs.

Utilization

Buckwheat straw is a good source of fodder and bedding material. It is said that ground whole buckwheat boiled with water if fed to milky animals it increases the milk production. Buckwheat can be utilized as green manure crop. Pancake of common buckwheat is prestigiously served to the tourist in the hotels along Kaligandaki River on the way to Muktinath. Breads and thick porridge are some of the food items prepared from buckwheat. *Fulaura* is a special item prepared especially from common buckwheat. To minimize the bitterness and make tastier, the flour of tartary buckwheat is usually mixed with wheat or finger millet or naked barley to prepare thick porridge. The leaves of young buckwheat plant are used as vegetables. Buckwheat is a very healthy diet especially rich in argenine and lysine. Sayoko et al. (1995) reported that buckwheat is a rich source of minerals vig. zinc, copper, manganese and magnesium. Jun et. al. (1995) reported significantly less total cholesterol and phospholipid in plasma lipid of rat fed with buckwheat protein extract as compared with soybean protein and casein.

A rapid rural appraisal (RRA) survey by Mr BR Adhikary and his team members in 1989 in selected high altitude districts of Nepal reported that rural people use buckwheat for medicinal purpose. Buckwheat bread is fed to sick people. Treatments against stomach disorder and fever is a common practice.

Future prospects

Hill crops research program (HCRP) is initiating to develop self-pollinated *mithe* buckwheat. Existing self-pollinated *mithe* buckwheat lines received from Dr. CG Campbell shatters before maturity with poor seed setting and needs vernalization for germination. So, there is possibility of developing a self pollinated *mithe* Buckwheat variety by crossing IR-13 and other Neplease *mithe* buckwheat germplasm with self pollinated *mithe* buckwheat lines which is initiated at Kabre.

HCRP is also selecting and maintaining superior genotypes from Nepal broad base population (NBBP) and Canadian broad base population (CBBP). From this work there is high possibility of developing a high yielding variety of *mithe* buckwheat with wider genetic base. One of the major cropping patterns in lower river basin is rice- spring maize. There is about 2.5 to 3 months gap between rice harvesting and maize planting which is enough time for *mithe* buckwheat cultivation. HCRP will be trying to explore this potentiality and possibility through its outreach network. Germplasm collection and characterization of buckwheat has been done by HCRP. However, further exploration, (especially from the remote and unexplored areas of Nepal), characterization and their utilization for buckwheat improvement needs to be continued.

To encourage the buckwheat cultivation, there should be assured market by establishing it as an industrial crop. Therefore, its potentiality to manufacture noodles and baby food should be utilized. Buckwheat flour contains considerable amount of essential minerals like Zn, Cu, Mg, P, K, Ca and Mn and suggested that this could be the dietary source of essential minerals. Udesky (1995) reported that lysine content of buckwheat (5%) is more than other cereal (2.7-3.7%) and fishmeal (4.82). He also added that other important amino acids like argenine and tryptophane is also more in buckwheat than in other grains.

Visualizing the findings of above scientists regarding the minerals and essentials amino acids content of buckwheat it is imperative to utilize buckwheat flour to prepare different recipes and use as tiffin especially to the school children and physically weak people.

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Response of different combination of plant nutrients on buckwheat

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Abstract

A study was done at Hill Crops Research Program (HCRP), Kabre (1740 masl) to know the response of IR-13 buckwheat variety (*F. esculentum*) on different level and combination of plant nutrients including lime and farm yard manure (FYM) for successive three years commencing from 1997. The experiment was laid out in randomized complete block design with twelve treatments and four replications. Plot size was 6 m^2. FYM as well as lime were applied two days before planting but after taking soil sample from each plot. Application of 10 t FYM ha^{-1} + 2 t lime ha^{-1} has no significant effect on grains yield as well as soil organic matter. Highest yield (804 kg ha^{-1}) and 1000-grain weight (23.6 g) was obtained with the application of 30:30:0 kg NPK ha^{-1} which was at par with 45:30:0 kg NPK ha^{-1} (777 kg ha^{-1}) and 30 kg N ha^{-1} but significantly higher than most of the treatments including 10 t FYM ha^{-1} and absolute control. Increasing nitrogen level above 30 kg ha^{-1} and application of other plant nutrients including FYM and lime had no significant effect on yield indicating that buckwheat is a low nutrient demanding crop and tolerant to acidic soil. However, economic dose of fertilizer still needs to be computed.

Key words: FYM, lime, NPK, yield

Introduction

Both cultivated species of common and tartary buckwheat (*F. esculentum* and *F. tataricum*) are important in high hills of Nepal and grown as catch and opportunity crop in mid hill regions of the country. Common buckwheat is also grown in Terai and *tite* buckwheat in above 3500 masl (Baniya et al., 2000). It is mainly a staple food for resource poor people of inaccessible mountainous region.

In mid hills, the crop is commonly grown in marginal land. Buckwheat can be considered as environment friendly crop because it make the soil friable, extracts less nutrients and act as a good source of nectar for bees and other insects which helps to maintain the natural ecosystem. Though the crop is usually grown with low external input, nevertheless visualizing its future potentiality it is very important time to generate information regarding the nutrient requirement of the crop. Considering this factor the experiment was conducted at Hill Crop Research Program (HCRP), Kabre with different levels and combinations of nutrients including FYM and lime. The main objective of the research is to investigate the optimum level of plant nutrients for buckwheat in mid hills of Nepal.

Methodology

An experiment of buckwheat (*F. esculentum*) was started in HCRP, Kabre, (1740 masl) Dolakha in randomized completely block design with twelve treatments (Table 1) and four replications. Soil was loamy with around 5.0 pH. Fertility status was in general good. Treatments were applied in 3- × 2-m plots with 25 cm inter row spacing. Continuous planting of IR-13 buckwheat variety was done with 50 kg seed rate ha^{-1}.

Table 1. Treatments details

No.	Treatment†
1	Control
2	15:0:0 kg NPK ha^{-1}
3	15:15:0 kg NPK ha^{-1}
4	15:15:15 kg NPK ha^{-1}
5	30:0:0 kg NPK ha^{-1}
6	30:30:0 kg NPK ha^{-1}
7	30:30:30 kg NPK ha^{-1}
8	0:0:30 kg NPK ha^{-1}+ 5 t FYM ha^{-1}
9	45:0:0 kg NPK ha^{-1}
10	45:30:0 kg NPK ha^{-1}
11	10 t FYM ha^{-1} + 2 t lime ha^{-1}
12	5 t FYM ha^{-1} + 2 t lime ha^{-1}

† FYM = Farm yard manure.

Urea, Di-ammonium Phosphate (DAP) and Muriate of Potash were the source of commercial fertilizers. Full dose of FYM and Agriculture lime were applied during land preparation. FYM contained 15.41%, OM, 0.79% N, 0.78% P and 2.9% K. Soil samples from each plot were taken after harvest of crop and analyzed for pH, organic mater, total nitrogen, available phosphorus, available potash and texture in the Soil Science Division, Khumaltar. Data were analyzed by using statistical package.

Results and discussion

Mean of three years of yields and other parameters of the experiment are given in Table 2. Different levels of nutrients had significant effect on grain yield, 1000-grain weight and plant height. Application of 30:30:0 kg NPK ha^{-1} produced the highest yield (804 kg ha^{-1}) followed by 45:30:0 kg NPK ha^{-1} (777 kg ha^{-1}). However, both these treatments were statistically at par. Application of only nitrogen @ 30 kg ha^{-1} was at par with all other treatments except treatment 8 ie (30 kg K ha^{-1} + 5 t FYM ha^{-1}) and control.

Application of agriculture lime @ 2 t ha^{-1} for first two years has slightly increased soil pH in the third year (from 5.1 to 5.5), though there was no significant effect on grain yield (Table 2 and 3). However, treatments without lime application showed slight decrease in soil pH. In general, soil of all plots was acidic in nature with 4.6 to 5.5 pH range. Application of FYM @ 5 t ha^{-1} and 10 t ha^{-1} had no significant effect on grain yield. Control plot and application of 10 t FYM ha^{-1} were statistically at par on the basis of chemical analysis, 10 t FYM ha^{-1} is equal to 79:78:290 kg NPK ha^{-1}. Also buckwheat yield with 30:30:0 kg NPK ha^{-1} was significantly higher then 10 t FYM ha^{-1}. Such situation might have created due to low minerlization of nitrogen induced by low soil temperature and poor decomposition of FYM.

Similar to grain yield, highest 1000-grain weight (23.6 g) was also obtained from treatment 6 (30:30:0 kg NPK ha^{-1}) which was followed by treatment 4 (23.3 g) (15:15:15 kg NPK $ha^{-1)}$ and treatment 10 (23.3 g) (45:30:0 kg NPK ha^{-1}) (Table 1), though the difference was not statistically significant. Application of 5 t FYM ha^{-1} along with 30 kg K ha^{-1} had lowest 1000-grain weight (21.5 g), and was significantly lower than treatment 2, 3, 4 and 6. Result also reveals that the treatment with lowest 1000-grain weight had also lowest yield and vice-versa showing positive correlation between 1000-grain weight and grain yield.

Various treatments had significant effect on plant height. Highest plant height (86 cm) was obtained with the application of 30:30:0 kg NPK ha^{-1} and was at par with 45:30:0 kg NPK ha^{-1} and 15:0:0 kg NPK ha^{-1} but differed significantly with rest of treatments. Lowest plant height (66 cm) was obtained with the application of 10 t FYM ha^{-1} + 2 t lime ha^{-1} and was at par with treatment 1, 3 and 8 (Table 2).

Different level and combination of plant nutrients had no significant effect on days to flowering, days to maturity and number of flower cluster $plant^{-1}$ (Table 2). Year wise detail information for three years (1997/98, 1998/99 and 1999/2000) regarding grain yield and other parameter are given in Appendix A, B and C.

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Table 2. Effect of plant nutrient on yield and other important parameters of buckwheat during 1997/98 to 1999/2000

Treatment†	Flowering days	Maturity days	Plant stand, m^{-2}	Plant ht, cm	Branch $plant^{-1}$	Flower cluster $plant^{-1}$	1000-grain wt, g	Yield, kg ha^{-1}	Treatment rank
Control	29	62	120	68	3.0	6.1	21.7	497	6
15:0:0 kg NPK ha^{-1}	29	63	120	81	3.1	6.7	23.1	587	10
15:15:0 kg NPK ha^{-1}	28	64	133	69	3.1	5.8	22.7	612	5
15:15:15 kg NPK ha^{-1}	29	63	130	79	3.0	6.5	23.3	609	7
30:0:0 kg NPK ha^{-1}	29	63	118	76	3.1	6.6	22.1	701	12
30:30:0 kg NPK ha^{-1}	29	64	151	86	3.2	7.7	23.6	804	3
30:30:30 kg NPK ha^{-1}	29	62	126	79	3.2	6.4	22.3	675	4
0:0:30 kg NPK ha^{-1}+ 5 t FYM ha^{-1}	28	63	121	67	3.0	6.5	21.5	463	9
45:0:0 kg NPK ha^{-1}	29	63	118	72	3.0	6.5	22.6	594	2
45:30:0 kg NPK ha^{-1}	29	63	140	81	3.4	6.7	23.3	777	11
10 t FYM ha^{-1} + 2 t lime ha^{-1}	29	63	124	66	3.1	5.6	22.5	587	1
5 + t FYM ha^{-1} + 2 t lime ha^{-1}	29	63	129	71	2.9	6.2	22.1	633	8
Mean	29	63	127	75	3.1	6.4	22.6	628.3	
CV, %	5.4	4.2	33.4	15.6	27.8	36.05	13.08	31.5	
Treatment	NS	NS	NS	**	NS	NS	**	**	
Year	**	*	**	**	**	**	**	**	
Treatment ×Year	*	NS	NS	NS	NS	NS	NS	-	
LSD at 5 %	1.0	2.2	25.9	6.25	0.61	1.68	1.12	132.15	

*, significant at 5%; **, significant at 1% and NS, non significant.
† FYM, Farm yard manure; LSD, Least significance difference.

Table 3. Soil Analysis data on different treatments during FY 1997/98, 1998/1999 and FY 1999/2000†

Treatment	pH			Organic matter, %			Nitrogen, %			Available P kg ha^{-1}			Available K kg ha^{-1}		
	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00
Control	4.77	4.97	4.8	2.000	2.415	2.9	0.137	0.139	0.111	214.81	257.36	67.7	391	393	467
15:0:0 kg NPK ha^{-1}	4.80	4.97	4.9	2.145	2.270	2.9	0.145	0.123	0.122	263.98	251.34	83.7	410	422	442
15:15:0 kg NPK ha^{-1}	4.95	5.12	4.7	2.242	2.312	2.8	0.139	0.123	0.109	215.63	226.64	86.6	405	340	551
15:15:15 kg NPK ha^{-1}	4.85	5.02	4.7	2.110	2.245	2.5	0.145	0.128	0.106	237.67	239.24	116.6	414	355	412
30:0:0 kg NPK ha^{-1}	4.80	4.90	4.6	2.310	2.545	2.8	0.139	0.141	0.121	218.03	244.48	74.8	377	350	359
30:30:0 kg NPK ha^{-1}	4.95	4.95	4.7	2.277	2.310	2.6	0.149	0.125	0.117	210.93	235.25	106.6	420	401	386
30:30:30 kg NPK ha^{-1}	5.05	4.95	4.8	2.412	2.445	2.5	0.165	0.133	0.125	236.05	243.88	119.5	391	342	545
0:0:30 kg NPK ha^{-1}+ 5 t FYM ha^{-1}	4.80	4.92	4.8	2.280	2.245	3.0	0.147	0.126	0.105	230.47	236.83	90.7	513	411	598
45:0:0 kg NPK ha^{-1}	4.87	4.82	4.7	2.077	2.447	2.7	0.166	0.124	0.138	222.92	236.53	83.1	465	416	455
45:30:0 kg NPK ha^{-1}	4.80	4.80	4.9	2.177	2.445	2.5	0.157	0.131	0.136	238.94	230.04	119.1	374	413	399
10 t FYM ha^{-1} + 2 t lime ha^{-1}	5.10	5.02	5.5	2.242	2.447	2.7	0.140	0.136	0.121	221.27	235.06	87.8	439	399	498
5 + t FYM ha^{-1} + 2 t lime ha^{-1}	5.35	5.02	5.3	2.445	2.512	2.7	0.149	0.144	0.116	220.70	243.92	98.9	374	442	464
Mean	4.91	4.98	4.88	2.227	2.389	2.7	0.148	0.131	0.119	227.58	240.05	94.19	414	390	464

† FYM, Farm yard manure.

Appendix A. Observation on different characteristics on buckwheat in different combination of treatments during 1997/98†

Treatment	Flowering days	Maturity Days	Plant stand, m^{-2}	Plant ht, cm	Branch $plant^{-1}$	Flower cluster $plant^{-1}$	1000-grain wt, g	Yield, kg ha^{-1}
Control	29	61	108	63.75	3.25	4.75	19.3	365
15:0:0 kg NPK ha^{-1}	29	63	99	74.5	3.5	4.5	18.8	449
15:15:0 kg NPK ha^{-1}	30	66	120	62.25	3.0	5.0	19.5	380
15:15:15 kg NPK ha^{-1}	28	63	131	68.0	2.75	5.25	19.8	432
30:0:0 kg NPK ha^{-1}	31	63	103	70.0	2.75	5.5	18.6	547
30:30:0 kg NPK ha^{-1}	31	64	96	75.0	3.0	4.75	19.5	646
30:30:30 kg NPK ha^{-1}	30	63	93	66.25	3.25	4.95	18.5	490
0:0:30 kg NPK ha^{-1}+ 5 t FYM ha^{-1}	29	65	96	63.25	3.75	4.75	18.0	290
45:0:0 kg NPK ha^{-1}	31	64	105	63.25	2.5	4.5	19.2	397
45:30:0 kg NPK ha^{-1}	30	63	100	71.25	3.75	6.5	19.6	370
10 t FYM ha^{-1} + 2 t lime ha^{-1}	31	66	107	62.0	3.0	4.5	18.8	400
5 + t FYM ha^{-1} + 2 t lime ha^{-1}	30	66	125	70.75	3.0	5.5	18.8	467
Mean	29.6	63.7	106.8	67.5	3.12	5.03	19.06	453
F-value	NS	*	NS	*	NS	NS	NS	**
CV, %	57.0	6.2	29.5	10.3	28.4	20.5	5.9	26.22
LSD at 5 %	2.17	3.27	37.75	8.32	1.22	1.42	1.59	112.59

*, significant at 5%; **, significant at 1% and NS, non significant.
† FYM, Farm yard manure; LSD, Least significance difference; ht, height; wt, weight.

Appendix B. Observation on different characteristics on buckwheat in different combination of treatments during 1998/1999†

Treatment	Flowering days	Maturity Days	Plant Stand, m^{-2}	Plant ht, cm	Branch $plant^{-1}$	Flower cluster $plant^{-1}$	1000-grain wt, g	Yield, kg ha^{-1}
Control	29	62	145	63.3	2.6	6.2	23.5	550
15:0:0 kg NPK ha^{-1}	30	63	147	82.4	2.6	8.3	25.2	581
15:15:0 kg NPK ha^{-1}	28	62	156	62.3	2.1	4.8	23.9	625
15:15:15 kg NPK ha^{-1}	29	62	157	68.65	2.7	7.7	25.4	631
30:0:0 kg NPK ha^{-1}	29	63	239	76.7	2.5	5.9	22.9	613
30:30:0 kg NPK ha^{-1}	29	63	203	85.25	2.5	5.8	24.8	659
30:30:30 kg NPK ha^{-1}	29	62	174	80.9	2.7	5.5	23.0	602
0:0:30 kg NPK ha^{-1}+ 5 t FYM ha^{-1}	28	62	163	61.55	1.9	4.1	21.5	387
45:0:0 kg NPK ha^{-1}	28	61	140	68.05	2.9	7.2	23.3	612
45:30:0 kg NPK ha^{-1}	30	63	142	84.9	2.7	7.1	24.2	769
10 t FYM ha^{-1} + 2 t lime ha^{-1}	28	62	141	61.75	2.3	4.9	23.5	640
5 + t FYM ha^{-1} + 2 t lime ha^{-1}	28	61	141	66.05	2.2	5.5	21.5	570
Mean	28.75	62.0	164.8	72.1	2.5	6.1	23.1	603.2
F- value	*	NS	**	**	NS	NS	*	**
CV, %	4.0	2.46	26.4	14.8	25.5	39.0	8.5	18.2
LSD at 5%	1.40	1.78	49.94	8.0	0.78	3.03	2.60	88.54

*, significant at 5%; **, significant at 1% and NS, non significant.

† FYM, Farm yard manure; LSD, Least significance difference; ht, height; wt, weight.

Appendix C. Observation on different characteristics on buckwheat in different combination of treatments during 1999/2000†

Treatment	Flowering days	Maturity days	Plant stand, m^{-2}	Plant ht, cm	Branch $plant^{-1}$	Flower cluster $plant^{-1}$	1000-grain wt, g	Yield kg ha^{-1}
Control	28	62	108	72	3	7.2	23.5	575
15:0:0 kg NPK ha^{-1}	28	64	115	85	3.4	7.3	25.4	731
15:15:0 kg NPK ha^{-1}	28	63	122	83	4.2	7.6	24.7	831
15:15:15 kg NPK ha^{-1}	29	63	115	89	3.4	6.5	25.6	764
30:0:0 kg NPK ha^{-1}	27	64	109	81	4	8.3	24.7	945
30:30:0 kg NPK ha^{-1}	27	64	121	96	3.8	9.2	25.3	1108
30:30:30 kg NPK ha^{-1}	27	63	112	91	3.5	8.6	25.5	932
0:0:30 kg NPK ha^{-1}+ 5 t FYM ha^{-1}	29	63	103	74	3.3	8.6	24.9	714
45:0:0 kg NPK ha^{-1}	27	63	107	85	3.6	7.7	24.6	774
45:30:0 kg NPK ha^{-1}	27	62	111	87	3.6	9.4	26.1	992
10 t FYM ha^{-1} + 2 t lime ha^{-1}	28	62	113	75	3.7	7	25.1	720
5 + t FYM ha^{-1} + 2 t lime ha^{-1}	28	63	92	77	3.5	7.5	25.0	861
Mean	28	63	111	82.9	3.58	7.93	25.0	828.9
F-value	**	NS	NS	**	NS	NS	NS	**
CV, %	3.62	2.02	18.21	13.62	17.86	27.8	4.3	19.53
LSD at 5 %	1.07	1.54	24.4	12	0.87	2.89	1.45	127.24

*, significant at 5%; **, significant at 1% and NS, non significant.
† FYM, Farm yard manure; LSD, Least significance difference; ht, height; wt, weight.

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Promoting local food culture as a method to conserve buckwheat diversity in agro-ecosystems in Nepal

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Abstract

Buckwheat (*Fagopyrum* spp.) is grown in Nepal from the lowland Terai to the high mountains as a subsistence crop in resource poor areas. Both *mithe* and *tite* buckwheat are cultivated in Nepal. Although later maturing than the *mithe* type, the *tite* type yields better. Very little breeding has been done to improve either type. Buckwheat is consumed in different forms; different food recipes are prepared from the grains and grain flour, fresh leaves are used either as vegetables or to make pickles and powder of dried leaves ground with naked barley is used as soup. Various porridge and bread types are commonly used in as a main course or snacks. Pickles and soup are often served along with porridge and bread. In resource rich areas, where other cereals including rice are easily available, buckwheat is considered a poor persons staple and used mainly as take-away food or snacks. Through household survey (n = 180) for *in situ* crop conservation global project in buckwheat areas of Jumla, focus group discussion conducted at different times and sites, the paper has been prepared. Initiatives of the *in situ* project, Annapurna Conservation Area project, buckwheat collaborative works between LI-BIRD and the International Plant Genetic Resources Institute (IPGRI) had been referred.Contribution of buckwheat to food security varying over contrasting agro-ecosystems and socio-cultural settings as a case has been discussed. The area of buckwheat in resource poor areas is higher than in resource rich areas. It is because the importance of buckwheat as staple crop is greater in resource poor areas. The analysis suggests that species diversity is linked with the richness in food culture. In Jumla where species diversity is higher, food culture is also rich as compared to Mustang and Manang areas with relatively poor species diversity. Rice is a crop with a diverse food culture. Farmers adopt knowledge associated with rice food culture to prepare various recipes of buckwheat, indicating that the diverse uses of rice influence diversity of buckwheat use. Villages with more diverse food culture were found to cultivate a higher number of buckwheat landraces. Conservation of landraces may thus be achieved if associated food culture can be promoted by creating markets through research on food recipes and networking to improve access and consumer awareness.

Key words: adding values, food culture, recipes, resource poor areas

Introduction

In subsistence farming, agriculture contributes not only in securing livelihoods but also for services related to medicine, cloths, religious and cultural needs. In Nepal, variable geographic, climatic and socio-cultural distributions have created inter and intra species diversity at different levels. For centuries farmers have been using these resources as a way of life. Through cultivation and selection their values[1] and benefits[2] were recognized and adopted as appropriate. As a result, those valued

[1] Values are quality traits that are either rare or excess and are acceptable to the public or fraction of a society. Values may be expressed in terms of money, sentiments, novelty, beliefs and so on.
[2] Benefits are often expressed in monitory terms but not always because the example shows that absentees benefit if a typed lecture note is provided

resources are still conserved on-farm. In order to be maintained these resources should hold specific use values either in socio-cultural, economic, ecological terms or preference traits (Jarvis et al., 1999). In other words, landraces having symbolic traits related to culture, religion or sentiments are often conserved locally. Of the direct and indirect benefits as described by Brush (1999), market method provides incentive for maintaining local landraces on-farm. Past studies have shown that conservation of local varieties is enhanced if they are valued in economic terms (Brush, 1999; Rijal et al., 2001). Of the many ways, promotion of certain food recipes improves use values thereby demand for raw material is increased resulting in increased cultivation of that landrace to meet the market demand. This phenomenon has been experienced in case of rice and taro landraces through *in situ* crop conservation global project implemented in Nepal (Rijal et al., 2001).

Rationale

Jarvis and Hodgkin (1997) suggested two main ways of adding values and benefits to crop genetic resources. First, the local landraces *per se* may be improved by adding use value through breeding means. Second, the demand of the farmers' cultivars or some derived products may be increased by providing market incentives, policy relief and consumer awareness. Experience shows that adding values on some local landraces will be the simple way to enhance on-farm conservation. The process and approaches for enhancing traditional food culture have been discussed elsewhere (Rijal et al., 2000). In order to make landraces competitive in times of pressures, breeding approaches to improve yield and quality traits to increase demand through non-breeding means is necessary. In this paper, value and benefits of local landraces associated with food culture as a focal point is discussed to show how enhancing food culture help conserve these resources on-farm. Little research has been conducted in this field to establish the relationship in Nepalese context.

Process and approaches

The authors with diverse backgrounds including value addition to local crop diversity inspired us to share our experiences with colleagues at large. Farmers' knowledge and practices acquired at different occasions and across sites through survey or Focus Group Discussions. Baseline studies in Jumla villages carried out under the global *in situ* crop conservation project have been analyzed and used. Experiences with promotional activities related to local food culture were useful lessons. Literature to adding values and benefits to local crop diversity was reviewed. Some of the successful initiatives already employed by a few institutions involving local level farmers' groups have been used as reference cases.

Importance of buckwheat in Nepalese context

No exact statistics under buckwheat is available, however, it is estimated that the area is between 43,000 and 50,000 ha (Vaidya et al, 1998). Buckwheat productivity was variable. The productivity level differed from survey results (Rana, et al., 2000) and those reported from the buckwheat growing areas (ADO, 055/56). Buckwheat (*Fagopyrum* spp.) in Nepal is grown from plain *Terai* during winter whereas in the hills and mountain it is grown during the summer season from east to the west (Baniya et al., 1992). In *Terai* and foothills, it is grown in paddy fields after rice whereas in mid hills buckwheat is grown after maize in upland *bari* conditions. Buckwheat grows well from less fertile soils to fertile soils under moisture deficit agro-ecosystems throughout Nepal. Different crop species or varieties adapted to a general or a niche specific environment or agro-ecosystems have been identified over time. Buckwheat matures early and fits well under diverse crop systems as inter, relayed or sequential cropping. Though buckwheat is grown across the agro-ecological zones, its contribution to food security for Mountain farmers is significant. In recent years, the crop has been cultivated as cash crop in plain Te*rai* areas. The farmers have identified local varieties suitable for specific food recipes.

Co-adaptation of food culture, social norms and biodiversity

Nepalese food culture is diverse which is specific to religion, culture and ethnicity that is co-adapted as determined by the natural factors. Importance of rice in Hindu culture is very vital in ceremonies particularly in areas where rice is grown. Plain *Terai* and mid hills are areas where rice based culture pre-dominates. Farmers of the western Himalayas are rich in knowledge with traditional rice culture associated with ecology and use values. Bishop (1990) documented that rice culture in Jumla valley was introduced via Kashmir about 900 years ago. On the contrary, rice in similar but low rainfall areas such as Mustang, has not even been introduced. Rice culture in other districts such as Dolpa and Manang is not common. The strategies for household (HH) food security and socio-cultural norms for non-rice farmers differ from those rice farmers. Social prestige with regard to buckwheat consumption pattern differed over contrasting socio-cultural settings. Rice in Jumla with *Aryan* society is considered as a prestigious crop. Opposite is true for buckwheat. Household status is rated using these symbolic crop species. Households that consume buckwheat items as main meal are of lower status with poorer categories and vice versa. Opposite is true for the case of rice. In a *Tibeto-Burman* society as in Mustang, a non-rice area, buckwheat as a staple crop is considered to have religious and prestigious values. Since these areas fall under trekking routes and outsiders perhaps become interested to try recipes prepared locally. Such tests not only enhanced market demand for local products but also motivated local people for co-adaptation of such culture together. Inability of the resource poor consumer to afford expensive rice imported from outside also perhaps de-motivated rice consumption. The knowledge level and use values thus depend on the degree of importance of the household needs provided adaptation of crop species remains favorable. The analysis indicates that social prestige and norms by species was established primarily on the basis of adaptation followed by their contribution to food security and preference traits. This is demonstrated by these two contrasting cases of rice and non-rice growing agro-ecosystems. Culture including food culture is thus subject to change but go together with species adaptation.

Food culture and local uses

Nepalese festivals linked with food culture are either modified or co-adapted according to a number of factors including ecology, socio-culture and religion. Farmers perceive that it is good to serve buckwheat products particularly for patients with diabetic, jaundice, cold, fever, intestinal disorder, pneumonia and gastritis. Rutin as a drug for treatment of vascular disorder is found in *F. esculentum* and *F. tartaricum (*Campbell, 1997). The highest concentration was in *F. tartaricum*. For this reason, farmers use bitter types for specific medicinal purpose. Bitter type in mountain areas is consumed as staple food.

Food recipes differ across the agro-ecological zones and socio-cultural settings. In middle hills *Aryan* society above a dozen festivals were documented requiring special food recipes (Rijal et al., 1999). The number may increase when location specific festivals as from Jumla are added (Annex 1). Farmers are thus rich in local knowledge related to food culture, use value and its ecology. As a result of that number of food recipes are evolved. Compared to Mustang, food culture richness was reported high in Jumla. This richness corresponds to high diversity of crop species including cereals, legumes and oil crops. The additional richness of rice culture in Jumla is absolutely due to species adaptation (Table 1).

The culture also differed on their types. In Mustang and Manang, buckwheat based food recipes are consumed as main course and snacks. On the contrary, buckwheat in Jumla is consumed either as snack or take-away food recipes. *Dheshu, selroti,* raw flour, bread and porridge in Jumla are major recipes consumed. Likewise in Mustang, porridge and bread are the traditional recipes commonly used. Bitter buckwheat is popular mainly because of higher yield with better adaptation. To reduce bitterness wet flour is kept over night. On the following day flour releases yellowish water which is removed before preparing any recipe. Bitterness is thus removed along with such yellowish water (Rijal, 2001) and also documented elsewhere (Vaidya et al., 1998).

Rice culture of Jumla is a century old practice (Bishop, 1990) and the people have created a diverse rice based food recipes. Such rice based food culture in Mustang is none. Food culture richness thus corresponds to rice culture. The analysis shows that buckwheat based recipes are adapted from that of rice culture (Annex 2). However, there are a few common ways of making these recipes but are named differently. The most common ones are described in Table 1. Culture of offering special recipes is presented in Fig. 1.

Table 1. Some special food options of buckwheat from the Nepal Himalayas

Recipes	Description	**Jumla**	**Mustang**
Dheshu	**Special take away thick bread cooked under the oven or fire place sandwiched by green leaves**	Special	Uncommon
Roti	A common type flat bread cooked on pan	Yes	Yes
Sel roti	Round hollow ring shaped is deep fried either in ghee or oil	Specific	Uncommon
Dhindo	A simple dish made by boiling flour in water, eaten specially as main course	Yes	Common
Lagar	A simple semi-solid soft dish made by boiling flour in water, eaten specially as main course	Special	Uncommon
Dalla	Balls made from buckwheat flour are made by boiling in water and served as snack	Yes	Uncommon
Dapra	Flour prepared by grinding dried leaves and naked barley used as an alternative to *Daal (*pulse soup)	None	Special
Chyakhla	Buckwheat grits that is used as *Bhat* (boiled rice)	Yes	Uncommon
Lache Saag	Dried leaves and petioles once outer skin is removed is consumed during off-season.	Specific	Fresh only
Aachar	Pickle prepared from leaves mixing yogurt and spices consumed with porridge	Uncom mon	Special

Ecological adaptation and landraces diversity

In a survey carried out in 13 villages of Jumla Poudel et al. (1998) found that there are at least six landraces being cultivated for generations of farmers. The socio-economic survey documented four types that were grouped either as *tite* or *mithe* (Rana et al., 2000).

Crop season varies with types of buckwheat variety. *Tite* buckwheat matures early and hence is adapted in a cereal-based cropping pattern. *Tite* buckwheat at higher hills and mountains is sequenced after the harvest of naked barley whereas *mithe* type is mono-cropped. *Mithe* types mature late (105 days) compared to *tite* one, which usually matures between 70 and 75 days after sowing. Late maturing varieties suffer more from cold injury and hence farmers often prefer early maturing cultivars (Annex 3). In general, late maturing crop varieties often produce better yield but on the contrary farmers reported that *tite* type often produce greater yield compared to late but *mithe* buckwheat. However, the maturity duration varies according to the altitude and sowing time. Varieties that are adapted to lower elevation such as Jomson local (1900 m) also grows at higher elevation but that produce more straw due to luxurious growth (Rijal and Subedi, 1998; Subedi et al., 2001). No external inputs are supplied to buckwheat but local compost. Since buckwheat is a rain-fed and low nutrient demanding species, grows well under a diverse fertility and moisture regimes. For this reason, buckwheat plots in Jumla are often marginal. But the case in Mustang does not hold true where buckwheat still contributes to rural food security.

Contribution of landraces to food security

The socio-economic baseline studies carried out in Jumla village (n = 180 HH) suggests that nearly 25% HH grow at least five different kind of buckwheat varieties. The estimated area was 2.3 ha with a productivity of 1.71 t ha^{-1} (Table 3). The estimated buckwheat area was the highest in Mustang (761 ha) followed by Manang (195 ha) and Jumla (13 ha) (Table 2). *Tite* buckwheat for food deficit areas of Humla, Jumla, Mustang, Manang and Dolpa districts contributes above one third of the total food requirements (Vaidya et al., 1998). In terms of area coverage under food crops (cereals, legumes and oil crops), buckwheat in Mustang occupy second position after wheat and third in Manang after potato and wheat where rice is not cultivated. In Jumla where wheat, maize, barley and rice occupy major areas, buckwheat comes last (ADO, 1999/00). The area coverage and its position indicated its importance in rural food security particularly where a limited species are ecologically selected.

Table 2. Estimated role of buckwheat in food security

Particulars	District		
	Mustang	**Manang**	**Jumla**
Diversity of important food crops (No.)	08	07	10
Total area under main cereals (ha)	3154	828	25166
Buckwheat area (ha)	761	195	13
Buckwheat area as % of total area	24	23	0.05
Price for coarse rice (Rs kg^{-1})	38	30	51
Price for medium rice (Rs kg^{-1})	46	32	55
Price for fine rice (Rs kg^{-1})	67	45	58
Variety composition	Landrace	Landrace	Landrace

Source: ADO Office, 2000/01; 1999/00.

It is apparent that diverse landraces of buckwheat are cultivated under marginal and rain-fed upland conditions. It has often been neglected from research and development (R&D) works though its contribution to rural food security in particular is significant. As shown in table 3 area and productivity under buckwheat varied across wealth categories. The survey revealed that buckwheat in rice growing area is considered neither prestigious nor important for food security. The area therefore was only about 04% under buckwheat. The majority of which was poorly fertile marginal lands. In terms of food sufficiency more than 80% households are either poor or very poor meaning that they are food deficit households. As shown in Table 3, well-off HHs (23%) holds more than 33% of the area under four crops. On the contrary, poorer HHs (45%) holds below 35 per cent cropping area. These 23% well-off households produce 39% of the total production. On the contrary, 45% poorer households produce only 34% of these cereals. The case for medium category was nearly proportionate (Table 3).

Table 3. Area (ha) by household with estimated productivity (prody) and production (ton), Talium, Jumla

Particulars	No. of variety	Wealth category						Total	
		Rich		Medium		Poor			
		Area	**Prody**	**Area**	**Prody**	**Area**	**Prody.**	**Area**	**Prody.**
Rice	17	6.14 (43)	2.77 (43)	5.4 (62)	2.58 (62)	5.57 (85)	2.02 (85)	17.11	2.55
Barley	4	9.63 (63)	3.60 (63)	8.81 (93)	2.75 (93)	9.95 (128)	3.10 (128)	28.39	3.15
Finger millet	12	2.03 (52)	2.46	2.45 (68)	2.34	3.04 (99)	2.89	7.52	2.56
Buckwheat	5	0.34 (13)	2.54 (13)	0.99 (20)	1.48 (20)	0.96 (27)	1.12 (27)	2.29	1.71
Total HHs		171(23%)		243(32%)		339 (45%)		753	
Area		18.14 (33%)		17.65 (32%)		19.52 (35%)		55.31	
Production		57.524 (37%)		45.345 (29%)		51.957 (34%)		145.84	
Productivity		3.18		2.57		2.87			

Abstracted from Rana et al. (2000). Figure in parenthesis without percentage indicates responding HHs.

In Jumla, barley followed by rice, finger millet and buckwheat were identified important in order of priority. These crops are grown in plots that are more fertile and buckwheat is grown where other crops hardly be grown. The trend analysis shows that well-off minority HHs yet hold more productive plots and therefore secure higher crop productivity. Comparatively, lower productivity even with reduced land size for poorer farmers was due to marginality of the cropping area. Another side of the coin as in Mustang, a non- rice area where buckwheat is a prestigious crop, is grown in better plots. For that reason, relatively higher yield of buckwheat (1247 kg ha^{-1}) has been reported in Mustang (Subedi et al., 2001). Similar is the case for rice culture in Jumla. Unlike little inputs for other crop species, Jumla farmers put more input to rice culture. Despite, farmers' efforts, higher yield of rice not yet been attained mainly because of severe blast disease coupled with cold injury. Clearly, value of crop and selection of plots often go together. Buckwheat itself is widely grown by many rural HHs either for ecological adaptation, use values or for food culture values. Thus, the degree of contribution of buckwheat varies in rural food security under contrasting agro-ecosystems.

Research and development links

An in-depth understanding of indigenous knowledge on landraces along with their use values is the pre-requisite for future R&D works. The paper documented knowledge base related to food culture, socio-religious and medicinal values as well as its contribution to rural food security. Until recently, the species *per se* is neglected and therefore, R&D works were at low profile. The research works through the Hill Crops Programme particularly characterizing diversity (Baniya et al., 1992) can never be under valued. As a result, a few promising materials have also been identified. Initiatives to promote food culture as precursor to enhancing conservation and use through non-technical means are very limited. This is so because there are no such programs in the formal sectors that provide training services for the promotion of local food culture. *In situ* crop conservation project (NARC/LI-BIRD/IPGRI) team of Kaski offered a training on baking and cooking to a few rural hoteliers (N = 6) jointly with the Pokhara Tourism Training Center. The purpose was to improve their skill also on locally popular food recipes. Since it is such area where multiple factors influence the decision little and positive effects are seen particularly in hygiene and sanitation. Such efforts, directly applicable for the promotion of food culture related to buckwheat, have been made by the Annapurna Conservation Area Project (ACAP) in its command area (Box 1).

Box 1. Initiatives for capacity building for rural hoteliers

Annapurna Conservation Area Project provided a series of training programs on baking and cooking, lodge management particularly to rural hoteliers of the Annapurna areas. As a result, one can observe some degree of success how locally based food culture could be promoted. Buckwheat based food recipes are served locally. Pancake, bread and porridge and some other deep fried dishes are served in Mustang trekking areas

ACAP conducted a series of skill oriented training programs over years particularly to rural hoteliers in trekking areas of Annapurna (Lama, 1995). A few recipes such as pancake, a Western European recipe has now been common even among the local consumers.

Through an improved packaging, processing and regular services such recipes can be popularized. Of the known recipes pancake, bread, porridge made from buckwheat are served with pulse soup in rural hotels in Mustang. Despite certain level of constraints, these hoteliers are able to commercialize local recipes by satisfying consumers. Such efforts not only helped raise incomes of the rural poor but also strengthen use values thereby enhancing on-farm conservation. The case of Jumla where buckwheat *per se* is socially under-valued needs special attention for public awareness. Thus the successful stories already experienced from similar areas can be transferred through a little effort.

Discussion and conclusion

The contribution of buckwheat to food security in low rainfall and less fertile areas that are constraints in terms of access to water and input resources in particular is apparent. In these areas, buckwheat is cultivated as staple crop and a variety of recipes are used as snacks and fresh vegetable. Buckwheat in these areas is thus accepted as a socially prestigious crop. However, the areas with good rainfall where diverse food crop species exist like in Jumla, buckwheat is a neglected crop. Despite these realities, buckwheat items are yet consumed either as snacks by all categories of farmers or *Dhindo* as main meal by poorer people. Jumla farmers perceive buckwheat as a socially under valued species. Any households that consume buckwheat items as main meal are categorized poor meaning that buckwheat is poor men's food. Despite these facts, different food recipes are used for snacks and take-away. The definition of social prestige against any species thus depends upon the potential contribution to secure food security. The species adapted to are exploited their values locally. Thus the adaptation of any species comes first and food culture thereafter.

Mountain areas are rich in buckwheat diversity which supports rural food security. Although literature is expanding to document the value of buckwheat and its diversity in Nepal, their traits related to use values (food culture, medicine) have not yet been exploited in realistic terms. To help secure foods promoting food culture as a method for enhancing conservation of landraces on-farm is important. The case of Mustang suggests that use values can be strengthened through improved menu options. Pancake perhaps is more preferred over local bread. We argue that local consumer will prefer such offers thereby increased consumptive use of buckwheat locally. Consumer awareness in terms of nutrition and associated values is necessary. The challenge is thus how R&D works can be integrated in a holistic manner. Conservation of buckwheat diversity in agro-ecosystems thus goes together with use values and improved food culture.

Way forward

There are a number of issues evolved that have not yet researched to establish scientific bases. Farmers perceive that *tite* buckwheat has medicinal values, however, it is not yet fully understood the scientific bases for that. In addition, some farmers reported that it is injurious to human health if *tite* type is eaten for long time. Further research is needed to translate farmers' perception into reality, that is, facts and figures on nutritional and bio-chemical content of these landraces.

It is often reported that *tite* type have medicinal values and a few farmers in Jumla reported that long term consumption of buckwheat can be hazardous to human health. The health question of the mountain people can be inferred here who still consume buckwheat. Experience shows that mountain people still suffer from a number of problems including gastritis. In addition, farmers perceive that it may be injurious if eaten for long time. Like wise, one experiences headache when the hot recipes are eaten. For, this reason, farmers of western Himalayas consume buckwheat when they are cold. Research is lacking in these kinds of myth and further studies to establish scientific bases needs to be carried out but not on beliefs with regard to culture and religious significance.

It is not yet explored use values with reference to the potential food recipes. Menus for different recipes have not yet been well known and if recognized they are not widely adopted. The research menus as to satisfy consumers' preferences have to be developed and distributed to hoteliers at large. Such initiatives should be planned on phase wise manner. And initiatives that facilitate networking are required. Attempts made to increase values on rice and taro based food culture have been effectively achieved (Rijal et al., 2001). The lessons learned from such initiative starting from problem analysis through to consumers' awareness may be adopted. Since the promotion of such complex agenda can hardly be successful therefore should be internalized into the main options currently exist.

Unlike trained manpower on exotic food culture, there are hardly any trained cooks on traditional recipes in Nepal. And there have no such courses yet been offered either through formal or informal sectors. Such courses should be designed together with exotic food culture. These initiatives once become successful will motivate farmers to cultivate landraces ultimately help their conservation on-farm.

The other important option for adding value is to utilize landraces for their derived products as raw materials to prepare recipe. There are already such isolated but successful examples already experienced by a few hoteliers eg Blue Bird in Pokhara. This option is very simple and can be integrated into the existing food culture with little efforts. Facilitation works in term of menu development, nutrient contents and networking help enhance uses thereby conservation on-farm.

Preparation of traditional food recipes

Buckwheat recipes are popular in Pokhara

Ways of offering special recipes in Jumla

Fig. 1. Buckwheat recipes.

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Annex 1. Description of crop species along with their food culture values in Talium, Jumla (1999)

Crop species	Food recipes	Potential farmers' groups
Paddy	*Cooked rice, Sell roti, Laddu, Lagad, Khatte, Chini Roti, Beaten rice, Jagadhulo*	Silam, Rokayabada
Barley	*Khaja, Satu, Litto, Bread, Horliks, Sarbottam pitho*	Silam, Rokayabada
Buckwheat	*Fresh vegetable, Dheshu, Flour, Lagad, Bread, Dalla, Dhindo, Sell roti, Chyakhla, Dried leaves, Lache saag*	Silam, Loharbada
Finger millet	Roti, Puwa, local brew, Dhindo, Lagar, Zaand	Silam, Loharbada
Taro	*Masyoura, Karkalo, Badi, Galmad (Corm), fresh leaf and Gava*	Khalla, Damaibada
Beans	*Kwanti, Daal, Phando, Seed (Dana), Badi and Phuraula*	Silam, Rokayabada, Khalla
Fox tail millet	*Khir, Cooked rice (Pudding for patients with small pox), Lagar, Roti and Laddu*	Khalla
Proso-millet	*Muri (cooked rice), Khatte*	Tallo Rokayabada
Soybeans	*Phando, Roasted grain as Khaja, Khir, Dalmot, Kadhi, Sarbottam pitho*	Rokayabada, Tallo Rokayabada, Khalla
Pointed gourd (Karela)	*Bhuja, Seed for pickle, Fresh for vegetable*	Silam, Khalla, Rokayabada, Tallo Rokayabada
Amaranths	Satu, Khaja, Roti, leafy vegetable, Chini roti and Laddu	Silam, Khalla
Mustard	*Oil, Leafy vegetables, Pickle*	
Guranuso (Masyang)	*Daal, Boiled seed*	Tallo Rokayabada

Source: Rijal and Tiwari, 1999.

Annex 2. Values and benefits associated with buckwheat in contrasting socio-economic settings

Variety	**Use values and benefits**	**Contrasting socio-cultural and agro-ecosystems**	
		Mustang (3500 m)	**Jumla (2300 m)**
	Nutrition	Rich both as food and feed	
Tite	Use of grain	Food as bread & porridge	Bread, Dheshu
	Feed	*Jhopa* for donkeys/horses/cattle	Straw for livestock
	Medicine	Gastritis	Medicine
	Taste	Poor	Poor mainly when consumed without treatment
	Adaptation	Marginal & cold tolerant	Grows in marginal and cooler areas
Mithe	Food	Porridge & Bread	Fresh flour, Dheshu, Lagad, Dalla, Snack, Chokhla, Sel roti, Dhindo
		Leafy vegetable	Leafy vegetable, dried leaf, Lache Saag
		Dapra	Not known or not practiced
	Feed	Only straw for livestock	Only straw for livestock
	Quality & social prestige	Good and high	Crop *per se* believed to be inferior, and those eating HH are of lower status
	Adaptation	Good fertile soils under mono-cropped condition	Grows in mono cropping conditions
	Serving recipes	Hot immediately after cooking	Buckwheat recipes are served once they become cool

Annex 3. Features of some buckwheat varieties as perceived by farmers

Characters	***Tite* types**	***Mithe* types**
Crop duration (Days)	70 to 75	95 to 105
Taste	*Tite*	*Mithe*
Nutritional status	More nutritious	Less nutritious
Yield potential	High yield (>15%)	Low yield
Values	Medicinal	Food
Height and biomass	Less biomass & short plant	High biomass & long straw
Cropping systems	Sown after naked barley	Buckwheat- fallow system
Nutrient demanding	High	Hardly manure applied
Uses	Horse and donkey feed (*Jhopa*,)	Human food as *dhindo* and *roti*
Milling recovery	High	Low
Grain size	Thick pericarp & small grain	Bold grain and thin pericarp
Adaptation	Rain fed	Demands 2-3 irrigation

Source: Rijal and Subedi, 1998.

Annex 4. Description of traits and area under diverse landraces in Talium, Jumla, 1999†

Variety	Traits (n = 48/180)		Area (*Ropani*)			SE
	Preferred	**Less preferred**	**Rich**	**M**	**Poor**	
Bhadule (n=108)	Livelihoods (n=19) Medicinal (n=7) Religious value (n=4) Flour recovery (n=5) Easy digestion (n=3) Good even if eaten raw and snack as bread (n=10) Adaptation (n=4)	Bitterness (n=12) Injurious to human health if eaten over time (n=5) Medium to poor taste (n=8)	0.6	1.4	0.8	0.2
Tilkunde (n=22)	Flour recovery (n=4) Good taste (n=4) Yield (n=2) Leafy vegetable (n=2) Easy milling (n=1)	Headache after eating Injurious to human health if eaten over time (n=2) Small grain (1)	0.6	0.0	0.6	0.00
Tite (n=68)	Good for snack, Lagad and bread (n=6) Livelihood (n=4) Adaptation (n=4) Religious (n=2) Early maturing (n=1)	Injurious to human health if eaten over time (n=13) Bitter taste (n=10) Low yield (n=5)	1.0	0.8	0.6	0.00
Mithe	Medicinal value (n=6) Prestigious (n=1) More contain feeling (n=1) Good taste (n=2) Religious value (n=1)	Low yield (n=2) Not easily digested (n=2)	0.00	0.6	0.6	0.00

† n indicates the total score made against each variety. Valid number for Bhadule (30), *Tite* (18), Tilkunde (4), *Mithe* (4) and Murali (1). M, medium; SE, standard error.

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Study of Nepalese *tite* buckwheat landraces at diversed agroecological regions of Nepal

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Abstract

Nepal has very diverse agro-ecological regions and a lot of bitter buckwheat diversity is reported. A total of 84 Nepalese bitter buckwheat landraces were characterized at four diversed agro-climatic conditions for their quantitative and qualitative traits. Farmers plant buckwheat when the maximum temperature is about 26^{o}C, and if it is not possible buckwheat is planted in early months. The results are erratic and inconsistent; however, days to 50% flowering was highest in Dolpa, average plant height was 156 cm, average stem diameter was also higher in Dolpa, grain yield per plot was higher in Khumaltar. In qualitative traits, inflorescence was loose, growth habit was mostly semi-erect, seed shape was intermediate of triangular and conical, seed surface varies across locations. The observed variations were mostly due to climatic difference and to some extent due to experimental error.

Key words: agro ecology, *tite* buckwheat, landrace, qualitative trait and quantitative trait

Introduction

Buckwheat (*Fagopyrum* spp.) is the neglected crop in Nepal, and it has not been studied well (Baniya, 1999). From national perspective, there is no priority to study buckwheat and its wild relatives. Again, this crop is grown in remote areas and its wild relatives also are found in these places. The remote areas are very much neglected from research and development of this crop. In buckwheat common type is preferred to tartary type. Being the self-pollinated crop, a lot of agromorphological diversity was observed in tartary buckwheat (Baniya et al., 1992 and 1995). We have found different types of weedy tartary buckwheat in mountainous areas of Nepal. The wild tartary (*F. tataricum* ssp. *potanini*) is found in Upper Mustang and Dolpa of Nepal (Baniya et al., 2000). Some agro-morphological characters of cultivated buckwheat landraces are documented.

The tartary buckwheat is mainly grown in the Hindu-Kush Himalayan region as autumn, spring and summer crop. It is grown as the main crop in the high hills in summer and at mid hills, it is an autumn crop and is grown as catch crop in high cropping intensity patterns. In this study, Nepalese bitter buckwheat landraces from different parts are evaluated in diverse agro-ecological regions.

From mid eighties, some surveys were carried out to collect buckwheat germplasm and information on indigenous knowledge. Preliminary studies of buckwheat landraces were conducted after the establishment of Hill Crops Research Programmed in 1986. Japanese scientists have already collected buckwheat landraces extensively and they have used these materials for different studies.

Materials and methods

During 1999 season an observation nursery was designed to characterize 84 bitter buckwheat in extremely diversed four agro climatic conditions across Nepal. The summarized materials are given in Tables 1 and 2. The sources of local bitter buckwheat were from 11 districts and some unknown districts, which were collected by different persons during their trips to the respective districts. Out of 87 varieties, 13 were collected from Mustang, 12 from Solukhumbu, 8 from Dolkha, 7 each from Dolpa and Jumla and so on (Table 2). The altitudes of the seed collected location vary from 1200 m to

3740 m (Appendix I). So, the varieties from extremely different areas were evaluated in diversed agro-climatic conditions. The temperatures at planting time was about the same and the total rainfall during the crop growing period was of the same amount.

This study was conducted in Mustang, Dolpa, Lalitpur and Kaski, whose altitude varies greatly (Table 1) and temperatures, annual average total rainfall and pattern were also different (Table 3). In Mustang and Kaksi, the meteorological data from the exact sites were not available, so the data are presented from the nearest place to the experimental site (Table 4). The trial was conducted in the research station in Khumaltar and Dolpa, whereas it was conducted at farmers' field in Mustang and Kaski. The spacing and seed rate were as recommended in Nepal. The modest amount of chemical fertilizers was applied in Dolpa and Khumal, farmers' compost was applied in Mustang, but no fertilizers and compost were applied in Kaski.

The data were analyzed by MSTATC package and simple parameters were computed for comparison across testing sites.

Table 1. Materials and methods†

SN	Location	Altitude, m	Entries	Plot size	Spacing	Fertilizer dose	Seed rate	Sowing date
1.	Mustang (Jharkot)	3480	85	$1m^{2*}$	Row to row: 25 cm. Continue sowing	Compost: 5 ton/ha	50 kg/ha	20 June 1999
2.	Dolpa (Juphal)	2500	84	$1m^{2*}$	"	30:30:0 NPK kg/ha	"	28 June 1999
3.	Lalitpur (Khumaltar)	1350	84	$1m^{2*}$	"	"	"	14 Sept 1999
4.	Kaski (Begnas)	1100	87	$0.5m^{2**}$	"	Not applied	"	7 Oct., 1999

† * Two rows of two meter length, 25 cm apart, Two rows of one meter length, 25 cm apart.

Table 2. Sources of bitter buckwheat from different districts

SN	District	Number of varieties	SN	Name of district	Number of varieties
1.	Mustang	13	7.	Sindhuli	1
2.	Solukhumbu	12	8.	Dhankuta	1
3.	Dolakha	8	9.	Arghakhanchhi	1
4.	Dolpa	7	10.	Rukum	1
5.	Jumla	7	11.	Bhojpur	1
6.	Ramechhap	4	12.	Unknown	31
	Total				87

Table 3. Meteorological data of four sites†

Month	Mean temperature °C												Total Rainfall, mm			
	Mustang			Dolpa			Lalitpur			Kaski			Mustang	Dolpa	Khumal	Kaski
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean				
Jan	9.9	-2.1	3.9	16.1	-2.0	7.1	16.9	1.6	9.3	19.5	6.6	18.1	5.6	23	13.8	21.2
Feb	11.4	-0.7	5.4	18.6	0.0	9.3	18.9	3.1	11.0	21.3	8.5	14.9	13.9	52	28.8	31.5
Mar	14.0	1.8	7.9	22.3	4.6	13.5	23.0	6.5	14.8	26.4	12.2	19.3	30.6	23	24.9	58.2
Apr	17.5	5.2	11.4	25.5	7.2	16.4	26.3	10.3	18.3	29.3	15.5	22.4	23.3	11	53.6	146.8
May	19.2	7.6	13.4	28.3	10.6	19.5	27.1	14.8	21.0	29.2	17.7	23.5	34.0	9	99.1	328.4
Jun	20.8	11.1	16.0	26.7	17.6	22.2	27.7	18.8	23.3	29.7	20.2	25.0	43.8	47	198.9	612.3
Jul	21.1	12.6	16.9	27.7	17.3	22.5	26.8	19.9	23.4	29.2	21.2	25.2	61.6	89	319.6	907.8
Aug	20.9	12.5	16.7	26.6	17.7	22.2	27.0	19.6	23.3	29.7	21.2	25.5	58.1	230	249.7	844.5
Sep	19.5	10.3	14.9	25.2	16.1	20.7	26.2	18.0	22.1	27.1	20.1	23.6	57.2	87	169.0	650.4
Oct	17.1	5.9	11.4	24.3	12.0	18.2	24.7	12.7	18.7	26.1	16.3	21.2	3.4	70	54.4	183.6
Nov	13.7	2.2	8.0	20.6	3.9	12.3	21.5	6.5	14.0	23.2	11.6	17.4	8.2	0	5.9	20.9
Dec	11.3	-0.6	5.4	18.7	2.0	10.4	18.4	2.3	10.4	21.6	7.5	14.6	7.9	0	18.1	17.2
Total													347.6	641.0	1235.8	3822.8

† Mustang: 1973 – 1993 mean, Dolpa: 1996 (one year), Lalitpur: 1970 – 1995 mean, Kaski: 1971 – 1993 mean.

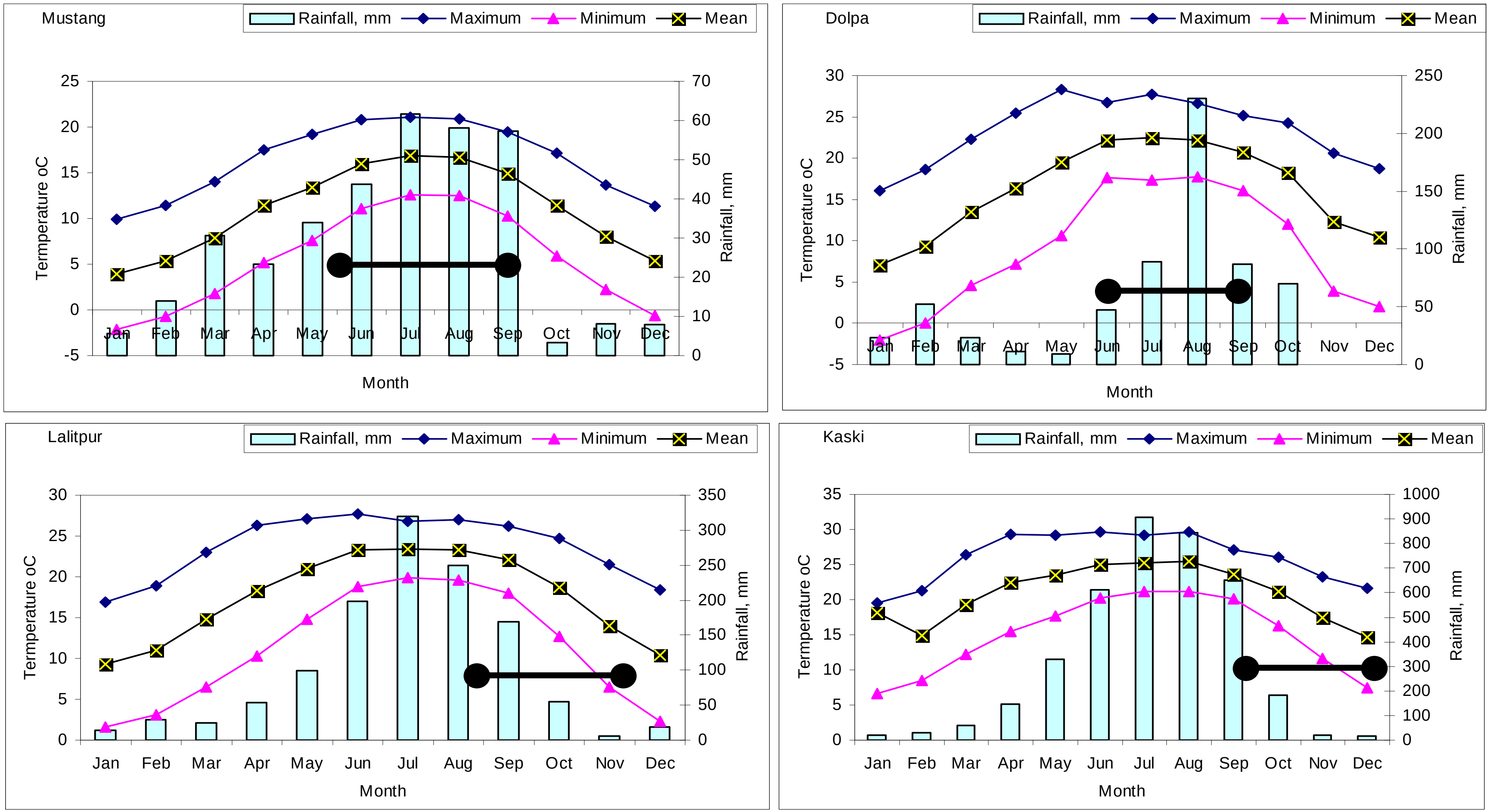

Fig. 1. Termperature and rainfall pattern in four districts at 1999. Black bold line indicate the growing period of bucwheat.

Table 4. Altitude of trial sites and meteorological sites†

Location	Meteorological station	Altitude (masl)	Altitude of the trial site (masl)	Source
Mustang	Thakamarpha	2566	3480 (Jharkot)	ARS, Marpha and DOHM
Dolpa	Airport (Juphal)	2500	2500 (Juphal)	District profile …
Lalitpur	Khumaltar	1350	1350 (Khumaltar)	ARS, Khumaltar and DOHM
Kaski	Airport (Pokhara)	827	950? (Begnas)	DOHM

† DOHM = Department of Hydrology and Meteorology, ARS = Agriculture Research Station.

Results and discussion

The means and ranges of 13 qualitative agronomical traits are presented in Table 5. As expected, the average day to 50 percent flowering was higher in Mustang (65 days) and lower in Khumal (36 days) but the value was higher in Kaski, which can be sensitive to short day in late planting. Surprising, there is not much different in days to maturity in Dolpa, Khumal and Kaski. This might have happened due to no differences in the temperatures during crop growing season. Farmers plant the buckwheat when the maximum temperature is about 26^{o}C. If this temperature remains below this farmers plant the crop in early month like in Mustang and meet the crop growing degree days (Fig. 1). The average plant height was the tallest in Dolpa (156 cm) and shortest in Kaski (33 cm) and not much different in Mustang and Khumal. It seems that Dolpa is optimum place for bitter buckwheat cultivation. Although number of clusters/cyme and number of seeds/cyme were low in Dolpa, but the number of seeds/cluster was 3 (9/3), which is the highest value among three sites. The range and mean value of stem diameter were also the highest (7 and 9 mm respectively) in Dolpa. So, the phenotype of bitter buckwheat was better in Dolpa as compared to other sites. But average grain yield/plant was highest in Khumal (83 gm) but 100 seed weight was more in Mustang (23 gm) and the number of leaves/plant was higher in Mustang (36) and leaf width was more (8 cm). The mean grain filling period was higher in Khumaltar than Kaski, which is expected.

Table 5. Means and ranges of quantitative traits of bitter buckwheat tested across four sites, 2000

SN	Agronomical trait	Sites							
		Mustang		Dolpa		Khumal		Kaski	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
1.	Days to 50% flowering	47-80	65	-	-	29-43	36	50-52	50
2.	Days to maturity	-	-	81-87	84	59-83	73	66-88	79
3.	Plant height (cm)	44-120	95	87-194	156	28-127	87	10-83	33
4.	Number of clusters/cyme	3-57	12	1-4	3	7-25	14	-	-
5.	Number of seeds/cyme	5-30	19	3-13	9	3-14	8	-	-
6.	Stem diameter (mm)	3-7	5	5-12	9	2-5	4	-	-
7.	1000 Seed weight (gm.)	14-35	23	14-29	17	16-32	21	-	-
8.	Grain yield gm./plot	13-60	35	-	-	6-224	83	0-66	22
9.	No. of primary branches/plant	2-7	4	3-9	5	3-9	5	-	-
10.	No. of leaves/plant	17-131	36	1-13	6	5-45	20	-	-
11.	Leaf width (cm)	1-13	8	-	-	1-5	2	-	-
12.	No. of internodes/plant	10-16	13	-	-	11-15	14	-	-
13.	Grain filling days	-	-	-	-	16-51	37	16-38	29
	Number of cases	85	53	67-84	37-52	77-84	45-52	83-87	51-52

The result of frequency and percentage of 12 qualitative morphological traits are given in Table 6. Most of the cultivars showed loose inflorescence, except in Dolpa, where the 60% entries had compact inflorescence (Table 6). The growth habit was mostly semi erect type in three sites but in Dolpa, 57% showed erect growth habit. In Mustang about 52% cultivars had white flower, in Kaski almost all showed greenish yellow flower colour and in Khumaltar, about 79% entries showed pink flower. In Mustang and Khumal some cultivars showed red flower. In Khumal majority of varieties had gray seed colour in Kaski blackish gray seed colour is dominate and black seed colour was observed in Mustang. In case of leaf blade shape, the varieties had either hastate or sagitate types. Pink leaf margin colour is common in three sites. In Kaski, the stem colour was either green or pink, but in Mustang and Khumal, pink stem colour was dominant, however in all four sites some red stem colour genotype was also reported. Similarly, majority of cultivars had pink colour petiole and some had red colour petiole (Table 6). Again flower stalk colour was either pink or red. Seed shape of some cultivars was either triangular or conical, however, intermediate type seed shape was more visible. In Mustang, the seed surface was reported smooth, wrinkled and rough in about equal proportion, but in Khumal majority of cultivars had rough seed surface and in Kaski wrinkled type seed surface was common and smooth type seed surface was also reported.

Table 6. Frequency and percentage of different qualitative morphological traits of bitter buckwheat tested across four sites, 2000

SN	Traits	Mustang		Dolpa		Khumal		Kaski	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1.	Compactness of inflorescence	85	100	67	100	84	100	87	100
	a) Loose (3)	55	65	14	21	65	77	87	100
	b) Semi compact (5)	30	35	13	19	19	23	-	-
	c) Compact (7)	-	-	40	60	-	-	-	-
2.	Growth habit	85	100	82	100	84	100	87	100
	a) Semi-erect (3)	44	52	20	25	66	78	83	95
	b) Intermediate (5)	15	18	15	18	4	5	-	-
	c) Erect (7)	26	30	47	57	14	17	4	5
3.	Flower colour	85	100	-	-	34	100	87	100
	a) White (1)	44	52	-	-	-	-	-	
	b) Greenish yellow (3)	2	2	-	-	-	-	84	97
	c) Pink (7)	27	32	-	-	27	79	3	3
	d) Red (9)	12	14	-	-	7	21	-	-
4.	Seed colour	79	100	84	100	83	100	87	100
	a) Gray (3)	26	33	56	67	67	80	17	19
	b) Blackish gray (5)	3	4	17	33	3	4	48	55
	c) Brown (7)	19	24	-	-	2	3	18	21
	d) Black (9)	31	39	-	-	11	13	4	5
5.	Leaf blade shape	85	100	84	100	83	100	87	100
	a) Ovate (1)	-	-	5	6	-	-	-	-
	b) Hastate (2)	11	13	44	52	17	21	58	67
	c) Sagitate (3)	68	80	34	41	66	79	29	33
	d) Cordate (4)	6	7	1	1	-	-	-	-
6.	Leaf margin colour	85	100	71	100	84	100	-	-
	a) Green (3)	-	-	10	14	-	-	-	-
	b) Pink (5)	67	79	42	59	65	77	-	-
	c) Red (7)	18	21	19	27	19	23	-	-
7.	Leaf vein colour	84	100	70	100	83	100	87	100
	a) Green (3)	1	1	18	26	-	-	84	97
	b) Pink (5)	71	85	39	56	68	82	2	2
	c) Red (7)	12	14	13	18	15	18	1	1
8.	Stem colour	85	100	69	100	84	100	87	100
	a) Green (3)	1	1	7	10	1	1	36	41
	b) Pink (5)	68	80	43	62	66	79	31	36

SN	Traits	Mustang		Dolpa		Khumal		Kaski	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
	c) Red (7)	16	19	19	28	17	20	20	23
9.	Petiole colour	85	100	-	-	39	100	-	-
	a) Green (3)	-	-	-	-	-	-	-	-
	b) Pink (5)	73	86	-	-	34	87	-	-
	c) Red (7)	12	14	-	-	5	13	-	-
10.	Colour of flower stalk	85	100	-	-	40	100	-	-
	a) Green (3)	1	1	-	-	-	-	-	-
	b) Pink (5)	52	61	-	-	19	48	-	-
	c) Red (7)	32	38	-	-	21	52	-	-
11.	Seed shape	78	100	84	100	83	100	87	100
	a) Triangular (1)	23	30	40	48	16	19	17	20
	b) Intermediate (2)	36	46	15	18	54	65	55	63
	c) Conical (3)	19	24	29	34	13	16	15	17
12.	Seed surface	73	100	84	100	84	100	87	100
	a) Smooth (1)	26	36	84	100	1	1	32	37
	b) Irregular or wrinkled (2)	28	38	-	-	4	5	55	63
	c) Rough (3)	19	26	-	-	79	94	-	-

In four sites, entries were the same, but the observations differed greatly in few cases. The differences in data might be due to two reasons: (a) real difference occurred because of climatic differences of the specific sites and (b) the differences in observation taken by the individuals who took the observation. The data recorder of Mustang and Khumal was the same person, so the differences between these sites can be attributed to differences due to climatic differences and human error is minimum. Again, the data recorder of Dolpa and Kaski were new; so the observed difference in different cases might be due to both reasons.

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Appendix I. Passport information†

SN	Trt	Genotypes	District	Village	Alt	DNo	Local Name
1	1	GF-212					
2	2	Acc. # 2234	Sindhuli	Ratumchura	1350	19	Titephapar
3	3	Acc. # 2223	Dolakha	Morudung	1500	17	Titephapar
4	4	Acc. # 2230	Dolakha	Okurini	1850	17	Titephapar
5	5	GF-216					
6	6	Local Bitter	Dolakha	Kabre	1750?	17	Titephapar
7	7	Acc. # 2227	Dolakha	Chhyagu	1700	17	Titephapar
8	8	Kabre Bitter	Dolakha	Kabre	1750?	17	Titephapar
9	9	Acc # 481-1	Dhankuta	Ghorlakharg	1200	7	-
10	10	Sample # 9-7					
11	11	Sample # 5-1					
12	12	UV-1*					
13	13	Sample # 7					
14	14	Sample # 6-1					
15	15	MY-2-27-1					
16	16	Acc. # 2227-1	Dolakha	Chhyagu	1700	17	Titephapar
17	17	Sampel # 8					
18	18	Acc. # 2201-1	Solukhumbu	Ringmo	2730	10	Phapar
19	19	GF-110					
20	20	Acc. # 2196-1	Solukhumbu	Dudko Namzang	1630	10	Titephapar
21	21	UV-2**					
22	22	Acc. # 2196	Solukhumbu	Dudko Namzang	1630	10	Titephapar
23	23	Coll. # 9104					
24	24	Coll. # 9022					
25	25	Acc. # 6507	Solukhumbu	Noonthala	2200	10	Tite
26	26	Coll. # 9027					
27	27	Acc. # 2182	Arghakhanchhi	Nuwakot	1260	44	Titephapar
28	28	Acc. # 2199	Solukhumbu	Jumbasi	2670	10	Titephapar
29	29	Coll. # 9188					
30	30	Acc. # 2201	Solukhumbu	Ringmo	2730	10	Phapar
31	31	Coll. # 9165					
32	32	Acc. # 2227	Dolakha	Chhyagu	1700	17	Titephapar
33	33	Coll. # 9021					
34	34	Coll. # 2193	Ramechhap	Sanbadhangda	2120	18	Titephapar
35	35	Acc. # 8506					
36	36	Coll. # 6575					
37	37	Acc. # 6513	Ramechhap	Yilchire	2270	18	Tite
38	38	Acc. # 2225	Dolakha	Kuseti	1340	17	Titephapar
39	39	Coll. # 9167					
40	40	Coll. # 9166					
41	41	Coll. # 9168					
42	42	Coll. # VD-1	Mustang	Lomanthang	3680	49	
43	43	Acc. # 9023					
44	44	Acc. # 6682	Jumla	Patrashi-1, Talphigaun	2603	61	Tite Phapar
45	45	Acc. # 2194	Ramechhap	Bander	2200	18	Barhe Phapar
46	46	Acc. # 6704	Jumla	Dillichaur-8, Lhama	2530	61	Bharule Phapar
47	47	Acc. # 2179	Rukum	Khadi	1900	53	Titephapar
48	48	Acc. # 494	Bhojpur	Ranibas	1323	11	Titechinia
49	49	Acc. # 6508	Solukhumbu	Ringmo	2720	10	Tite

SN	Trt	Genotypes	District	Village	Alt	DNo	Local Name
50	50	Coll. # 9008					
51	51	Coll. # 9173					
52	52	Acc. # 2201	Solukhumbu	Ringmo	2730	10	Phapar
53	53	Coll. # 9024					
54	54	Coll. # 9001					
55	55	Acc. # 6515	Ramechhap	Chuchure	1820	18	Tite
56	56	Acc. # 2200	Solukhumbu	Solung	2970	10	Titephapar
57	57	MY-2-28-FT-29					
58	58	MY-2-34-FT-32					
59	59	Acc. # 2198	Solukhumbu	Seti	2520	10	Titephapar
60	60	Coll. # BSD-01	Dolpa	Rasi	2900	50	
61	61	Coll. # BSD-012	Dolpa	Ruma	2300	50	
62	62	Coll. # BSD-05	Dolpa	Sahartara	2600	50	
63	63	Coll. # BSD-08	Dolpa	sahartara	2600	50	
64	64	Coll. # VD-3	Mustang	Chhoser	3740	49	
65	65	Coll. # BSD-03	Dolpa	Rasi	2900	50	
66	66	Coll. # BSD-06	Dolpa	Sahartara	2600	50	
67	67	Coll. # VD-5	Mustang	Charang	3380	49	
68	68	Coll. # VD-7	Mustang	Marang	3610	49	
69	69	Coll. # BSD-29	Solukhumbu	Basa	2650	10	
70	70	Coll. # BSD-16	Jumla	Guthichaur	2900	61	
71	71	Coll. # BSD-17	Jumla	Guthichaur	2900	61	
72	72	Coll. # BSD-20	Jumla	Manisangu	2900	61	
73	73	Coll. # BSD-26	Mustang	Khobang	2450	49	
74	74	Coll. # BSD-18	Jumla	Guthigaun	2700	61	
75	75	Coll. # VD-9	Mustang	Dhakmar	3540	49	
76	76	Coll. # BSD-23	Mustang	Gajankot		49	
77	77	Coll. # BSD-19	Jumla	Guthigaun	2700	61	
78	78	Coll. # BSD-28	Solukhumbu	Phaplu	2369	10	
79	79	Coll. # BSD-15	Jumla	Guthichaur	2900	61	
80	80	Coll. # VD-11	Mustang	Ghami	3380	49	
81	81	Coll. # VD-13	Mustang	Ghilling	3380	49	
82	82	Coll. # VD-15	Mustang	Samrr	3420	49	
83	83	Coll. # VD-17	Mustang	Chaile	3470	49	
84	84	Coll. # VD-19	Mustang	Tetang	3320	49	
85	98	Tite Jumla	Jumla			61	
86	100	Tite Mustang	Mustang			49	
87	102	Bhate Dolpa	Dolpa			50	

† SN = Serial number, TrtNo = Treatment number, Genotypes = Accession number/Collection number/Other identification number and cultivars names, District = Name of district where collected, Village = Name of village where collected, Alt = Altitude (masl), DNo = District number (1 = Most easterly, 75 Most westerly given by Dr. Lohani, 1974), Local name = Local name of landraces, * UV-1 = Unidentified bitter buckwheat cultivars entitled "GF 5234" (Seed source: IET-Bitter, 1997, National Hill Crops Research Programme, Kabre, Dolakha), ** UV-2 = Unidentified bitter buckwheat Cultivars entitled "GF 5170" (Seed source: BW, GEPM, National Hill Crops Research Programme, Kabre, Dolakha).

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Performance evaluation of buckwheat landraces in different agro-ecological zones of Nepal

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Abstract

To assess the effect of climatic factors on bitterness as well as to assess comparative performance of buckwheat varieties, a study was conducted in three contrasting agro-ecosystems of Nepal: Mustang (3489 masl), Kaski (1100 masl) and Chitwan (350 masl) districts. Five buckwheat landraces representing both *F. esculentum* and *F. tartaricum* specific to mountain areas of Dolpa, Manang, Mustang and Jumla of western Nepal were tested on-farm along side the farmers' own varieties in the respective study sites as checks. Organoleptic assessment carried out on popular dishes: porridge (*dhindo*) and bread of these varieties revealed that the bitterness can be both genotype specific as well as influenced by the environmental factors. But bitterness of recipes prepared from Mustang *mithe* and Manang *mithe* was not influenced by the natural factors, no matter in whichever agro-ecosystems they were grown. In other cases, the degree of bitterness inversely correlated with altitude. This means that, bitterness increases as altitude decreases and vice-versa. Bread and porridge of sweet buckwheat were more preferred than that of bitter types. Manang *mithe* was preferred for its bold grain with sweet taste. Because of quality products, sweet types such as Manang and Mustang *mithe* fetch higher market price than bitter types. Newly introduced landraces performed equally or even better than local varieties. Irrespective of the topography, Dolpa bhate attained the shortest height and was completely failed in warmer area of Chitwan. Regardless of the eco-sites, Mustang *tite* matured early whereas Manang *mithe* matured latest. Jumla *tite* out yielded all followed by Mustang and Manang *mithe*, which also had lodging tendency. Irrespective of the eco-sites, no pests and diseases attack were reported. Jumla *tite* was generally preferred across the agro-ecosystems mainly for higher grain yield. The reaction for other varieties was variable and site specific. Despite low yield of Dolpa *bhate*, it was liked by Mustang and Kaski farmers for its bold grain and loose husk, which can be cooked as rice. Both varieties namely Manang and Mustang *mithe*, were liked by Kaski and Chitwan farmers.

Key words: agro-ecosystems, landraces, bitterness

Introduction

Buckwheat (*Fagopyrum* spp) in Nepal is grown under diverse agro-ecosystems from plain *Terai* up to the Mountain (2800 masl). Buckwheat in the hills and mountains is grown before or after the monsoon rain and during winter season in the *Terai*. Thus, buckwheat is a widely adapted species more toward stressed temperature, moisture and fertility regimes (Baniya et al., 1992). It is one of the neglected and under-utilised crops grown largely by farmers of marginal areas.

Traditional recipes of buckwheat such as porridge and bread are popular, particularly among the mountain *Tibeto - Burman* societies. Varieties that are suitable for these sorts of recipes are preferred. Loose husk is an important trait of buckwheat consumed as cooked rice. Grains with loose husk are easily dehusked without removing endosperm such as Dolpa *bhate*. Conservation of landraces may be enhanced if their values are added and accessed to areas of their adaptation.

In Nepal, both bitter (*F. tartaricum* L. Gaert.) and sweet (*F. esculentum* L. Moench.) types are grown. Bitter buckwheat is often disliked as far as preferred food recipes is concerned. Bitter types deserve medicinal and religion values. Both types are, therefore, widely grown under a range of agro-ecosystems. Farmers perceive that bitter types are better adapted even under more stressed environments. Farmers perceive that bitter varieties often produce more yields than sweet types. A majority of buckwheat varieties grown in *tarai* are sweet types. However, there are no such explanations available for this. It may be that they are either not adapted or their quality fall when grown under hotter climates. There is no such established fact whether bitterness is linked with natural factors so far. Some of the research questions to be addressed include: Do natural factors influence eating quality including bitterness when grown to alien environments? To understand adaptive values, a study was conducted in three contrasting environments representing the Mountain, Mid hill and Plain *Terai* (Map 1). The paper summarises the research findings.

Map 1. Showing eco-sites used for the study.

Research objectives

- To study the comparative performance of buckwheat landraces under contrasting environments
- To study ecological effects on the bitterness of buckwheat landraces

Research methodology

Description of the study sites

Three contrasting buckwheat growing eco-sites representing Mountain, Mid hill and Plain *tarai* were selected (Map 1). In each site, a quick survey using PRA tools and techniques was conducted. In this exercise, farmers' preference traits and local practices related to buckwheat culture were described. Agro-ecosystem factors such as the distribution of rainfall, temperatures (Fig. 1), aspect and altitude were recorded. The crop was managed locally as adopted by respective site farmers of the area.

Genetic materials for testing

Manang, Mustang and Jumla are potential districts where buckwheat is widely grown. In these districts both bitter and sweet types are found. *Dolpa* is another mountain district where specific loose husk buckwheat is cultivated. Five landraces such as *Manang mithe*, *Mustang mithe Mustang tite,* Dolpa *bhate* and Jumla *tite* were tested each in eight farms across study sites.

Genepools were tested using participatory variety selection (PVS) techniques with farmers. PVS is the selection of released or pre-released varieties or landraces by farmers in target environments (Witcombe et al., 1996; Sthapit et al., 1996). Two kilograms of seed was given to each participating farmer. To ease the comparison, farmers were instructed to grow these varieties side by side with farmers' variety.

Evaluation process

Farmers' evaluation on post-harvest traits was surveyed to understand the adoption or rejection of a particular variety. Farmers' preference ranking was done both for pre and post harvest traits. Household questionnaire was administered subjectively to assess different agronomic, post harvest and quality traits.

Farm walk and focus group discussion

A participatory method of evaluation was employed. Different PRA tools such as farm walk, Focus Group Discussion (FGD) and household surveys were used. Farm walk followed by FGD+, as a process was conducted in each site involving both male and female farmers. This was organised in all eco-sites when the crop was at maturity stage. Comparative performance and preferred and non-preferred traits of each variety were discussed. Number of participant farmers varied across eco-sites. A total of 42, 19 and 26 farmers participated in farm walk and FGD in Mustang, Kaski and Chitwan, respectively.

Sensory evaluation

A panel consisting of male and female evaluated cooked recipes prepared separately from landraces grown in different agro-ecosystems. The panel was briefed the purpose, process and score to be used for sensory evaluation. All panelist rinsed their tongue after each test. Evaluation of bread was done and porridge thereafter. Appealing characters for porridge and bread were evaluated for their bitterness, appearance, texture and softness or hardness using defined scales. A total of 15 panelists evaluated the cooked recipes. Different food recipes, porridge and bread were cooked as per local practice.

Data analysis and reporting

The data were compiled and analysed in terms of descriptive statistics. Data generated through FGD, surveys and sensory evaluation are either presented in tabular form or through graphics. Farmers' perception data have been compiled by eco-sites.

Management of the study in the field

Farmer's within each village were selected through participatory technique employed locally. Further description of the eco-sites is presented in Table 1.

Table 1. Details of the eco-sites in Mustang, Kaski and Chitwan districts

District	Village Development Committee	Villages	Eco-sites	Altitude, masl	No. of farmers involved
Mustang	Muktinath-4, 5 & 6	Jharkot	High hill	3480	38
Kaski	Lekhnath-10	Majthar Dandathar Archalthar	Mid hill	850-1100	40
	Lekhnath-11	Adhikarithar Kalimati			
Chitwan	Phulbari- 4 Phulbari- 6	Bisnupur Ganesganja	*Plain tarai*	350	30

Research findings

Research findings are presented under four sub-headings. Agro-ecosystems are first described for buckwheat based local practices, climatic distribution and land use. Farmers' perception with regard to economically valued traits and quality traits are discussed. Post-harvest traits to explore possible effects of agro-ecosystems over test varieties are discussed thereafter. Discussion along with the conclusion is drawn out of these activities carried over these three contrasting agro-ecosystems.

Description of agro-ecosystems

Monthly mean temperatures (minimum and maximum) and rainfall for these sites are shown in Figures 1a, 1b and 1c. Buckwheat in the study sites of Mustang and Kaski was sown in B*ari* land (Bari land is un-bunded upland used for growing a number of crop species) while in Chitwan it was absolutely on *Khet* lands (*Khet* land is bunded irrigated land, low land used for growing transplanted rice under puddled conditions). Buckwheat in Mustang is sown during July and August. In Kaski, it was sown in October and December and during November in Chitwan. Irrespective of eco-sites, 63% farmers sow new varieties as for existing varieties. For one and other reasons, rests sow either late (27%) or early (10%) to that of normal sowing time.

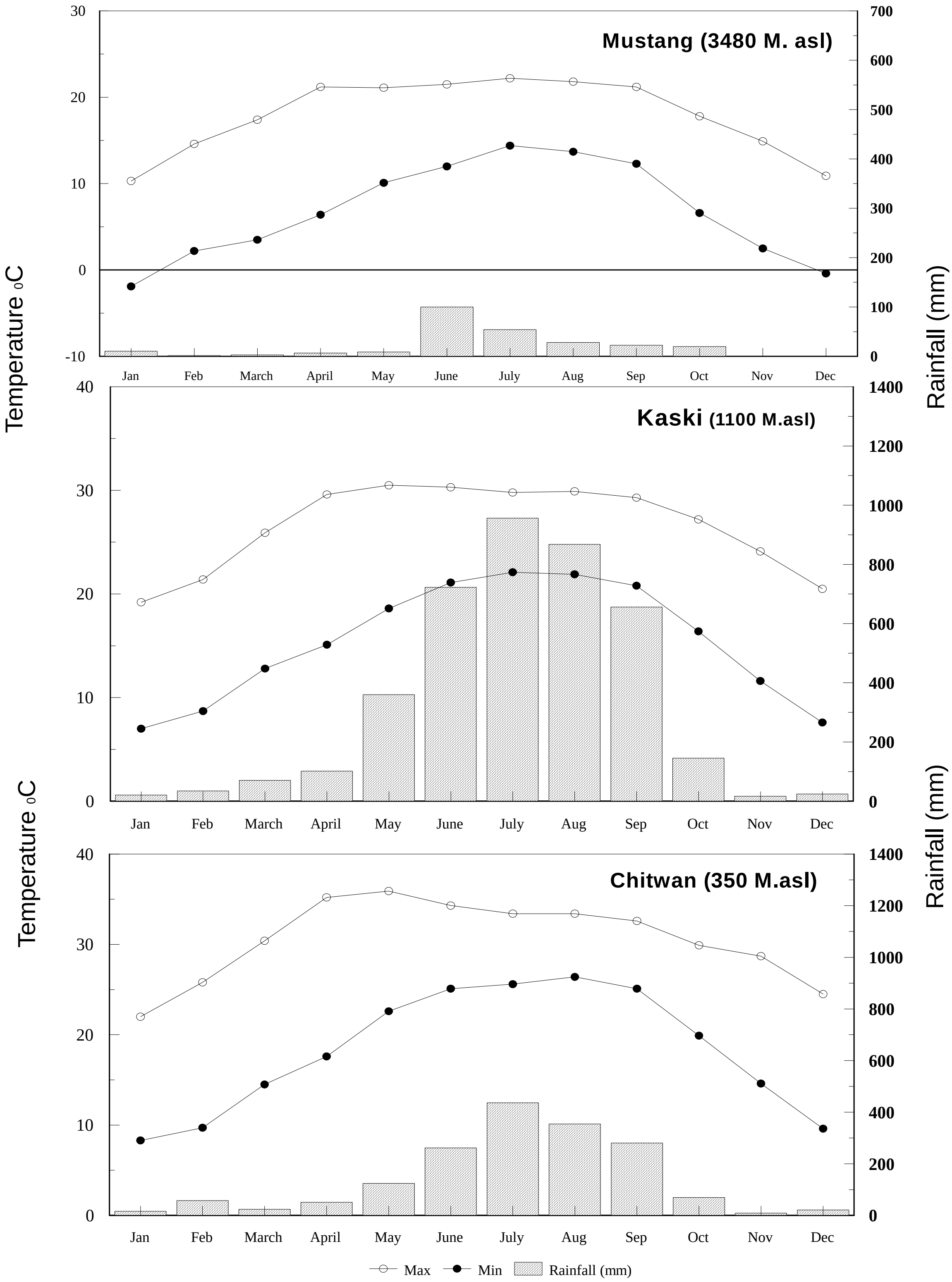


Fig. 1. Distribution of temperature and rainfall in three eco-sites.

Adaptation of crop varieties

The species *per se* is widely adapted and the adaptive value differed by its type. Bitter type for example, reported to be more adapted under poor fertility and moisture stressed conditions. In the mountain regions, two crops per year are possible if short maturing types such as bitter buckwheat are selected. Despite its bitterness, farmers still grow bitter buckwheat because of early maturing character. Thus bitter buckwheat is grown throughout cooler areas and marginal soils. While *mithe* that grows better in warmer areas with relatively better soil conditions.

Farmers' response to agronomic traits

Irrespective of the eco-sites, *Manang mithe*, *Dolpa bhate* and *Mustang mithe* produced more number of branches per plant. *Jumla tite*, on the other hand, produced less number of branches per plant (Figure 2). Likewise, farmers' response on germination and plant height is presented in Fig. 3. Introduced varieties were reported equally better as existing varieties across study sites.

Unlike late maturing types, *tite* buckwheat of early types can escape frost and also allow enough time to grow the succeeding crops. Majority of farmers (70%) reported that *Mustang tite* matures early as compared to farmers' local. Farmers reported that *Manang mithe* (67%) followed by *Dolpa bhate* (60%), *Jumla tite* (30%) and *Mustang mithe* (19%) matured late and hence are less preferred.

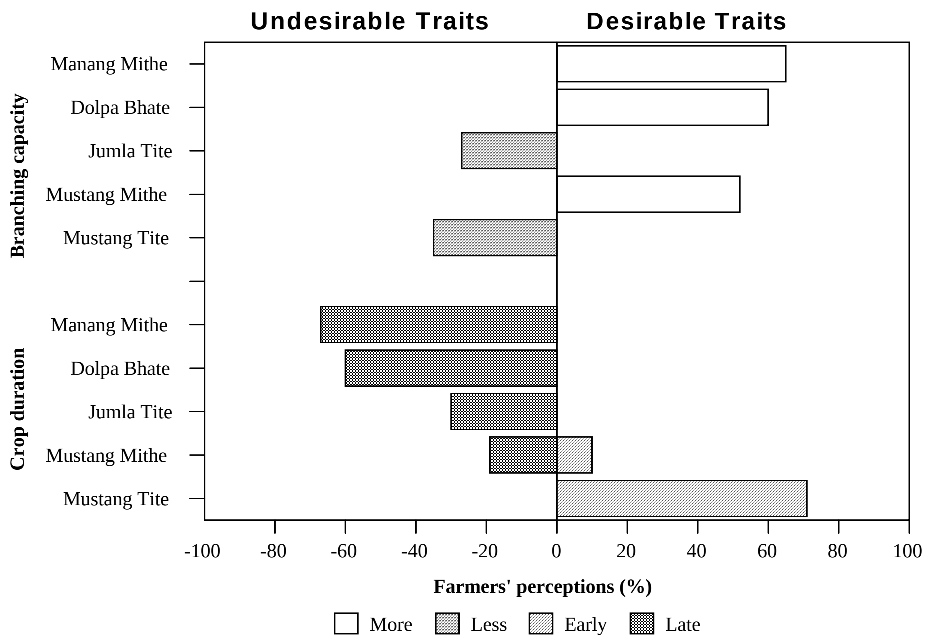


Fig. 2. Response to branching behaviour and crop duration.

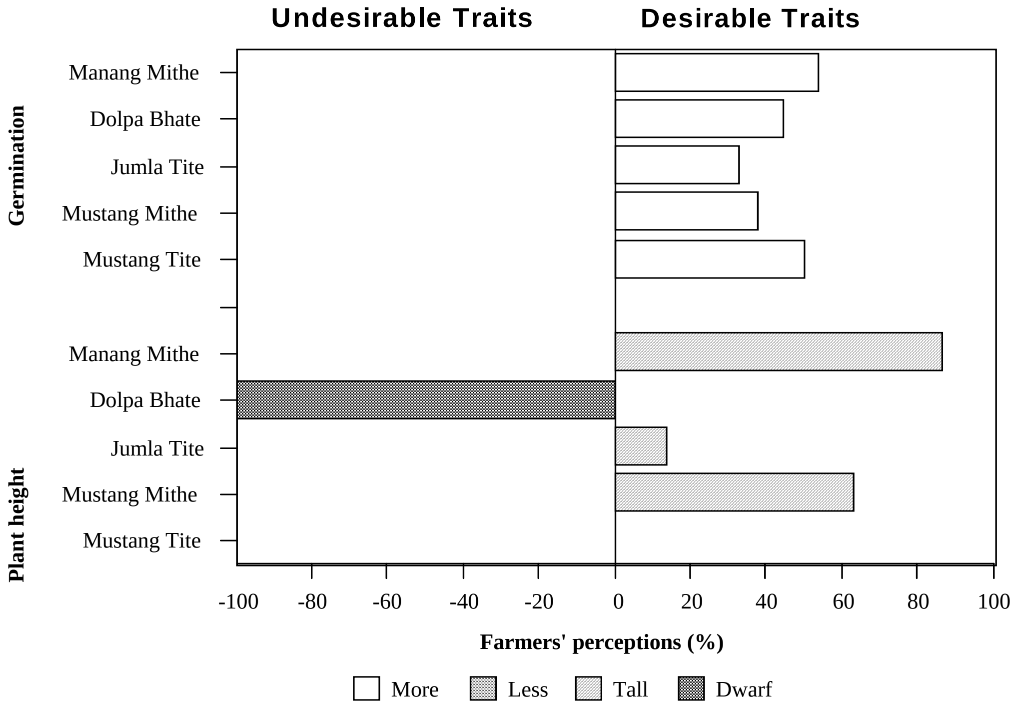
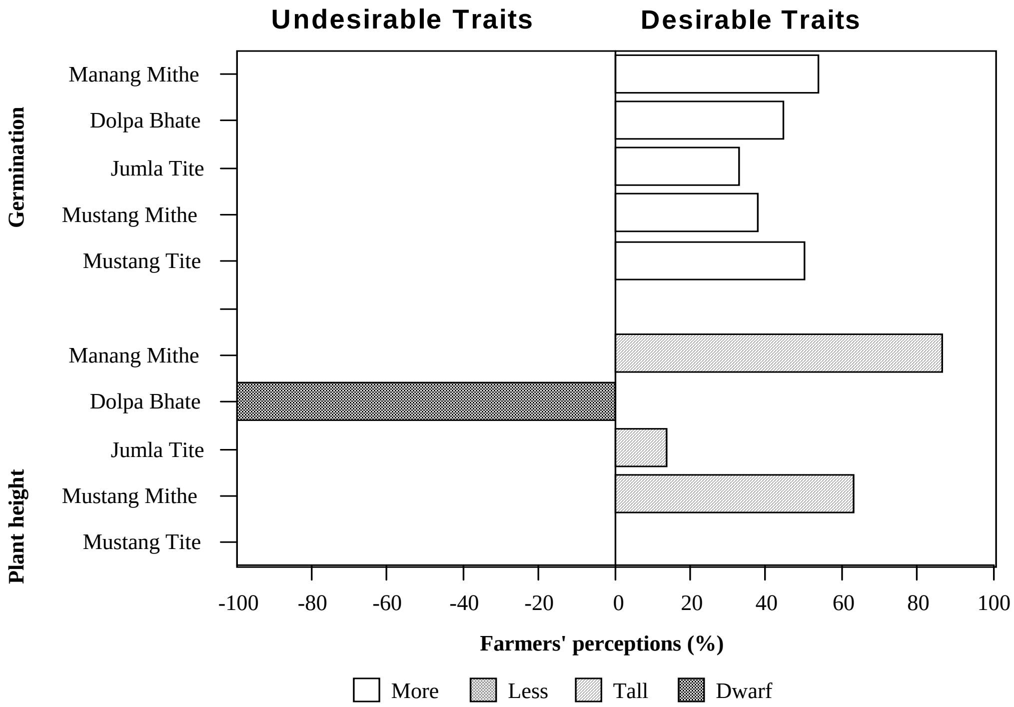


Fig. 3. Farmers' response on germination and plant height.



Grain yield

Grain yield estimated on farmers' units was converted onto common metric measures. Farmers' perception and direct measured traits was cross - checked with farmers' perceived data.

Jumla tite produced higher mean yield (1185 kg ha^{-1}) followed by *Mustang mithe* (1111 kg ha^{-1}) and *Manang mithe* (962 kg ha^{-1}). Across-eco-sites, *Jumla tite* consistently produced higher yield (Fig. 4). Results suggest that there is interaction between variety and the environments. Some varieties found widely adapted across the sites such as *Jumla tite and Mustang mithe. Dolpa bhate* produced lower yield across the agro-ecosystems. It means that *Dolpa bhate* is poorly adapted when introduced to new environments, no matter whether it is warmer or cooler. *Mustang tite* poorly adapted to warmer areas. *Mustang mithe* was another variety consistently produced greater yield after *Jumla tite*. *Manang mithe* produced greater yield in Chitwan. On the other hand, *Mustang tite* along with respective farmers' varieties produced lower yield in Chitwan. Since there is genotype and environment interaction no generalised statements could be drawn.

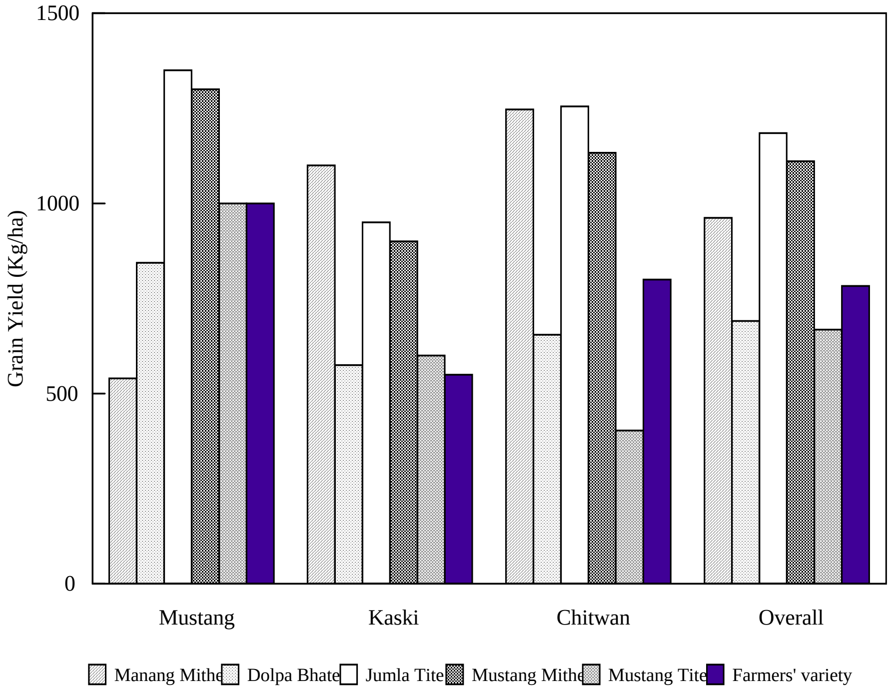


Fig. 4. Comparative grain yield of buckwheat varieties across eco-sites.

Grains per plant

Of the test varieties, *Manang mithe* counted the highest number of grains per plant followed by *Dolpa bhate*, *Jumla tite* and *Mustang mithe* when compared to farmers' varieties. Only *Mustang tite* had the lowest grains per plant.

Lodging behaviour

Lodging can influence grain yield and quality of the produce. None of the farmers mentioned that *Dolpa bhate* and *Jumla tite* did not have lodging problem. Majority of the farmers mentioned that *Manang mithe* and *Mustang mithe* are more susceptible to lodging. None of the farmers, perceived pests or diseases as problems.

Eating quality

Bitter buckwheat (*F. tartaricum* (L) Gaertn.. is cultivated in high altitude mountainous areas of Asia and to a much lesser extent elsewhere (Campbell, 1997). Likewise, in Nepal, bitter types are grown mainly in higher hills and mountains both for food for human and feed for donkeys. Buckwheat grown in Nepal *tarai* is of *F. esculentum*. Depending upon the uses, bitterness as a trait having relative significance. Bitter buckwheat is known for its medicinal values (Campbell, 1997). Locally bitter types are preferred for its higher yield, short maturity and medicinal values. On the other hand, bitterness may be unwanted while making common food recipes. There are local ways of reducing bitterness. Accordingly, flour is dipped in water over night. Once the yellowish water floating on the flour is removed such bitterness will dramatically reduced. In addition, farmers perceive that such trait is attached inside seed husk. To remove such trait grain is de-husked locally. Such practices are also documented elsewhere (Vaidya et al., 1998). Despite these facts, bitterness is yet another important trait deterring food quality.

Bitterness is a variety specific trait. However, little is known whether such trait is influenced by natural factors. The analysis revealed that *Jumla tite* (90%) and *Mustang tite* (78%) tasted bitterer than rest of the varieties (Fig. 5). Irrespective of the test varieties, bitterness was the lowest when grown in the mountain agro-ecosystems i.e. Mustang. *Dolpa Bhate* was tasted bitterer than any other varieties even though grains gathered from Dolpa were used. In terms of bitterness both *Manang mithe* and *Mustang mithe* rated lowest, no matter whichever agro-ecosystems they are grown. This suggests that there was no role of any natural factors to cause bitterness meaning that it is genetic character. On the contrary, bitterness for rest of the varieties inversely associated with the topography. Bitterness increases with a decrease in altitude and vice versa. (Fig. 5). Thus the analysis clearly suggests that the bitterness is genotype specific trait as well as interacts with the natural factors. In general, eating quality was poor with those cultivated in warmer agro-ecosystem ie Chitwan and vice versa.

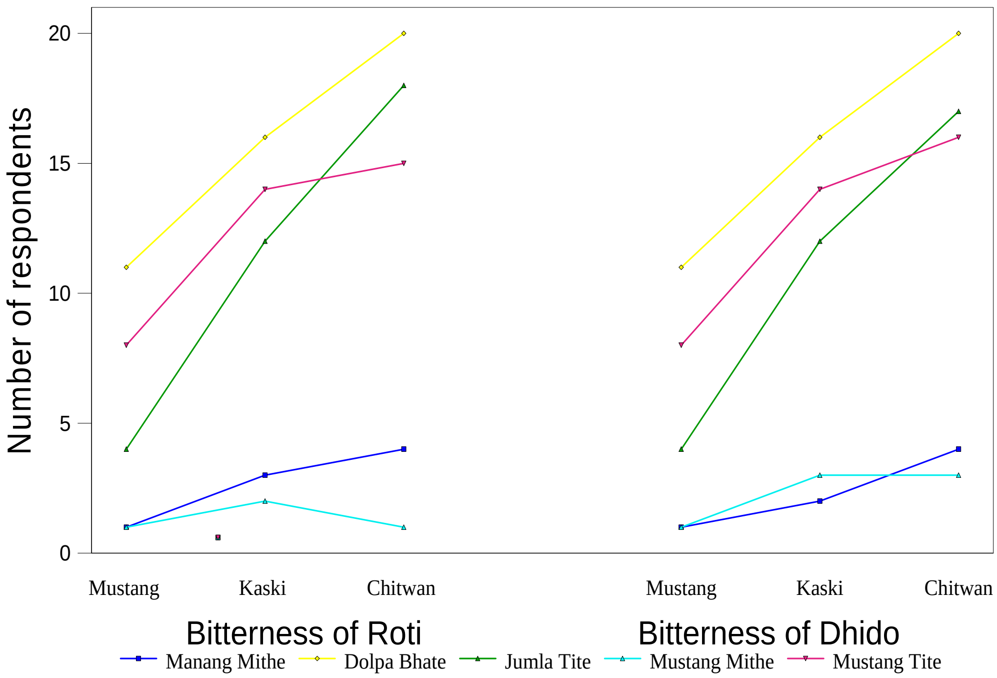


Fig. 5. Organoleptic test assessment of buckwheat varieties cultivated across agro-ecosystems.

Softness, colour and phenotypic appearance

Sensory evaluation revealed that *Manang mithe* and *Mustang mithe* were rated as soft while *Jumla tite* and *Mustang tite* as hard and *Dolpa bhate* to be very hard. No effect due to agro-ecosystems was felt on the softness of bread and porridge. The appealing traits for both bread and porridge rated good for *Manang mithe*, followed by *Mustang mithe* and *Mustang tite*.

Market price

Market price influences farmers' decision on which variety to be grown. A mixed reaction was gathered. A majority of farmers perceived that both *Manang mithe* (70%) and *Mustang mithe* (40%) fetch higher price than others. Because of no consumer demand for loose husk types Chitwan farmers rejected *Dolpa bhate* even though its performance was satisfactory.

Farmers' reaction

Mustang farmers rejected *Manang mithe* variety for its late maturity as it was prone to frost damage. Unlike importance of early maturing trait in Mustang, this trait was not important for other sites if any variety fits well into the existing cropping patterns and escapes from the frost or drought. *Manang mithe* was liked in Kaski and Chitwan for its preferred height, grain size and grain yield. Farmers liked *Dolpa bhate* for its loose husk, easy husking and for grains that can be cooked as rice. In Chitwan, growth of *Mustang tite* was very poor and was rejected straight way. Relative ranking and farmers' evaluation for Buckwheat varieties is presented in Annex 1.

The analysis shows that farmers preferred different varieties across the contrasting agro-ecosystems. At least one or two were preferred either for their higher grain yield or other agronomic traits (eg loose husk, early maturity). The significant amount of seed saved for the next year's sowing indicates that this increased diversity help serve farmers' needs. However, the question to be asked is whether they replace existing varieties or cultivate in new areas.

Discussion and conclusions

Buckwheat is grown under varied agro-ecosystems for its diverse or specific use values related to adaptation, grain yield, local recipes and medicinal purposes. Diverse landraces of bitter type i.e. *Jumla tite* found adapted to more moisture, fertility and temperature stressed conditions. Such varieties performed better meaning to have wider adaptation across the environments. On the contrary, *Dolpa bhate* is poorly adapted when introduced to different environments. Some landraces have niche, but strong adaptive traits such as *Mustang tite*, *Manang mithe* and *Dolpa bhate*. Adaptive value in this case is assessed on the basis of their relative performance and quality traits.

Studies clearly indicated that farmers use a set of criteria while selecting varieties. These criteria include grain yield, maturity, lodging, milling recovery, branching capacity, number of grains per plant and grain size. Post-harvest traits such as eating quality are other important criteria considered by the farmers. The study revealed that bitterness increases with a decrease in altitude and vice versa.

Except *Dolpa bhate* in Chitwan, varietal performance in these contrasting agro-ecosystems was impressive. *Mustang mithe* was the most preferred variety followed by *Jumla tite* and *Manang mithe*. Varieties like *Dolpa bhate, Jumla tite and Mustang tite* taste bitter and the appearance was less appealing. Quality of the recipes can be indicated using colour as indicator. Varieties with yellow grain or flours were often described as bitter types whereas white grained are sweet types. According to the farmers, bitterness of bread *(Roti)* may be reduced if cold water for flour is used during the preparation process of the food. Similarly, bitterness decreases if porridge is prepared in boiling water.

Manang mithe was liked in terms of morphologic traits such as grain yield, branching, grains per plant, more milling recovery and bold grain size. Appealing post-harvest traits including colour and softness of bread and porridge were other positive reactions. Mustang farmers rejected *Manang mithe* for its late maturity.

Early maturity is important trait particularly in the mountain agro-ecosystems. *Mustang tite* as an early variety not only escapes from frost damage but also allows for growing succeeding crops.

Mustang farmers therefore liked this variety. Chitwan farmers rejected this variety for its poorer adaptation. It was disliked also because of undesirable post-harvest traits.

Acknowledgements

The present study on buckwheat was funded by the International Plant Genetic Resources Institute (PGRI), South Asia Office, New Delhi, India. LI-BIRD expresses its sincere gratitude to IPGRI south Asia office, and Dr PN Mathur for his kind support to this collaboration. The authors would also like to thank Dr BR Sthapit IPGRI-APO (Pokhara) for his advise on the project

Hard work of Community Organisers of LI-BIRD, Messrs Indra Prasad Poudel, Mahendra Chaudhary and Pitambar Shrestha in implementing the field trials is highly appreciated. Ms Radha Tiwari, LI-BIRD Motivator is acknowledged for her efforts in carrying out this study in Begnas. DADO staff of Mustang is highly appreciated for their support completing the project in Mustang. Finally, we are grateful to farmers of Mustang, Kaski and Chitwan sites for their co-operation without which the activities of the study would not have been successfully accomplished.

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Annex 3. Summary of PRA exercise for relative ranking of buckwheat varieties tested under contrasting environments†

Variety	Positive comments	Mustang	Kaski	Chitwan	Negative comments	Mustang	Kaski	Chitwan
Manang	1. Tall plant height	9	9	9	1. Late maturing	9	9	9
Mithe	2. More branching capacity	9	9	9	2. Lodging	9	9	9
	3. Bold grain size	9	9	9	3. Rejected by the farmers	9	θ	θ
	4. Sweet taste	9	9	9	4. Small leaf blade	θ	9	9
	5. Higher grain yield	9	9	9				
	6. Bold grain	θ	9	9				
		θ	9	9				
Dolpa	1. Loose husk	9	9	9	1. Bitter taste	9	9	9
Bhaate	2. More Branching.	9	9	9	2. Short plant height	9	9	9
	3. Non-lodging.	9	9	9	3. Late maturity	9	θ	θ
	4. Medium maturity	θ	9	9	4. Small grain size	9	9	9
	5. Large leaf blade	θ	θ	9	5. Less grain yield.	9	9	9
						9	9	
Jumla *Tite*	1. More grains yield.	9	**M**	9	1. Late maturing	9	9	9
	2. Bold grain size.	9	9	9	2. Less branching	9	9	9
	3. Non-lodging.	9	9	9	3. Bitter taste	9	9	9
	4. Large leaf blade	9	9	9	4. Difficult husking	9	9	9
	5. Medium plant height.	9	9	9				
	6. More cymes per plant	9	9	9				
		9	9	9				
Mustang	1. More grains yield.	9	9	9	1. Lodging.	9	9	9
Mithe	2. Sweet taste	9	9	9	2. Late maturing	9	θ	θ
	3. Medium plant height	9	9	9				
	4. Medium maturity	9	9	9				
	5. More branching	9	9	9				
	6. Bold grain size	9	9	9				
	7. Large leaf blade	9	9	9				
	8. Easy for husking	9	**M**	**M**				
		9	9	9				
Mustang	1. Earliest maturing	9	9	9	1. Bitter taste	9	9	9
Tite	2. Satisfactory grains yield	9	θ	θ	2. Short plant height	9	9	9
	3. Non-lodging		9	9	3. Small size of grain and leaf	9	9	9
					4. Difficult for husking	9	9	9
					5. Low grain yield	θ	9	9
					6. Earliest maturing			**EE**

† 9=Yes, θ =No, M = Medium, EE = Extra early.

Report from rapporteurs

Hari Bahadur KC and Bal Krishna Joshi

On the first day of this workshop, 12 different research papers were presented and discussed. In the discussion, different interested and important questions/queries and suggestions were raised by research scientists and answered by the concerned researcher and authority. Especially in the discussion forum, questions and suggestions were raised on: immediate need of new improved buckwheat varieties; post-harvest problems; quality and marketing problem; fertilizer dose and nutrients uptake by buckwheat at farmer level; its medicinal values and consideration as a commercial crop.

During the second day of discussion session, 15 participants raised different issues over 11 papers. Some of the important comments/suggestions are given below.

- *Bhate phapar* is native landrace to Dolpa. It is very important to consider it for *in situ* conservation.
- During the field survey information on soil fertility is also to be noted which may help better understand the diversity.
- For studying the changes in diversity over years, monitoring should be carried out at least for 5 years.
- Research on food technology and processing techniques should be carried out.
- Some international scientists also attended the workshop but because of Nepali language used in the workshop, they felt difficult to understand.
- Major issue is that how we can conserve cultivated species *in situ*.
- In Nepal there may be many buckwheat species. So it is necessary to explore them at large.
- Rutin is medicinally useful. It needs chromatography technique to analyze the rutin content in buckwheat.
- All agreed that buckwheat is a medicinal plant. But there is lack of information on quantity of buckwheat needed to cure a disease. In China 100 g/day of buckwheat consumption is recommended.
- In Mustang, shattering is the main problem. During harvest period, wind creates difficult to harvest buckwheat. About 15% grain is lost during transportation from field to store house.
- Breeding work is most urgent sector to be considered for buckwheat development. Variety is necessary to all areas in Nepal. In Chitwan, market price of buckwheat is not stable. It depends on Indian market. Thus farmers are worried even though they are interested to cultivate buckwheat. Buckwheat is cultivated in those lands and time where and when rice and maize are not suitable. It is a neglected crop yet treated as an important at a time of food deficit.
- One stall in Lalitpur is established o sell the agricultural products including buckwheat. This stall is willing to purchase any amount of buckwheat from the farmers.
- Complete package on buckwheat cultivation including IPM should be developed. Research and teaching should be carried out together. Information on the regular consumption of buckwheat in human being and animals and effect of meteorology on quality is lacking.
- Study at the genetic level help to identify useful genes. Genetic diversity over locations and times is necessary to develop a variety.
- Long term strategy should be developed for buckwheat development. Government of Nepal should give priority to this crop.
- Quality is affected by location (environment), so location wise study on quality is important for better utilization of buckwheat in medicinal purposes.

Programs for the workshop

Venue: Radission Hotel, Lazimpat, Kathmandu, Nepal

Inaugural Session

13 Sept 2001

8.00 - 9.00 : Registration
9.00 - 10.30 : Inaugural Ceremony
Convenor : BMS Basnet
Chairperson : HS Tripathi, Ho'nble Member, NPC
Invitation to distinguished guests in the dais

- HS Tripathi, Member, National Planning Commission
- RL Kayastha, Secretary, Ministry of Agriculture and Cooperative
- T Nagamine, NIAS, Japan
- MD Zhou, IPGRI/ Office for East Asia, China
- D Joshy, ED, NARC

Welcome address: D Joshy, ED, NARC
Inauguration of the workshop by the Chairperson: HS Tripathi
Introduction of the project and objectives of the workshop: HP Bimb, Project Leader

Few Words

- D Joshy, ED, NARC
- RL Kayastha, Secretary, Ministry of Agriculture and Cooperative
- T Nagamine, NIAS, Japan
- MD Zhou, IPGRI/ Office for East Asia, China

Vote of thanks: RP Sapkota, Chief, Agriculture Botany Division, NARC
Concluding remarks and closing of session: Chairperson

Exhibition

10:30 - 11:00 Hi tea

13 Sept 2001

Technical session (total 24 papers)

Chairperson: DS Pathic, Director of Crops & Horticulture, NARC
Rapporteur: HB Khatri Chhetri, ABD/NARC

Time	*Title and Author/s*	*Abstract No.*
11.00 - 11.20	Buckwheat research in Nepal: An overview BK Baniya	*15*
11.20 - 11.40	Field survey and collection of *Fagopyrum species* for *in situ* conservation in Nepal H Nakayama, K Tsuji, HP Bimb, BK Baniya, DR Sharma, & PP Kurmi	*8*
11.40 - 12.00	Prospects and possibilities of buckwheat development	*2*

Time	*Title and Author/s*	*Abstract No.*
	through biotechnology BK Joshi & HP Bimb	
12.00 - 12.20	Buckwheat variety improvement in Nepal: Overview and future prospect SB Biswokarma, RP Upreti & SR Upadhyay	*17*
12.20 - 12.40	Response of different combinations of plant nutrients on buckwheat PR Shakya & RP Upreti	*16*
12.40 - 13.00	Cyme, flower cluster and seed setting dynamics on buckwheat and their relation to grain yield DR Bhandari & SK Sah	*5*
13.00 - 14.00	*Lunch break*	
14.00 - 14.20	Scenario of buckwheat (*Fagopyrum* spp.) trading K Sherchand	*6*
14.20 - 14.40	RAPD analysis for genetic variation in Nepalese populations of wild buckwheat (*Fagopyrum cymosum* Meisn.) with reference to *in situ* conservation HP Bimb, H Nakayama, S Fukuoka, K Ebana & T Nagamine	*3*
14.40 - 15.00	Marketing and commercialization of buckwheat in Nepal DMS Dongol, BK Baniya & A Priyadarshi	*11*
15.00 - 15.20	Status of buckwheat in Chitwan, Nepal M Regmi, D Paudel	*14*
15.20 - 15.40	A situational context on buckwheat cultivation in Dolkha, Nepal T Mulicha	*19*
15.40 - 16.00	*f]Nkf lhNnfdf kmfk/ v]tL la la w/nf	*20*
16.00 - 16.20	*Tea Break*	
16.20 - 16.40	Allozyme variation in *tite* buckwheat (*Fagopyrum tataricum* Gaertn.): A preliminary study in landraces from Jumla, Nepal J Bajracharya, D Panday, BK Baniya, B Sthapit MP Upadhyay, D Jarvis & HP Bimb	*4*
16.40 - 17.00	Discussion and concluding remarks by the chairperson	

14 Sept 2001

Technical session (contd…)

Chairperson: RP Sapkota, Chief, Agric. Botany Division, NARC
Rapporteur: BK Joshi, ABD/NARC

Time	*Title and Author/s*	*Abstract No.*
09.00 - 09.20	Genetic diversity in Nepalese populations of *Fagopyrum tataricum* revealed by RAPD assays HP Bimb, S Fukuoka, K Ebana & T Nagamine	*1*
09.20 - 09.40	Effect of ABT-4 rooting powder on seed germination, seedling growth, chlorophyll content and yield parameters in buckwheat (*Fagopyrum esculentum*) BN Prasad	*10*

Time	Title and Author/s	Abstract No.
09.40 - 10.00	Growth hormone enhanced cation mobilization in common buckwheat (F*agopyrum esculentum* Moench.) A Jha, BP Chaulagain, VNP Gupta & BP Rajbhandari	*12*
10.00 - 10.20	Promoting local food culture as a method to conserve buckwheat diversity in agro-ecosystems: experience from western mountains of Nepal DK Rijal, RB Rana, PR Tiwari, LP Pant & D Jarvis	*13*
10.20 - 10.40	Study of Nepalese *tite* buckwheat landraces at diversed agroecological regions of Nepal BK Baniya, ML Baidya, DR Sharma, DMS Dongol, I Paudel & HP Bimb	*21*
10.40 - 11.00	Cultural and religious values of buckwheat in Nepal DR Sharma	*7*
11.00 - 11.15	*Tea break*	
11.15 - 11.35	Monitoring of genetic variations using RAPD markers in three populations of wild buckwheat (*Fagopyrum cymosum* Meisn.) in Nepal HP Bimb, H Nakayama, S Fukuoka, K Ebana & T Nagamine	*9*
11.35 - 11.55	--------------- A Subedi et al.	*Not included*
11.55 - 12.15	Pollination ecology of common buckwheat (*Fagopyrum esculentum*) in different agro-ecozones of Nepal with particular reference to the role of the Himalayan honeybee *Apis cerana* MM Singh	*18*
12.15 - 12.30	ADO, Mustang	*Not included*
12.30 - 12.45	ADO, Kaski	*Not included*
12.45 - 13.00	ADO, Lalitpur	*Not included*
13.00 - 14.00	*Lunch break*	
14.00 - 14.30	Discussion	
14.30 - 16.00	Group formation, Preparation for the workshop recommendations and concluding remarks	

Concluding session

16.00 - 17.00

Chairperson: D Joshy, ED, NARC

Presentation of the recommendations and discussion

Remarks: MD Zhou, IPGRI/ Office for East Asia, China
T Nagamine, NIAS, Japan

Vote of thanks: HP Bimb

Concluding remarks and closing of the workshop: D Joshy, ED, NARC

18.00 - 20.00

Farewell dinner

Recommendations

During the workshop, three groups were formed to compile the outcomes from the presentations. The groups found the following achievements and drafted recommendations for the research and development on buckwheat crop.

1. Research and Collaboration Group

Achievements

- PRA of *in situ* sites (Dolpa and Mustang)
- Survey and collection of plants and seeds from different regions (Kathmandu valley, Dolakha, Kaski, Mustang and Dolpa)
- Genetic diversity analysis of wild (*Fagopyrum cymosum*) and bitter (*F. tataricum*) buckwheat using RAPD markers.
- Identification of buckwheat samples in species and sub species levels
- Establishment of biotechnology lab at Khumaltar, NARC. This can be used for other crops
- The pipeline varieties in common (sweet) buckwheat are IR-13, FG 5283 and GF 5274 and in bitter type Acc 2227-1 Acc 2223, My -2-27-1, Acc 2230 and Jumla local
- Identification of in situ sites for wild buckwheat using molecular techniques
- NPK dose @ 30:30:0 kg ha^{-1} is found economical dose
- Linkage with farmers, extension and other project is established.

Recommendations for further studies

- Research on crop management
  - Agronomy (Varieties and environment interaction, seeding dates in different environments, cropping system)
  - Nutrients requirements in different environments
  - Making inventory of insects and pests, loss assessment
  - Water requirements
- Varietal development for sweet and bitter types.
- Survey and collection of wild, bitter and sweet in western as well as eastern Nepal.
- Study of genetic diversity using molecular/biochemical techniques should be continued.
- Socio -economical study with reference to bitter buckwheat should be continued.
- Utilization of useful genes for the development of variety through integrated approach.
- Initiation of *in-situ* conservation on wild species and on farm conservation of bitter buckwheat.
- Study on monitoring of genetic diversity over time should be continued.
- Priority is sought from the government on research, development and capacity buildings.

Collaboration

- TU/IAAS/HICAST
- Farmers
- NARC
- DOA
- NGO/INGO
- Processors
- Traders/Dealers
- Medicinal department

- Collaboration should be guided by policy, fund and other resources
- Research, teaching and extension should go together.

2. Processing and Marketing Group

Recommendations
- Study on existing practices/knowledge
- Nutrient content analysis
- Chromatography needs to be established in Food tech. lab.
- Explore possible machine appropriate for milling
- Product development i.e. pizza, noodles, bakery products etc.
- Review existing practices at different levels on local, regional, national basis.

Marketing

Recommendations
- Facilitation for networking among researchers, producers, promoters/traders and consumers
- Development of research base recipes and trained man power in collaboration with food science's (CTEVT)
- Dissemination of market related information through electronic, print media.

3. Uptake and Dissemination Group
- Technologies should be generated on ecosystem basis

Package of practices should be developed on:
1. Variety
   - Pipeline varieties (Sweet)
   - Local landraces (Bitter)

2. Cultural Practices
   - Fertilizer Recommendation
   - Optimum pH of Soil
   - Optimum seed rate
   - Date of planting (crop calendar)
   - Cropping pattern
   - Schedule for irrigation
   - Weed management (plant type)
   - Plant protection (Army worm, White grub, Thrips, Rhizoctonia)
   - Harvesting and production

3. Cost of cultivation
   - Comparative study

4. Quality production should be based on:
   - Food security for hill farmer
   - Export quality
5. Market information with respect to production & price
6. Medicinal value (specific)
7. Cropping system inventory
8. Statistics on buckwheat (district and national wise)

Dissemination

- Should be taken as a national priority
- Should be institutionalized in the program planning of the annual budget

Awareness and Adaptation

- Training
- Demonstration (Minikit)
- Publication (posters, pamphlets, booklets, leaflets etc.)
- Electronic media
- Partnership with line agencies
- Women participation
- Monitoring and evaluation

Concluding Session

Some 70 persons including crop experts, extensionists, agro-entrepreneurs, farmers, representatives from universities, government and non-government organizations took part in the workshop. Twenty four (24) working papers on buckwheat research and development were presented, discussed and interacted among the participants. The "Exhibits" (seeds, plants, products of buckwheat from Nepal and Japan were also organized.

The participants were divided into three groups namely: 1. processing and marketing; 2. research and collaboration and 3. uptake and dissemination. The group's suggestions and recommendations were presented by the respective group leader Mr. D.K. Rijal, Mr. B.K. Baniya and Mr. D.R Bhandary respectively.

Some of the highlights of presentations on buckwheat were lack of trained manpower with equipment's, information, knowledge, processing mechanisms to obtain quality grits and source. It is suggested for products development, value added products, research and collaboration with the industries, networking, review existing situations. Development of pipeline varieties like IR-13, GF 5283 and GF 5274 of sweet type and Acc # 2227-1, Acc#2223, My-2-27-1, Acc# 223 and Jumla Local of bitter buckwheat.

Some of the recommendations of the workshop were: need to develop improved varieties with package of practices, survey and collection of wild, bitter and sweet buckwheat in western and eastern Nepal. Study of genetic diversity using molecular techniques should be continued with reference to socio-economic study in bitter buckwheat. Utilization of useful genes for the development of varieties through integrated approach. Government should give priority to buckwheat research and development through capacity building. Collaboration with the stakeholders in research, teaching and extension should go together hand-in-hand. Quality production, sharing of market information and cropping system inventory should be maintained. Sensitization of the people to create the public awareness on the value and importance of buckwheat should be carried out through print, electronic (radio, television) and other media.

The concluding session of the workshop was chaired by the Executive Director of NARC Mr. Dhruva Joshy. He emphasized the values of group's recommendations and their follow-up. He also thanked Dr. T. Nagamine on behalf of Nepalese Government to Japanese Government and Prof. M. Zhou for their support in the research and development of buckwheat in Nepal and expressed hope to continue such efforts in coming days too. He mentioned that the workshop was successful for achieving its objectives.

Prof. M. Zhou in her remarks advised the participants for sharing the research results, increasing the public awareness and the productivity of buckwheat. She observed that the workshop was successful.

Likewise, Dr. T. Nagamine expressed his pleasure to participate in the workshop. He suggested for the conservation and utilization of buckwheat in Nepal. He emphasized in information sharing and further added that the recommendations were well analytical and informative. He appreciated the coverage of workshop events in the newspapers and television.

At the end, Dr. Hari Prasad Bimb (project leader) extended the vote of thanks to the workshop management, participants, invitees who helped in one way and other for the successful completion of the workshop.

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गहुँखेतीमा वन्यजन्तुको आँखा परेपछि

चितवनका कृषक फापरखेतीमा आकर्षित

गोरखापत्र समाचारदाता — ... ७ गते। वन्यजन्तुबाट ... गहुँखेती ... गहुँखेती लगाउनुभन्दा "फापर" लाभदायिक रहेको अर्थ कृषक हनुमान थारू बताउनुहुन्छ।

जिल्ला कृषि विकास कार्यालयको ... तीन वर्षदेखि फापरखेती ... कृषक थारू ... फापरखेती लगाइने गरेको पाइन्छ। गहुँमा जस्तै घुनकीरा नलाग्ने फापर स्वदेशमा प्रति के.जी. १० देखि १८ र बिदेशमा ३० देखि ५० रूपियाँमा बिक्री वितरण भइरहेको पाइन्छ।

फापर ग्यास्टिक लगायत पेटको रोगीहरूका लागि "आयुर्वेदिक" औषधि - कमजोरि मान्छेका लागि भिटामिनयुक्त ... बालिविज्ञान ... पौष्टिक आहार ... गो छ। ... महाशाखा ... ली अन्तरगत ... यले यसको ... सम्बन्धमा ... तर, ... प्रसाद ... गका ... एको ... खी ...

विशेषज्ञहरू फापरखेतीप्रति आकर्षित

– नयाँ सडक संवाददाता

काठमाडौं- धार्मिक, सामाजिक, सांस्कृतिक, आर्थिक र औषधीय दृष्टिकोणले महत्वपूर्ण फापर बालीको अनुसन्धानका साथै विकास एवं विस्तारमा सहयोग पुऱ्याउने उद्देश्यले आयोजित दुईदिने राष्ट्रिय कार्यशाला गोष्ठी बिहीबार सुरु भयो।

नेपाल कृषि अनुसन्धान परिषद् (नार्क) राष्ट्रिय कृषि जैविक विज्ञान संस्था जापान र अन्तर्राष्ट्रिय वनस्पति अनुवांशिक श्रोत संस्था इटालीद्वारा संयुक्तरूपमा आयोजित उक्त गोष्ठीमा सम्बन्धित ... विशेषज्ञ, कृषक र विश्व... सरकारी तथा गैर... प्रतिनिधि... जुट्न विशेषज्ञहरूलाई आह्वान गर्दै फापरको उपोयोगिताको व्यापक प्रचार प्रसार हुनुपर्नेमा जोड दिनुभयो।

नार्कका कार्यकारी निर्देशक ध्रुव जोशीले उच्च रक्तचाप, मुटुको समस्या, मधुमेह, अल्सरजस्ता महत्वपूर्ण रोगहरूको औषधीको रूपमा प्रयोग गर्न सकिने फापर बालीको विस्तार एवं विकासका लागि नार्कले काम गरिरहेको जानकारी दिनुभयो ... वैज्ञानिक ... हरिप्रसाद ... जैविक ... ख डा. ... स्पति ... का ...

Buckwheat protection stressed

KATHMANDU, Sept 13 (PR) – Various agricultural experts from Nepal, Japan and China have stressed the need to take concrete action for protecting one of the major staple foodgrain, buckwheat, cultivated in hilly and mountain region of Nepal.

The experts were speaking at a ... workshop "Research and ... on buckwheat: an ... neglected ... organized by Nepal ... Research Council ... Plant ... stitute ... known ... In ... European ... farming ... Agricultu... Ming-D... carried ou... sustainab... food in th... "Buck... economic ... security and raise the socio- altitude so as to ensure food ... can res... in the ... well th... vide ...

फापरबालीसम्बन्धी कार्यशाला गोष्ठी आयोजित

रासस

काठमाडौं, २८ भदौ

धार्मिक, सामाजिक, सांस्कृतिक, आर्थिक र औषधिय दृष्टिकोणले महत्वपूर्ण फापर बालीको अनुसन्धानका साथै विकास एवं विस्तारमा सहयोग पुऱ्याउने उद्देश्यले आयोजित दुई दिने राष्ट्रिय कार्यशाला गोष्ठी बिहीबार राजधानीमा सुरुभयो।

नेपाल कृषि अनुसन्धान परिषद (नार्क) नेपाल कृषि जैविक विज्ञान संस्था ... राष्ट्रिय कृषि ... अन्तरराष्ट्रिय ... इटाली ... गोष्ठीमा ... विश्वविद्यालय ... संघ संस्था ... सहभागिता ... गोष्ठी ... आयोगका ... परम्परागत ... सुधार गरी ... उत्पादन वृद्धि ... आग्रह गर्नुभ... कृषि ... सचिव रत्नेश... हावापानी सुहाउँ... महत्वपूर्ण फापर...

उत्पादनका लागि जुट्न विशेषज्ञहरूलाई आह्वान गर्दै फापरको उपोयोगिताको व्यापक प्रचार प्रसार हुनु पर्नेमा जोड दिनुभयो। नार्कका कार्यकारी निर्देशक ध्रुव जोशीले उच्च रक्तचाप, मुटुको समस्या, मधुमेह, अल्सर जस्ता महत्वपूर्ण रोगहरुको औषधीको रूपमा प्रयोग गर्न सकिने फापर बालीको विस्तार एवं विकासका लागि ... गरिरहेको ...

फापरलाई तिरस्कृत बालीको रूपमा नलिन आग्रह

२०५८/५/२५ Sept. 14, 2001

स्पेसटाइम

काठमाडौं, भदौ २८ — नेपालमा फापरखेतीको पर्याप्त सम्भावना हुँदाहुँदै पनि फापरलाई तिरस्कृत बालीको रूपमा लिइएकोमा विज्ञहरूले गुनासो ... फापरविज्ञ डा. विम्बले केही वर्ष अघिदेखि भने सीमित क्षेत्रमा फापरखेतीमा जोड दिन थालेको जानकारी दिनुभयो जसमा डोल्पा, मुस्ताङ, सोलुखुम्बुलगायतका केही जिल्लाहरू छन्।

नेपालले फापरखेतीमा जोड दिनुपर्ने उद्देश्यअनुरूप कृषि अनुसन्धान परिषद, राष्ट्रिय कृषि जैविक विज्ञान संस्था जापान र ... नेपालको एक महत्वपूर्ण तर तिरस्कृत बाली' विषयक एक कार्यशालागोष्ठी बिहीबारदेखि सुरु गरिएको छ। शुक्रबारसम्म सञ्चालन हुने उक्त गोष्ठीको उद्‌घाटन गर्दै त्रिपाठीले फापरको उत्पादन क्षेत्र र उत्पादकत्व ... कुरा बताउनुभयो। कृषि तथा सहकारी मन्त्रालयका ... कायस्थले फापरलाई औषधीजन्य बालीको ... जानकारी दिनुभयो। ... फापरविज्ञ जापानिज नागरिक डा. ... हेले फापरलाई उच्च ... रूपमा प्रयोग गर्न ... कार्यक्रममा ...

... गुनासो गरेका हुन्। फापरविज्ञ डा. हरिप्रसाद ... विस्कुटलगायत ... उक्त गुनासो गरेका हुन्। फापरको मह, नुडल्स, चिया, विस्कुट ... जापानमा फापरको ... फापरलाई अन्न र गरिब जनता ... बनाइन्छ तर नेपालमा फापरलाई ... रूपमा मात्र लिने प्रचलन छ।

नेपालमा कति जमिनमा फापरखेती गरि... स्पष्ट तथ्यांक पाईदैन। वरिष्ठ बाली... हुन्छ भन्ने ... सन् १९८५ मा ४२ हजार हेक्टरमा ... बस्नेतले सन् ... मेट्रिक टन उत्पादन भएको र सन् १९... हजार हेक्टरमा फापरखेती लगाइएको ... ५७ हेक्टरमा ... नगरिएको जानकारी दिनुभयो ... सकिने फापर ...

उपत्यकामा आज

- साहित्यिक कार्यक्रम एवं कवि गोष्ठी।
  स्थान : स्थानीय विकास मन्त्रालय, दुर्गम क्षेत्र विकास समितिको हल, श्रीमहल।
  समय : साँझ ५:०० बजे।
- एकल कलाप्रदर्शनीसम्बन्धी पत्रकार भेटघाट।
  स्थान : नाफा हल, नक्साल।
  समय : दिउँसो ३:०० बजे।
- फापरका बारेमा राष्ट्रिय कार्यशाला गोष्ठी।
  स्थान : र्‍याडिसन होटल।
  समय : बिहान ९:०० बजे।

Executive Director, D Joshy giving a concluding remarks in closing ceremony.

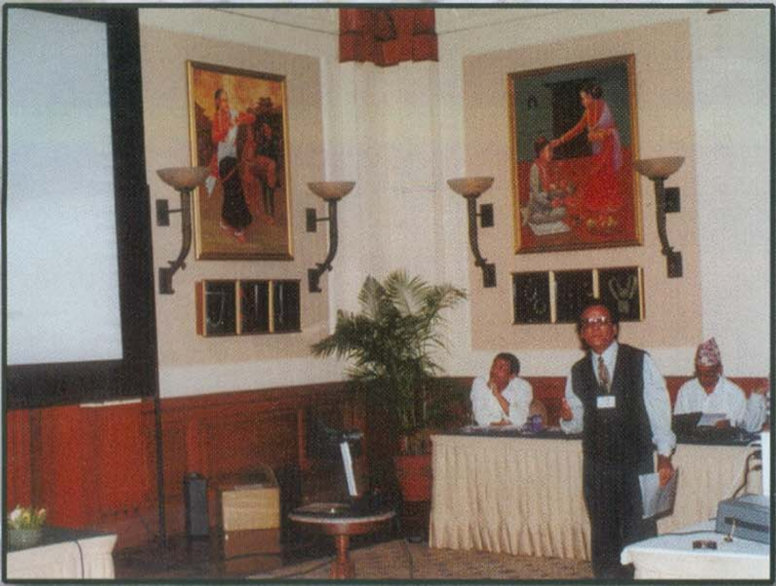
Researchers in survey and collection mission of buckwheat diversity in Mustang.

Researchers in survey and collection mission of buckwheat diversity in Mustang.

Glimpses of buckwheat diversity in Mustang.

A typical habitat of F.cymosum in Dolpa.

Glimpses of buckwheat diversity in Mustang.

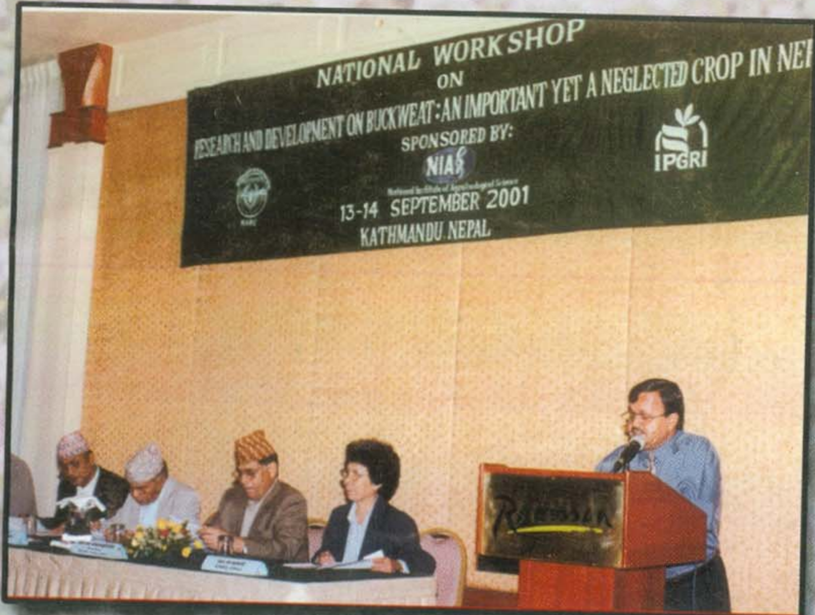


Participants attending workshop presentation.

Participants attending workshop presentation.

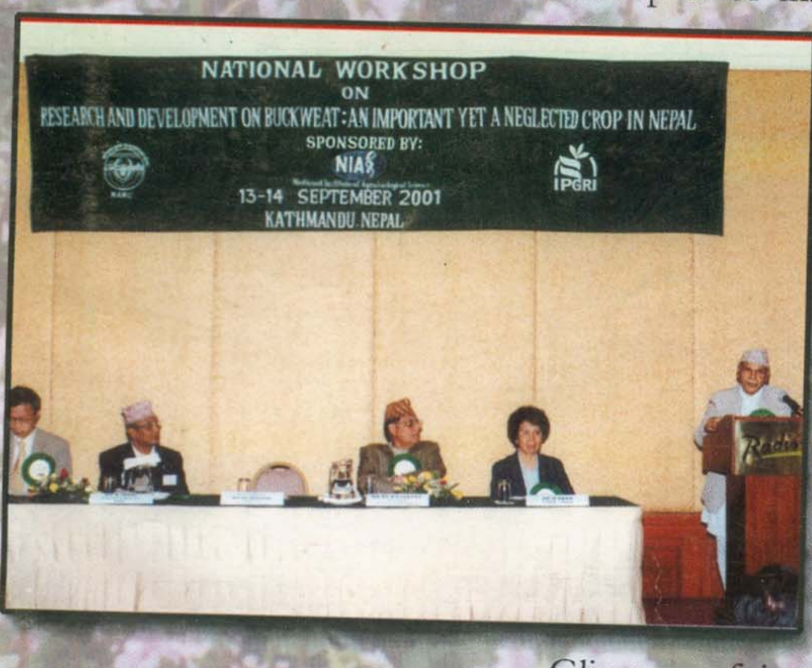
Participants attending in a group discussion.

Exhibition of buckwheat diversity in plants and products.



Glimpses of inauguration ceremony.

Glimpses of inauguration ceremony.



Glimpses of inaurguration ceremony.

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राष्ट्रिय कार्यशाला गोष्ठी ू फाप/मा अनुसन्धान तथा विकास । नेपालमा एक महत्वपूर्ण तर तिरस्कृत वाली ू .

भदौ २८-२९, २०५८ -१३-१४ सेप्टेम्वर, २००१

नेपालमा फाप/को खेती कति क्षेत्रफलमा लगाइन्छ भन्ने आ.क*ा अधावधि उपलव्ध छैन तथापि फाप/ एक महत्वपूर्ण वालीको रुपमा उच्च पहा*ी जिल्लाहरु मुस्ता*० , *ोल्पा, जुम्ला, दोलख, सोलुखुम्बुका कृषकहरुले कतै मुख्य खाद्यान्नको रुपमा त कतै सा.स्कृतिक महत्वका लागि उपयोग गर्दै आएका छन . नेपालमा दुई किसिमको फाप/ तीते तथा मिठे को खेती गा/न्छ . मुस्ता*०मा मीठे फाप/को तथा *ोल्पामा मुख्यतया तीते / मिठे फाप/को खेती गा/न्छ . यसै गा/ मुस्ता*०मा सि.चित क्षेत्रमा लगाइन्छ भने अन्य जिल्लाहरुमा असि.चित क्षेत्रमा लगाइन्छ . त/ाई चितवनमा मिठे फाप/को खेती व्यापा/िक प्रयोजनको लागि गा/न्छ . फाप/लाई ` कुअन्न ` पनि भनिने गा/न्छ . यसैले धौ/ जसो पहा*ी जिल्लाहरुमा यसको खेती सिमान्त जग्गामा तथा जग्गा बा.भ्रो /हने जाने अवस्थामा गा/न्छ . कृषकहरुले यो वालीलाई अन्य वालीको दा.जोमा खेती गर्दा कमै हे/चाह पु(्याउ.छन् . यो एउटा विचित्रको वाली हो . मिठे फाप/ प/–प/ाग से.चनद्धा/ा तथा तीते फाप/ स्व–प/ाग से.चनद्धा/ा दानाको विकास हुने भएकोले मिठे फाप/को उत्पादन तीते फाप/ भन्दा कम हुन्छ . हालसम्म यसको जातीय सुधा/मा काम भएको देखिदैन . कृषकहरुले पूर्वकाल देखि लगाई आएका विउ अद्यावधि जगेर्ना गर्दै आएका छन् त/ यसको खेती क्रमिक रुपमा घट्दै आएकोले यो वालीको मासिने सम्भाव्यतालाई भने नकार्न सकिन्न . उच्च पहा*ी क्षेत्रमा फाप/ दिगो वालीको रुपमा लिन सकिन्छ, अरु वालीको खेतीको प्रचलन यस भेगमा दिगो कृषि विकासको लागि अनुपयुक्त हुन सक्छ . का/ण प्रष्ट नै छ . अन्य मुख्य खाद्यान्न वालीहरुको पोषक तत्व तथा पानीको माग बढी हुने / प्रचलित वाली प्रणालीमा समाहित हुन नसक्ने भएकोले धान, गहु., मकै जस्ता वाली त्यस भेगका लागि दिगो कृषि प्रणाली हुन सक्तैन . फाप/ एउटा गुणका/ी वाली हो . यसको औषधी गुणको का/णले गर्दा हाल यसको उपयोग विकसित देशमा बढेको छ . यसमा ' रुटीन ' भन्ने तत्व पाइन्छ . जसले उच्च /क्तचाप तथा ह्रदय /ोगका /ोगीहरुलाई औषधीय गुण प्रदान गर्दछ . क्याना*ा, चीन, बर्मा तथा यू/ोपेली देशहरुमा यसको व्यावसायिक खेती गा/न्छ . जापानमा फाप/को विशेष माग छ . जापानमा हाल तितोपना हटाउने प्रविधिको विकास भै सकेको छ . यी देशहरुमा यसको प्रयोग चाउचाउ, पाउ/ोटी, विस्कुट, मिठाईको रुपमा गा/न्छ . हाम्रो देशमा यसको प्रयोग मुख्य तथा ढि*ो तथा /ोटीको रुपमा गा/न्छ . हामी कहा. हालसम्म /ाम्रो पीठो निकाल्ने कलको सम्म पनि विकास नभएको तथा ढुवानी / बजा/को समुचित व्यवस्था नभएबाट यस वालीको विकासमा बाधा पुगी /ाखेको छ . नेपालका शह/ी क्षेत्रमा फाप/को प्रयोग यसको औषधीय गुणले गर्दा बढ्न थालेको छ . त/ ढुवानीको समस्याले गर्दा पहा*ी क्षेत्रमा यसको आपूर्ति हुन सकि/हेको छैन . कृषि तथा खाद्यान्न सु/क्षणको दृष्टिले यस वालीलाई महत्व दिई इ+स+ १९९९ मा नेपाल कृषि

अनुसन्धान पा/षद्, /ाष्ट्रिय कृषि जैविक श्रोत स.स्थान, जापान तथा अन्त/ाष्ट्रिय वनस्पति जैविक श्रोत स.स्थान, /ोम, इटालीले स.युक्त रुपमा काम गर्ने तीन वर्षे सम्झौता ग/्यो . यस योजना अन्तर्गत हाल सम्म खेती गा/ने फाप/का जात स.कलन, ज.गली फाप/ प्रजातीहरुको यथास्थान अध्ययन / पहिचान तथा विउ स.कलन, स.कलन गा/एका जातहरुको विभिन्न हावापानीमा पा/क्षण तथा तीते फाप/ तथा ज.गली फाप/को जैविक विविधता अध्ययन श्री+एन+ए+ स्त/मा भयो . हाल नेपाल कृषि अनुसन्धान पा/षद्को कृषि वनस्पति महाशाखामा /हेको जैविक प्रविधि प्रयोगशालाको भौतिक तथा प्रविधि विकासमा यो योजनाले महत्वपूर्ण टेवा प्रदान गो/को छ . यो वर्ष यस योजनाको अन्तिम वर्ष भएकोले योजनाबाट अध्ययन / अनुसन्धान गा/एका विषय / यसको उपलब्धि बा/ अवगत ग/ाउन यस कार्यशालाको आयोजना गा/एको हो . यस कार्यशालामा विभिन्न क्षेत्रबाट फाप/मा गा/एका अनुसन्धान बाहेक विकास सम्बन्धि कार्यकलाप, फाप/को आर्थिक, सामाजिक, औषधीय, सा.स्कृतिक तथा धार्मिक महत्व बा/ विषय विशेषज्ञबाट कार्यक्रम प्रस्तुत गा/ने छ . यस सम्मेलनमा /ाष्ट्रिय तथा जापान, चीन लगायतका प्रतिनिधिहरु समावेश भएको फाप/ सम्बन्धि विषय विशेषज्ञ कृषि विकास अधिकृत, कृषकहरु गै/–स/का/ी स.स्था तथा विश्व विद्यालयका प्रतिनिधिहरुले भाग लिई /हेका छन् . यस दुई दिने - १३–१४ सेप्टेम्व/ २००१ कार्यशाला गोष्ठीको आयोजना तीन मुख्य उद्देश्यहरुलाई प्राथमिकता दिई स.चालन हुन लागेको छ .

१ खेती गा/ने फाप/का जातहरु तथा ज.गली जातहरुको विविधता बा/ ज्ञान प्रकाशमा ल्याउने .

२ यथास्थान स./क्षण प्रविधिको बैज्ञानिक खोज सम्बन्धि जैविक /सायन तथा श्री+एन+ए प्रविधिको अध्ययन .

३ फाप/को विविधताको उपयोग फ/ाकिलो पार्ने

यस कार्यशाला गोष्ठीले नेपालमा फाप/ सम्बन्धि अनुसन्धान तथा विकासका कार्यहरु लगायत यस वालीको धार्मिक, सामाजिक, आर्थिक महत्वको ज्ञान तथा सीपको स.गालोको रुपमा एक पुस्तक पनि प्रकाशन गर्ने छ . जो फाप/स.ग चाख /ाख्ने सबै पाठकवर्गहरुलाई निश्चय नै उपयोगी हुने विश्वाश गा/एको छ .

अनुसन्धानबाट प्राप्त नतिजा अनुसा/ नेपालको फाप/को '**रुटीन**' तत्वको प्रतिशत बढी मात्रामा छ .