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AGRICULTURAL RESEARCH FOR POVERTY ALLEVIATION AND LIVELIHOOD ENHANCEMENT

Proceedings of the 3rd SAS-N Convention
27-29 August 2008, Lalitpur



Nepal Agricultural Research Council
(NARC)



Society of Agricultural Scientists, Nepal
(SAS-N)

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

Third SAS-N Convention

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Foreword

The Government of Nepal recognizes the importance of agriculture in its plans and policies. Technologies play vital role to achieving the goals set forth in the agricultural plans. Nepal Agricultural Research Council (NARC), an apex body for agricultural research in the country, visions to encompass wider spectrum of the stakeholders to drive agricultural research for development. NARC has been closely working with various stakeholders, including professional organizations to conduct research and document research findings. In this context, scientific gatherings like workshops and conventions are instrumental for sharing, compiling, and disseminating agricultural technologies.

Convention of the Society of Agricultural Scientists, Nepal (SAS-N) is an important event that provides the forum for professional gathering of agricultural scientists and researchers working in different organizations. For the last 17 years, Nepal Agricultural Research Council (NARC) has been collaborating with SAS-N in different activities, including the joint publication of 'Nepal Agriculture Research Journal'. Now, NARC is happy to support SAS-N for publishing the Proceedings of 3rd SAS-N Convention, which I believe, will be of wider use among stakeholders for betterment of agriculture in the country.

I would like to congratulate SAS-N for the publication of the proceedings and look forward to maintaining the scientific collaboration in years to come.

Dil Bahadur Gurung, PhD
Executive Director
Nepal Agricultural Research Council

Preface

The Society of Agricultural Scientists, Nepal (SAS-N) is a non-profit professional, scientific organization dedicated to the research and development of agriculture in Nepal. The Society serves as a common forum for the agricultural scientists and researchers scattered throughout Nepal in various agricultural and related institutions. The SAS-N aims to bring agricultural scientists and researchers of Nepal to a common forum by way of protecting their professional integrity and improving the standard of their research works in order to contribute to a common goal of the country's economic development through the growth of agricultural sector. SAS-N organizes its convention in every three years and publishes proceedings of the paper presented during the convention.

This is the third proceedings of the Society of Agricultural Scientists, Nepal (SAS-N). The first proceedings - Advances in Agricultural Research in Nepal (March 29-31, 1999) was published in 2001. The second proceedings - Agricultural Research for Enhancing Livelihood of Nepalese People (30 July-1 August 2003) is available online (www.sas-nepal.org).

Poverty alleviation and livelihood enhancement has been a major challenge for overall development of Nepal. This challenge can be resolved only through sustainable development in agriculture sector as it generates employment to two-third of the population and contributes one-third of the gross domestic products of the country. In other words, agriculture is the main engine for the nation's development and agricultural research is the 'fuel' for this engine. So, the theme of the Third SAS-N Convention, 27-29 August 2008, 'Agricultural Research for Poverty Alleviation and Livelihood Enhancement' rightly addresses the national agenda for development.

The objectives of the convention were to (1) create a scientific forum for sharing of knowledge and experience of agricultural research and development, (2) explore new research areas for crops, horticulture, livestock and fisheries, including veterinary, natural resources, socio-economics, extension, communication and linkage, and other development prospects, (3) explore some agriculturally potential developmental models of poverty alleviation, and (4) promote and contribute for poverty alleviation and livelihood enhancement. I hope the strategic papers and research findings presented in this proceedings will be useful for researchers, development workers, teachers, students, planners and policy makers.

I would like to greatly acknowledge the then President of SAS-N, Dr. Adarsha Pradhan and the Executive Committee for successful completion of the 3rd SAS-N Convention on which this proceedings is based. Special thanks are due to Editor-in-Chief, Dr. Krishna Prasad Paudyal and other members of the Editorial Board for their valuable contribution in compiling and editing papers to bring the proceedings in this shape.

Because of financial constraints SAS-N was not able to bring the proceedings in a print form earlier, but was made available online. With the generous support of NARC it has now been published in the present form. For this, on behalf of SAS-N, I extend my sincere thanks to the Executive Director Dr. Dil Bahadur Gurung and the NARC management. SAS-N anticipates such support and collaboration from NARC in the future, too.

Hira Kaji Manandhar, PhD
President
Society of Agricultural Scientists, Nepal (SAS-N)

Editorial Note

Society of Agricultural Scientists, Nepal (SAS-N) organized its Third Convention from 27 to 29 August, 2009 (11-13 Bhadra, 2065) in Lalitpur with the main theme of 'Agricultural Research for Poverty Alleviation and Livelihood Enhancement'. The main objective of the convention was to create a scientific forum for sharing of knowledge and experience of agriculture research and development. Parallel technical sessions were conducted in different research and development thematic sectors namely (1) crops, (2) horticulture, (3) livestock, (4) fisheries and aquaculture, and (5) policy, socioeconomic and communication. The present volume of the proceedings includes the technical and thematic papers presented in the convention.

The papers presented during technical sessions were compiled and edited in the form as submitted. Therefore, the authenticity of the papers and the opinion expressed therein are those of the respective author(s). A couple of papers that have been published in other journals are excluded from this proceedings. I hope the information and findings presented in the proceedings bear a meaningful and productive impact on agriculture research and development in Nepal. I also believe that its readership finds the proceedings informative and useful.

I would like to thank the members of the Editorial Board who voluntarily contributed their valuable time in editing manuscripts. Dr. Hira Kaji Manandhar, President of SAS-N and his team deserve special acknowledgement for all the support and help extended to the Editorial Board. I apologize for any error and shortcomings in this volume and will be pleased to receive valuable suggestions and feedbacks for future improvement.

Krishna Prasad Paudyal, PhD
Editor-in-Chief

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Highlights on Rice Varieties of Various Environments of Nepal

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ABSTRACT

Rice is the major crop of Nepal contributing 58 percent of the total food grain production and sharing 20 percent to agriculture gross domestic product. There are various types of rice growing environments in the country. It is grown in all three major agro-ecological regions terai/inner terai (70.1%), mid hills (25.6%) and high hills or mountain (4.3%). The national seed board and variety releasing committee has recommended 56 rice varieties (including 12 recently denotified varieties) for various production systems.

In terai and inner terai (60-300 masl), various production systems like Boro rice (especially in Jhapa and Morang), Chaite/Spring rice, Bhadaiya rice (especially in central terai) and main season Barkhe rice are the common rice production systems in either fully or partially irrigated environment. Some promising lines like Bridhan 35, Bridhan 36 and DN 5 are identified suitable for Boro rice. CH 45, Chaite 2 and Hardinath 1 are the popular varieties for Chaite rice. Similarly, in Bhadaiya rice, Ghaiya 2, Hardinath 1 and Chaite 6 are common varieties. The major varieties for fully or partially irrigated Barkhedhan are Sabitri, Masuli, Radha 4, Makwanpur 1, Radha 12 and Kanchhi Masuli (unofficial source). Radha 12 and Kanchhi Masuli are grown especially in eastern terai. Sabitri is popular from Central to western terai whereas Radha 4 is mainly grown in central to western and farwestern terai. Mithila, a new variety is gaining its popularity especially in eastern and central terai. In rainfed Barkhe rice, Radha 4, Radha 7, Radha 11, Radha 12, and Masuli are predominant in midwetland khet. The native varieties are still common in shallow drought prone aus khet and submergence prone lowland areas. The new variety Loktantra is also spreading in rainfed shallow system.

In foot hills and valleys (300-900 masl) Chaite, Barkhe and upland or Ghaiya rice are the existing rice production systems. In Chaite rice CH 45 and Hardinath 1 are the most common varieties. In Barkhe rice Radha 7, Makwanpur 1, Masuli, Rampur Masuli Loktantra and Mithila are grown in large areas. In upland system mostly the native varieties are predominant. Warm temperate rice in mid hills (900-1500 masl) include both partially irrigated to fully irrigated systems. Taichung 176 and Khumal 11 are suitable varieties for this domain. In general Khumal 4 is widely grown in mid hills. Khumal 8, the newly released variety is increasing popularity in lower hills. In high hills (1500- 2621 masl), mostly the cold tolerant native varieties are grown as cool temperate rice. Chandannath 1 and Chandannath 3 have got popularity in Jumla and are competent varieties to native Jumlimarshi. Chhamrong and Machhapuchhre 3 are popular in Chhamrong areas in western high hills.

INTRODUCTION

Nepal is a landlocked agricultural country and its farming is mostly for subsistence. Agriculture contributes 33 percent to gross domestic product (GDP) and 66 percent to employment of Nepal (MOAC 2007). Agriculture growth rate is slightly slower (2.0%) than the population growth rate (2.25%). Rice is the major crop of Nepal contributing 58 percent of the total food grain production and sharing 20 percent to agriculture gross domestic product (AGDP). The total rice area is 1.43 million ha and annual production is 3.68 MT with a productivity of 2.55 mt/ha (MOAC 2007). Considering the contribution of

rice in national economy, department of agriculture established national rice development program in 1972 (presently named as National Rice Research Program under Nepal Agricultural Research Council) which is mandated to develop the improved varieties for increasing the rice productivity in Nepal (NARC 1997). Till date there are 56 varieties released in Nepal and CH 45 was the first variety that was released in 1958.

RICE ENVIRONMENTS AND RELEASED VARIETIES

Rice is grown in three distinct major agro-ecological zones, which are Terai and inner Terai (60-300 masl), mid hills (300-1,500 masl) and high hills (1,500-2,621 masl). The Terai and inner Terai consist of major portion (70.1%, MOAC 2007) of rice area (Table 1). The mid-hills and high hills consist of 25.6% and 4.3% of the total rice area, respectively. Based on water regime, prevailing rice ecosystems are irrigated either fully or partially (51%), rainfed lowland (41%), and upland (8%) of the total rice area (MOAC 2005). Some part of Terai plains also consist of deep-water rice, which is very negligible to be considered. The rainfed lowland has various diversified rice environments with predominance of drought prone rainfed. Upadhyaya (1996) specifically explained 11 rice recommendation domains based on rainfall and altitude regime (Table 2). He also found altitude and rainfall as two major factors in explaining the variability among rice domains. Considering all these factors, the major prevailing rice production systems are given in Table 3.

Table1. Rice area and production by ecological region (MOAC, 2006/2007)

Ecological belt	Area (ha)	Production (kg)	Yield (t/ha)
Mountain	62,258 (4.3%)	120,172 (3.0%)	1.93
Hills	3, 67,657(25.6%)	933,852 (25.0%)	2.54
Terai and Inner Terai	10, 09,551 (70.1%)	2626,815 (72.0%)	2.6
Total Nepal	14,39,525 (100%)	3680839 (100%)	2.55

Table2. Recommended rice domains (Upadhyay, 1996)

Altitude (m)	<500	<500	<500	500-1000	500-1000	500-1000	1000-1500	1000-1500	Kathmandu valley
Rainfall (mm)	<200	200-500	>500	<200	200-500	>500	<200	200-500	

Table 3. Major rice production systems in Nepal

Agro-Ecological Zone	Altitude (masl)	Water Regime and Land Type	Crop Season
A. Terai and Inner Terai			
Boro rice	60-200	Irrigated lowland	October-June
Chaite rice	60-300	Irrigated lowland	March-July
Normal rice	30-300	Irrigated and rainfed lowland	June-November
Deep water rice	60-100	Deepwater lowland	May-December
B. Valley and Mid-Hills			
Chaite rice	300-900	Irrigated lowland	February-June
Normal rice	300-900	Irrigated and rainfed lowland	May-October
Upland rice	300-900	Rainfed upland	April-August
Warm Temperate rice	900-1500	Irrigated and rainfed lowland	May-October
C. High Hills			
Cool Temperate rice	1500-2621	Irrigated and rainfed lowland	April-October

The National Seed Board has recommended 56 rice varieties for various agro-ecological zones and environments (Table 4). Out of 56, 12 varieties have been recently denotified as they were already discarded by the farmers.

Table 4. List of rice varieties released in Nepal

Varieties	Parentage/Source	Origin	Year	Growing Season and Environment
CH-45	Selection at CRRRI	China	1959	Chaite, Terai, Inner terai and foot-hills
Taichung-176	Tsai-Yuan-Chung/Dee-geo-woo-gen	Taiwan	1967	Barkhe, Warm Temperate areas
Chainan-2	C-luamchu/Shiniri-Aikoku//Taichung-65	Taiwan	1967	Barkhe, Warm Temperate area
Chainung-242	Hsinchio-4/Taichung-150//Taipei-7/Tainung145	Taiwan	1967	Barkhe, Warm Temperate areas
Tainan-1	Tsai-Yuanchung/Dee-Geo-Woo-Gen	Taiwan	1967	Barkhe, Warm Temperate areas
IR 8+	Peta/Dee-geo-woo-gen	IRRI	1968	Barkhe, Terai, Inner terai and foot hills
IR 20+	IR 262-24-3/TKM6	IRRI	1972	Barkhe, Terai, Inner terai and foot hills
IR 22+	IR8/Tadukan	IRRI	1972	Barkhe, Terai, Inner terai and foot hills
Parwanipur-1+	Peta *4/TNI	IRRI	1973	Chaite, Terai, Inner terai and foot hills
Jaya+	TNI/T 141	India	1973	Barkhe, Terai, Inner terai and foot hills.
Masuli	Mayang Ebos 80*2/Taichung 65	Malayasia	1973	Barkhe, Terai, Inner terai and foot-hills
IR 24+	IR8///Century patna/SLO17//Sigadis	IRRI	1975	Chaite, Terai, Inner terai and foot hills
Chandina+	Peta *3/TNI/TKM6	IRRI	1978	Chaite, Terai, Inner terai and foot hills
Durga+	Jaya//IR8/Latisail	India	1979	Barkhe, Terai, Inner terai and foot hills.
Janaki	Peta 3/TNI//Remadja	Sri Lanka	1979	Barkhe, Terai, Inner terai and foot hills.
Sabitri	IR 1561-228-1/IR 1737//CR 94-13	IRRI	1979	Barkhe, Terai, Inner terai and foot hills.
Laxmi+	IR833-6-2-1-1//IR 1561-149-1/IR 1737	IRRI	1979	Chaite, Terai, Inner terai and foot hills
Bindeshwari	TN 1/Co 29	India	1981	Chaite, Terai, Inner terai and foot hills
Kanchan	CR126-42-5/IR2061-21-3	IRRI	1982	Barkhe, Warm temperate areas
Himali	CICA-4/Kulu	IRRI	1982	Barhe, Warm temperate areas
Mallika+	CP-SLO2/Sigadis	Bangladesh	1982	Chaite, Terai, Inner terai and foot hills
Khumal-3	China 1039 /IR 580	India	1983	Barkhe, Warm temperate areas
Khumal-2	Jarneli/Kn-Ib-361-Blk-2-8	Nepal	1987	Barkhe, Cool temperate areas
Palung-2	BG 94-2/Pokhareli Masino	Nepal	1987	Cool temperate areas
Khumal-4	IR28/Pokhareli Masino	Nepal	1987	Barkhe, warm temperate areas
Chaite-2	BG34-8/IR2061-522-6-9	IRRI	1987	Chaite, Terai, Inner terai and foot hills
Chaite-4	BG34-8/IR28//IR2071-625-1-252	IRRI	1987	Chaite, Terai, Inner terai and foot hills
Barkhe-2+	C4-63 GB/B 531b-TK-39	Indonesia	1987	Barkhe, Terai, Inner terai and foot hills.
Khajura-2+	RP72/Mutant 65	India	1987	Barkhe, Mid-western terai
Makwanpur-1	Ob678/IR20//H4	Sri Lanka	1987	Terai, Inner terai and foot hills.
Ghaiya-2	MTU/W.Kakaiku	India	1987	Ghaiya, Sub-tropical Upland areas
Khumal-5	Pokhareli Masino/Kn-Ib-361-Blk-2-8	Nepal	1990	Barkhe, Warm Temperate areas
Khumal-7	China 1039 DEF MUT/Knlb-361-1-8-6-10	IRRI	1990	Barkhe, Warm Temperate areas
Khumal-9	K28-76-B-1/Knlb-214-1-4-3	IRRI	1990	Barkhe, Warm Temperate areas
Chhomrong	Selection of local germplasm	Nepal	1991	Barkhe, Cool temperate areas in western hills.
Dhan				
Radhakrishna-9	IR 42/Masuli	Nepal	1991	Barkhe, Terai, Inner Terai and foot-hills
Radha-7	Janaki/Masuli	Nepal	1991	Barkhe, Terai, Inner Terai and

Chaite-6	NR6-5-46-50/IR 28	Nepal	1991	foot-hills
Radha-4	BG34-8/IR2071-625-1	IRRI	1995	Chaite, Terai , Inner terai and foot hills
Radha-11	Selection of TCA 80-4	India	1995	Barkhe, Rainfed lowland, western terai
Radha-12	TNI/T141//Annapurna	India	1995	Barkhe, Rainfed lowland, central terai
Machapuchre 3	Fuji 102/Chhomrong	Nepal	1996	Barkhe irrigated & rainfed areas of estern terai
Rampur masuli	Lalnakanda/IR 30	India	1999	Kathmandu valley and similar climate
Khumal 6	IR 13146-45-2-3/IR17492-18-6-1-3-3	Nepal	1999	Terai, Inner terai and foot hills.
Chandannath 1	Sel.of Jingling 78-102	China	2002	Kathmandu valley and similar conditions
Chandannath 3	Sel. Of Yunlen	China	2002	Jumla (high hills) and similar conditions
Manjushree-2	Fuji 102/NR10157 -2B-7	Nepal	2002	Jumla (high hills) and similar conditions
Khumal-11	AKIYUDAKA/BARKAT	Nepal	2002	Kathmandu valley
Hardinath 1	BG 951///79-3348/H4//BW 288-1-3	Sri Lanka	2004	Kathmandu valley and similar climate
Loktantra	Mahsuri/IR 4547-6-2-2	Nepal	2006	Chaite, Terai , Inner terai and foot hills
Mithila	Fortuna//Milfor 6*2/Azucena	Philippines	2006	Rainfed shallow lowland areas of Terai, inner terai and foot hills
Ram	Mahsuri/ IR 30	India	2006	Barkhe, Rainfed lowland, western terai
Barkhe 3004	IR 64/Kalinga 3		2006	Irrigated and partial irrigated areas of Chitwan and Nawalparasi
Pokhrel	Selection of Jethobudho	Nepal	2006	Barkhe, Terai and Inner terai
Jethobudho	Jumli marshi /IR 36	Nepal	2006	Warm temperate and river basin areas in Kaski
Khumal 8	Mutant of PusaBasmati 1	India	2008	Warm temperate and river basin areas of mid hills.
Sunaulo				Barkhe (aromatic rice), Terai ,
Sugandh				Inner terai and foot hills.

+ denotified varieties (NARC's circular, July 2008)

The varieties were developed either by introduction or hybridization and selection from national breeding system. The objectives were higher grain yield, proper maturity to fit in different production systems and desirable plant and grain characteristics with resistant to major diseases (blast and bacterial blight) and insect pests (gall midge, brown plant hopper and stem borer). The major environments, production systems, and dominant rice varieties are briefly discussed in the following headings.

A. Terai and inner Terai (60-300 masl):

1. Irrigated rice

- a. **Boro rice:** The crop is sown in second to third week of November, transplanted in first to second week of February, and harvested in last week of May to first week of June. It is mainly planted in eastern Terai especially in the Rangeli area of Morang and some parts of Jhapa districts. It is planted in about 2,000 ha (Anonymous 2007). Some of the farmers in central Terai are also planting this crop. Farmers commonly grow the Jaya variety. Some of the promising lines identified by the research system are Bridhan 35, Bridhan 36, and Bridhan 29, DN 5-2-3, and DR 11.
- b. **Chaite or spring rice:** The crop is sown in last week of February to first week of March and follows transplanting of 30-40 days old seedlings. The month of transplanting coincides with the Nepali month "Chait" and so is named as Chaite rice. This crop also needs assured irrigation system, which is either government made, farmer managed river canal, or tube well source. In total, 11 rice varieties are released for this rice system. The popular varieties are CH 45, Chaite 2, 4, and 6, and

Hardinath 1. Chaite 2 is most popular in eastern Terai. Hardinath 1 is increasing popularity in most of the Chaite rice areas. It has almost replaced the old rice variety CH 45 in Chitwan valley. Table 5 illustrates the traits of some of these popular varieties.

Table 5. Characteristics of popular Chaite rice varieties

Varieties	Parentage	Origin	Maturity Days	PH	Grain type	GY	Bl	BB	Dormancy
Chaite 2	BG 34-8/IR 2061-522-6-9	IRRI	115-125	100	Medium	5.0	R	R	Good
Chaite 6	NR 6-5-46-50/IR 28	Nepal	110-120	90	Medium	4.5	R	R	Mild
Hardinath 1	BG 951///79-3348//H4 //BW288-1-3	Sri Lanka	105-115	90	Fine	4.5	R	R	Mild
CH 45	Selection	China	105-115	120	Coarse	3.5	S	MR	Weak

PH = Plant height, GY = Grain yield, Bl = Blast, BB = Bacterial Blight, R = Resistant,

MR = moderately resistant

c. Bhadaiya rice: It is a partial irrigated system. This system is common in central Terai especially in Bara, Parsa, and Rauthat. The cropping season starts from last week of May to first week of June depending on the onset of first monsoon shower and the crop is harvested around mid-September, the Nepali month “Bhadau” which denotes for naming as Bhadaiya rice. The cropping season is 105-120 days. The farmers transplant rice either with rain water or supplemental irrigations from tube wells or river canal irrigation system that entirely depends on rainfall. Short duration varieties recommended for Chaite season are grown in this system. Gyaiya 2, Hardinath 1, Chaite 6, and Philips (source unknown) are the popular varieties (Table 6). This crop is followed by a second crop of main season double transplanted (Kharuwan) rice or other winter crops including vegetables.

Table 6. Characteristics of recommended rice varieties in Bhadaiya season

Varieties	Parentage	Origin	Maturity Days	PH (cms)	Grain Type	GY (t/ha)	Bl	BB	Others
Ghaiya 2	MTU/W.kakaiku	India	100-105	90	medium	4.0	R	MS	Drought tolerant
Hardinath 1	BG 951///79-3348 //H4//BW288-1-3	Srilanka	100-105	95	fine	4.0	R	R	
Chaite 6	NR6-5-46-50/IR 28	Nepal	105-110	95	medium	3.9	R	R	

MS = Moderately Susceptible, S = Susceptible

d. Main season irrigated rice: Fifty-one percent of the rice area is either fully or partially irrigated in Nepal (MOAC 2005). This is the main season rice that starts from June and ends in October to November. Rice varieties with 120-160 days of maturity are grown in this system depending upon the land type and the prevailing cropping system. In total, 15 varieties are recommended for this system. Sabitri, Radha 4 and 12, Makwanpur 1, Kanchhi Masuli (unidentified source) and Masuli are the popular varieties in this system. Traits of some of these varieties are given in Table 7. Some farmers also grow traditional fine and aromatic rice varieties. The types of aromatic rice varieties vary from location to location. The varieties with basmati names are common in most of the Terai regions. Lalka or Rato (Red husk color), and Ujarka or Seto (white husk color) are common in central Terai. Some are Kalanamak, Chananchur, and Brimful, among others are photo-periodically sensitive and mature in late November. Farmers also plant these varieties in double transplanting or Kharuwan. In double transplanting the usual seedlings are first transplanted in a limited plot area and the tillers from these hills are again transplanted in the main field. The practice is generally followed either in normal Bhadaiya rice pattern or when the seedlings get limited due to stress conditions of drought or flood damages. The practice is especially common in eastern and central terai. The recently released aromatic variety Sunaulo Sugandha is disliked by the farmers in eastern terai.

Table 7. Characteristics of some popular and new varieties in irrigated areas of terai, inner terai, and foothills

Varieties	Parentage	Origin	Maturity days	PH (cms)	TGW (gm)	GY (t/ha)	BI	BB	Others
Masuli	Mayang Ebos 80*2/Taichung 65	Malaysia	150-155	125	16.2	4.0	S	MR	
Sabitri	IR 1561-228-1/IR1737//CR94-3	IRRI	140	105	20	5	R	MR	
Makwanpur -1	Ob678/IR20//H4	Srilanka	150-155	110	25	5-5.5	M R	MR	MR to Gall midge
Rampur Masuli	Lalnakanda/IR 30	India	135	105	18.2	4.0	R	MR	
Mithila	Fortuna//Milfor 6*2/Azucena	Philippines	135	105	18.3	4.0	R	MR	

MR = Moderately resistant, S = Susceptible, R=Resistant, TGW = Thousand grain weight, PH=Plant height, TGW=Thousand grain weight, GY=Grain yield, BL=Blast, BB=Bacterial blight

Rainfed lowland rice

This system denotes rice crop transplanted with rainwater in the bonded rice field. It is mostly transplanted rice. This system includes the aus crop with short duration rice varieties to lowland field with submergence-tolerant local varieties. Seven varieties are recommended for this system. The aus crop represents drought-prone rainfed lowland environment where varieties recommended for upland areas like Bindeswari and Ghaiya 2 are popular, and some other varieties like Chaite 2 and Hardinath 1 are also grown. Some of the farmers still grow the traditional short duration drought-tolerant varieties as aus crop. In medium land type, Radha 4, Radha 7, Radha 11, and Radha 12, Rambilash (unidentified source) and Masuli are commonly planted. The traits of the popular varieties are given in Table 8. In submerge prone areas, Mahsuri and Radha 12 are also planted but mostly local coarse to medium grain varieties are still grown by farmers. These are tall and photo-periodically sensitive. Some varieties are Amagauz, Karma, and Lajhi, among others. In favorable rainfed areas, farmers successfully adopted the varieties recommended for irrigated condition. Examples are Mahsuri, Sabitri, and Makwanpur 1.

Table 8. Popular and new rice varieties for rainfed lowland areas

Varieties	Parentage	Origin	Maturity days	PH (cms)	TGW (gm)	GY (t/ha)	BI	BB
Radha 4	BG 34-8/IR 2071-625-1	IRRI	130	95	25.2	3.5	R	MR
Radha 7	Janaki/Masuli	Nepal	135	130	25	3.5	MR	MR
Radha 11	Selection from TCA 80-4	India	145	120	21	3.5	S	MR
Radha 12	TN 1/T 141/Annapurna	India	150	110	25.2	4.0-4.5	R	MR
Loktantra	Mahsuri/IR 4547-6-2-2	Nepal	130	115	20	3.5	R	MR

B. Valley and mid hills (300-1,500 masl)

1. Foot hills and valleys (300-900 masl)

- a. **Chaite rice.** The Chaite rice crop in this area is 2-4 weeks earlier than in Terai and inner Terai. It is grown mostly in perennial source of local canal irrigation system. River basin areas of mid-hill region throughout the country are potential belt for growing this crop. The crop is also called "Hiunde" rice as it is sown in winter months (first to second week of February). Besides earlier mentioned varieties, the hill variety Taichung 176, Chainung 242 and Khumal 11 are also grown as Chaite rice in this region. Hardinath 1 is increasing popularity and replacing CH 45.

- b. **Normal rice:** It is a partially irrigated system. The amount of irrigation is often determined by the frequency of rainfall. Popular rice varieties are Radha 7, Radha Krishna 9, Makwanpur 1, Masuli, and Rampur Masuli. Loktantra and Mithila are also gaining popularity. In the upper altitude areas (750-900 m), Khumal 4, Khumal-8 and local varieties are also grown in some areas.
- c. **Upland rice:** The unbounded sloppy upland areas exist in this region. The crop is broadcasted in April and harvested around mid- to last week of August. The potential areas are Gorkha, Lamjung, Tanahun, Surkhet, and Dailekh, among others. Mostly traditional tall drought-tolerant varieties are grown in this environment. In some areas, the crop is grown as mixed crop with maize. Bindeswari and Ghaiya 2 are two varieties recommended for this system but could not gain popularity due to its short stature plant type. They are early maturing and resistant to blast (Table 9).

Table 9. Characteristics of two recommended upland varieties

Varieties	Parentage	Origin	Maturity days	PH (cms)	TGW (gm)	GY (t/ha)	BI	BB
Bindeswari	TN 1/Co29	India	110-115	90	22	1.5-2.0	MR	MS
Ghaiya 2	MTU/Wkakaiku	India	105-110	85	23	2.0-2.5	MR	MS

2. **Warm temperate rice (900-1,500 masl):** This environment of mid-hill rice includes both rain fed/partially irrigated and irrigated ecosystem. The farmer-managed irrigated canals are monsoon dependent. Various types of sub-domains exist including Kathmandu valley under this system. The duration of the crop is from last week of May to November. There are 17 varieties recommended for this system including the old four Taiwanese varieties. Taiwanese varieties Taichung 176 and Chainung 242 are still popular in Kathmandu valley. Khumal 11 is an alternative to these varieties. In the other mid-hill region, Khumal 4 is the most popular variety. Their major traits are given in Table 10. The few other popular varieties are Kanchan, Khumal 5, Khumal 6, and Khumal 7. The recently released variety Khumal 8 is increasing popularity especially in foothills.

Table 10. Performance of some popular and newly released warm temperate rice varieties

Varieties	Parentage	Origin	Maturity	PH (cms)	TGW (gm)	GY (t/ha)	BI	BB
Taichung 176	TsaiYuanChung/Dee-Geo-woo-gen	Taiwan	139	115	26.4	6.7	S	MS
Chainung 242	Hsinchio/Taichung 170//Taipei 7/Tainung 145	Taiwan	141	110	26.8	6.5	S	MS
Khumal 4	IR 28/Pokhrela Masino	Nepal	141	133	17.8	6.3	R	MS
Khumal 11	Akiyudaka/Barkat	Nepal	134	101	27.3	6.3	MR	MS
Khumal 8	Jumli marshi/IR 36	Nepal	156	110	25.7	8.5	MR	MR

C. High hills (1,500-3050 masl)

1. Cool temperate rice:

The cool temperate rice needs highly cold tolerant rice varieties. Jumla (2621 masl) is perhaps the highest altitude in the world where rice is grown (Shahi and Heu 1979). Originally, farmers in this area were growing only one variety known as Jumli Marsi. However, Chandannath 1 and 3 have been recently released for this area and increasing popularity. However, most of the farmers who do not offer higher doses of fertilizer as demanded by these improved varieties are still willing to grow Jumli Marsi. The location specific varieties like Palung 2 for Palung valley, and Chhamrong and Machhapuchhre 3 for Gandruk areas in western hills are recommended as cool temperate rice. The performance of these varieties is given in Table 11. Traditional varieties are gradually replace by these improve varieties in other areas of high hill.

Table 11. Performance of recommended varieties in high hills (data from Khumaltar)

Varieties	Parentage	Origin	Maturity days	PH (cms)	TGW (gm)	GY (t/ha)	Blast
Palung 2	BG 94-2/Pokhreli Masino	Nepal	129	148	22.9	6.3	R
Machhapuchhre 3	Fuji102/Chhamrong	Nepal	139	152	27.2	4.9	MR
Chandannath 1	Sel. of Jingling 78-102	China	129	123	20.3	2.1	MR
Chandannath 3	Sel. Of Yunlen	China	139	141	22.4	3.3	MR
Chhamrong	Sel of land race	Nepal	133	145	22.9	3.5	MR

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Adoption of Rice-based Technologies in Marginal Uplands in Siwalik

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ABSTRACT

Adoption of improved rice-based technologies was assessed in the marginal uplands of Bhabsi and Patu villages situated in Siwalik range of Mahottari after two years of technology intervention by the collaborative project of IRRI with NARC for household food security and environmental sustainability. Among the new varieties, Radha-32 was adopted by 75 percent of farm households mainly because of high yielding, drought tolerance, disease resistance, fair eating quality and medium milling recovery. Hardinath-1 became also popular variety adopted by 60 percent of farm households due to high yielding and short duration maturity and fit in low land conditions for normal as well as early rice. Adoption of low cost technologies like seedling broadcasting and integrated weed control measure was increasing. The new rice varieties replaced the local varieties which were low yielder and susceptible to blast disease. Farmers had adopted cropping patterns like rice-chickpea and rice-lentil and inter cropping of rice with peanut, cowpea or maize as new technologies. The average rice yield was increased by 319 kg/ha in upland condition and 221 kg/ha in lowland condition after two years of technology intervention by the project.

INTRODUCTION

Marginal upland is the important land for resource poor farmers to maintain their livelihood in hills and foot hills of Nepal. Upland rice has a substantial contribution to food security of these households. However, soil erosion and fertility degradation is ever increasing problem with rice cultivation in marginal uplands. So, improvement in rice based farming with technology intervention is the best way out to enhance the food security and maintain the environment. A collaborative project entitled "Managing Rice Landscapes in Marginal Uplands for Food Security and Environmental Sustainability" was started in 2005 according to agreement signed between NARC and IRRI. The project was funded by IFAD with the objective of developing and disseminating rice based technologies in marginal uplands for food security and environmental sustainability in Nepal. The program was carried out in three districts viz. Doti, Lamjung and Mahottari. In Nepal, upland rice is grown in all 75 districts however, in Mahottari, it is grown in 3605 hectare and number of upland rice growing households are 7606 (CBS 2002). In 2008, an assessment was carried out in Mahottari to identify the adoption status and changes after adoption of rice based technologies. There were two project sites in Mahottari, one was Bhabsi and another was Patu, both populated by mixed type of community. Bhabsi area is dominated by marginal uplands whereas Patu area is dominated by lowlands. The objective of this study was to understand the adoption status of rice-based technologies and identify the changes after project intervention.

METHODOLOGY

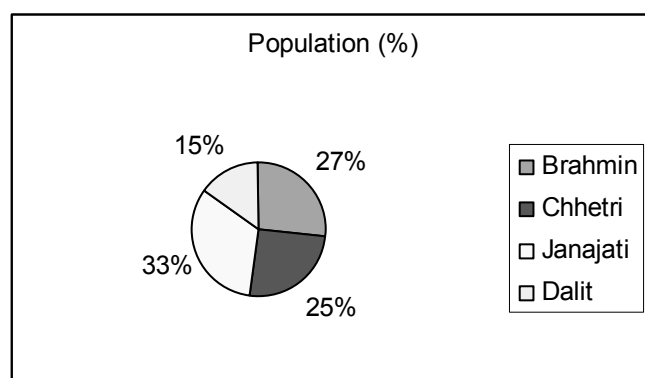
The study was carried out with focused group discussion (FGD) and household survey in both the project sites of Mahottari district. Thirty households selected by random sampling in each site were interviewed

using semi-structured questionnaire and FGD was carried out using checklist. Field observation along with farmers' interaction was also carried out mainly for standing rice crops (early rice).

FINDINGS

Demographic features

The project sites are resided by mixed type of community with Brahmin, Chhetri and Janajati and Dalits (the backward ethnic group). The overall community of both the project sites is made up of Brahmin (27%), Chhetri (25%), Janajati (33%), and Dalit (15%). Among them, Chhetri ethnic group has the highest literacy rate (67%) and Dalit has the lowest literacy rate (36%). Highest literacy rate of Chhetri ethnic group is against the general situation of Nepal where higher literacy of Brahmin is commonly found.



Janajati has the largest family size (6.7) whereas Dalit has the smallest one (4.7) in the project area. Traditional joint family system of Janajati may be the cause of large family size. In the project sites, the average family size is 5.5 per household and the mean literacy of over 6 years age is 49 percent. Low farm productivity and lack of income opportunity in the village have caused less literacy percentage among the people. Uneasy road access and lack of school infrastructure in the village were other constraints for attaining the education.

Table 1. Demographic features of upland farmers in Siwalik (n=60)

Ethnicity	Literacy (%)	Family size
Brahmin	50	5.6
Chhetri	67	5.8
Janajati	44	6.7
Dalit	36	4.7
Mean	49	5.5

Source: On-farm survey, 2008

Socio-economic characteristics

The mean land holding in project sites was 0.57 hectare which was less than national average 0.79 ha (MoAC 2007). Among the ethnic groups, Chhetri had largest land holding ie 0.84 ha. and Dalit had smallest land holding i.e. 0.31 ha. Farmers in Bhabsi had special issue of land ownership problem as they did not have ownership certificate which was required to get loan from financial institution. The cultivated area of Bhabsi was made after forest clearance in the past, however government of Nepal has not distributed the land ownership certificate to the local people. The land ownership problem has hindered in getting loan from financial institutions resulting less investment in their agriculture that ultimately results low production.

Regarding the food sufficiency level, there was not much difference among the ethnic groups as Dalit, Brahmin, Janajati, and Chhetri have food production for 7.5 months, 8 months, 8.6 months and 9.2

months respectively. On average, the farm households in project sites had food production for only eight months which shows the lack of food security situation in the project sites. Regarding livestock, Dalit farm households had less number of livestock whereas Brahmin, Chhetri had large number of them. On average, number of large livestock (cattle and buffalo) was 2.6 and that of small livestock (sheep, goat, pig) was 4.0 in the project sites (Table 2).

Table 2. Socio-economic characteristics of upland farmers in Siwalik (n=60)

Ethnic groups	Land holding (ha)	Food Sufficiency (month)	Large livestock (no.)	Small livestock (no.)
Brahmin	0.68	8	2.9	4.6
Chhetri	0.84	9.2	2.7	5.3
Janajati	0.53	8.6	2.7	3.7
Dalit	0.31	7.5	2.3	2.7
Mean	0.57	8.1	2.6	4.0

Source: On-farm survey, 2008

Adoption status of rice varieties

Among the new rice varieties, Radha-32 was getting popular as it was adopted by 75 percent of farmers in 2008. The adoption rate of this variety has been increased substantially as it was adopted by 2 percent in 2006 and 33 percent in 2007. Hardinath-1 was adopted by 60 percent in 2008 and 48 percent in 2007 since it was most popular early rice in lowland area. Loktantra and Radha-4 were adopted by 32 percent and 20 percent, respectively in 2008 (Table 3). Radha-4 is mostly cultivated in upland condition where irrigation facility is not available.

Table 3. Percentage of adopting households (n=60)

Rice Varieties	2006	2007	2008
Radha 32	2	33	75
IR-55435-5	2	3	8
Loktantra	-	20	32
Radha 4	-	13	20
Hardinath-1	-	48	60

Source: On-farm survey, 2008

Adoption status of other rice technologies

The project had introduced different types of rice based technologies including rice based cropping patterns. Most of these technologies and cropping patterns were getting popular with increased adoption rate. Rice growers adopted the method of seedling broadcasting a low cost rice technology with minimum drudgery by 13 percent in 2007 and 18 percent in 2008 in lowland areas. For weed control, integrated weed management practice was adopted by 18 percent in 2006 and 32 percent in 2007. The new cropping pattern rice-chickpea was introduced by 20 percent in 2006 and 57 percent in 2007. Similarly, farmers adopting rice-lentil cropping pattern was increased from 27 percent in 2006 to 67 percent in 2007. The intercropping of upland rice with peanut, cowpea, and maize was introduced by 17, 10 and 18 percent, respectively in 2007 (Table 4).

Table 4. Percentage of adopting households (n=60)

Varieties	2006	2007	2008
Seedling broadcasting	-	13	18
Herbicide use after one hand weeding	18	32	-
Rice-Chickpea	20	57	-
Rice-Lentil	27	67	-
Upland Rice+Peanut	13	17	-
Upland Rice+Cowpea	7	10	-
Upland Rice+Maize	15	18	-

Source: On-farm survey, 2008

Radha-32 variety of rice was much popular in Bhabsi as compared to Patu since 87 percent of households in Bhabsi had adopted the same variety against 63 percent of them in Patu. The grain yield of Radha-32 was higher with better lodging resistance as compared to local varieties. Loktantra, another rice variety was adopted by 27 percent households in 2006 and 37 percent households in 2008 in Bhabsi. Farmers had not preferred Loktantra because of its lodging character although the straw yield was higher in their field. Adoption of Radha-4 was higher in Bhabsi as the variety was much suitable in rainfed condition of Bhabsi.

Table 5. Location wise percentage of adopting households (2008)

Varieties	Bhabsi (n=30)	Patu (n=30)	Total (n=60)
Radha 32	87	63	75
IR-55435-5	17	-	8
Loktantra	27	37	32
Radha 4	30	10	20
Hardinath-1	30	90	60

Source: On-farm survey, 2008

Seedling broadcasting was mainly adopted in lowlands of Patu where farmers had reported that there would be risk of washout the seedlings in case of heavy rainfall or flood. For weed control, integrated weed management was adopted by 50 percent farm households in Bhabsi and 13 percent in Patu. Despite the realization about the cost efficiency of herbicide use, most farmers had less affordability for purchasing the herbicide. The cropping pattern of rice with chickpea was adopted by 63 percent in Bhabsi and 50 percent in Patu. Another cropping pattern of rice with lentil was adopted by 70 percent in Bhabsi and 63 percent in Patu. Introduction of pulses in the farming system increased the food and nutrition to the farm households. Intercropping of rice with peanut, cowpea, and maize was adopted by 30, 20 and 37 percent, respectively in Bhabsi.

Table 6. Location wise percentage of adopting households (2008)

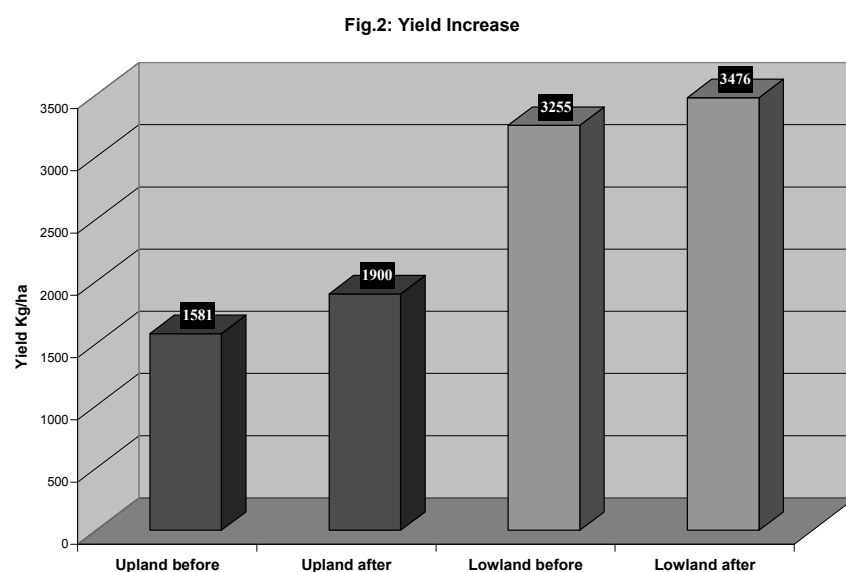
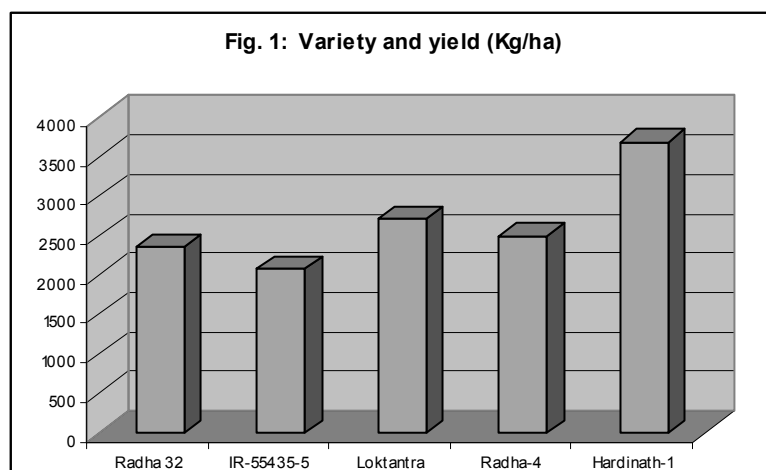
Varieties	Bhabsi (n=30)	Patu (n=30)	Total (n=60)
Seedling broadcasting	3	37	18
Herbicide use after one hand weeding	50	13	32
Rice-Chickpea	63	50	57
Rice-Lentil	70	63	67
Upland Rice+Peanut	30	3	17
Upland Rice+Cowpea	20	-	10
Upland Rice+Maize	37	-	18

Source: On-farm survey, 2008

Varietal performance in farmers' field

Among the introduced varieties, Hardinath-1 was highest grain yielder which was followed by Loktantra, Radha-4, Radha-32, and IR-55435-5 (Fig. 1). Loktantra was not preferred due to its lodging character having tall height with long duration maturity. The most preferred varieties were Radha-32 in upland condition and Hardinath-1 in low land condition. The milling recovery of both of these varieties was reported higher with good cooking quality as compared to other varieties. Another reason of farmers' preference on these varieties was less infestation of disease and pest so far they got experience.

In 2006, the average productivity of rough rice was 1581 kg/ha in upland fields of Bhabsi and 3255 kg/ha in lowland fields of Patu (Gauchan et al 2006). In 2008, it increased up to 1900 kg/ha in uplands with net increase of 319 kg/ha and 3476 kg/ha in lowlands with net increase of 221 kg/ha due to technology intervention (Fig 1). Farmers, in focus group discussion had realized and expressed satisfaction over the changes due to project work. They were also optimistic on further increase in the farm productivity of rice based cropping system with increased cash income through vegetables production.



CONCLUSION

The adoption of rice based technologies was encouraging in the project sites. Two outstanding varieties, Radha-32 and Hardinath-1 had contributed to increase in average rice productivity of the farm households. Despite the introduced varieties, the other rice based technologies had caused rice farming a cost effective and labor saving farm enterprise. The new introduced crops in rice cropping pattern had increased food and nutritional security of marginal farmers. There is a need to upscale these successful technologies in wider area with further support of R&D agencies in Nepal.

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Rice Varieties under Direct Dry Seeding: Prospect for Resource Conservation Practices

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ABSTRACT

Two separate experiments were conducted at Agronomy farm, Khumaltar to assess the performance of rice varieties in direct dry seeded condition during 2006/07 and 2007/08. Ten rice varieties namely Khumal-4, NR10488-6-3-1, NR10490-94-3-1-3, NR10491-57-2-1, NR10492-7-2-2, NR10514-14-3-2-2, NR10515-69-1, NR10353, Khumal-11 and Chinung 242 having different plant stature and grain type were included in this study. Land preparation was accomplished by Chinese hand tractor (2 passes) after wheat harvest. Rice was seeded manually on line. Weed management was done by the application of pre-emergence herbicide plus one weeding. Plant height was less than 97 cm in 2 varieties (NR 10514-3-2-2 and NR 10353). But plant height ranged from 99 cm to 129cm in rest of other varieties. Rice yield were less in the year 2007/08 compared to 2006/07. Rice yield reduction ranged from 13 percent in NR10353 to 65 percent in Khumal-11. Highest yield (5963 kg/ha) was recorded in NR10353 followed by NR 10490 -94-3-1-3, NR10492-7-2-2 (5694 kg/ha), Khumal-4 (5421 kg/ha), NR 10491-57-2-1 (5322 kg/ha) and lowest yield in Chinung 242 (3689 kg/ha). Two years data showed that few varieties yielded low in both the years. However, five varieties yielded more than 5000 kg /ha. The present study showed that most of the tested varieties performed well in direct dry seeding. But for proper weed management pre-emergence herbicide application should be followed by either weeding or post emergence herbicide.

Key words: Rice varieties, direct seeding, weed management, yield

INTRODUCTION

With the introduction of modern crop varieties, the use of inputs has been increased getting a favorable environment to many pests. Weeds are one of the important biotic factors that reduce the crop yield. Most of the modern cultivars of rice (*Oryza sativa* L.) have less ability to compete with weeds and poor adaptation ability to weeds. Due to high weed competition, the rice growers in many parts of the world became more attractive towards the herbicides. In much intensive rice growing areas of Nepal, herbicide use is increasing over time. Use of herbicide alone is not a perfect solution to eliminate the weed problem. Hence, the need of environmentally sound and economically feasible alternate weed management practice has been realizing by the researchers and growers.

Rice could be planted by different methods such as transplanting, direct seeding in wet soil, direct seeding in dry soil, minimum tilled soil, and no till soil etc (Ranjit and Suwanketnikom 2005). But transplanting is still the most popular method of rice planting throughout the country. Hence, almost all the present rice varieties were selected in transplanting environment. There is no particular rice varieties selected for direct dry and wet seeded environment. In the past research it showed that rice varieties that were selected in transplanting condition could be planted in direct dry seeded environment when weeds were managed properly (Ranjit and Suwanketnikom 2003).

Rice cultivars vary in their ability to compete with weeds. The modern high yielding rice cultivars are generally less competitive against weeds than the traditional cultivars. Some researchers have

mentioned plant height as highly correlated with weed competitive ability of rice (Jennings and Jesus 1968). The tall cultivars are generally known to be more competitive with weeds than the shorter, modern cultivars (Moody 1979, Seavers and Wright 1999). Various research teams have identified several hundred rice accessions which show indications of allelopathic compounds 60 of them showing allelopathic activity against one or more weeds (Olofsdotter et al 1995).

Research on screening the crop cultivars has been lacking under the weed competition environment in direct dry seeding in Nepal. Little focus has been made in the development of competitive crop cultivars for weed management. In most of the research system, rice cultivars are selected in the weed free situation resulting in cultivars that are less competitive against weeds. With identification of competitive rice cultivars, breeding programs could be benefited for transferring the genes into other cultivars to enhance their weed suppressing ability thereby, minimizing the reliance on herbicide use. In one study rice cultivars with coarse and fine grain, gave promising yield in direct dry seeded condition planted by Chinese Seed Drill (Ranjit 1999). Fuji (1992) has reported Nepal no. 8 rice cultivar having allelopathic potential on *Lactuca sativa*.

Besides breeding aspect, when resource conservation technologies are concerned, direct dry seeding could become an important alternate technology to transplanting with regard to less water consumption, use of minimum labors and minimum hard pan formation in soil. At that situation rice varieties and weed management will become as important as other inputs. So far sixty four rice varieties were released and registered for general cultivation for mid hills, valleys, inner terai, terai, high hills (2300 masl) and foot hills of Nepal under rainfed and irrigated situations from 1960 to 2007 (NARC 2007). But almost all the varieties were selected in transplanting environment.

As resource conservation technologies especially direct dry seeding are concerned it has been felt that there should be proper rice varieties for planting in direct dry or wet seeding condition. So, considering these things, the present study was initiated to see the performance of rice varieties under direct dry seeding in minimum tillage condition.

MATERIALS AND METHODS

Two separate experiments were conducted at Agronomy farm, Khumaltar to assess the performance of rice varieties in direct dry seeded condition during 2006/07 (2063/64) and 2007/08 (2064/65). In 2005/06 preliminary study was initiated in 10 rice varieties with two seed rates as 30 and 50 kg/ha. The mean yield attributes were presented in Table 1a. But rice varieties were modified and only 7 varieties were further included in the subsequent years 2006/07 and 2007/08.

Ten rice varieties namely Khumal-4, NR10488-6-3-1, NR10490-94-3-1-3, NR10491-57-2-1, NR10492-7-2-2, NR10514-14-3-2-2, NR10515-69-1, NR10353, Khumal-11 and Chinung 242 having different plant stature and grain type were included in this study. Land preparation was accomplished by Chinese hand tractor (2 passes) after wheat harvest. Chemical fertilizer was applied at 100:50:30 NPK kg/ha. Nitrogen was applied in 3 split dose as basal at tillering and at flowering stage. Seed rate was used at 50 kg/ha. Rice was seeded manually on line. Rice seeding was done in May 16, 2006 (2063-2-2) and May 26, 2007 (2064-2-12) in 2006/07 and 2007/08 respectively. Harvesting was started on Sep.28, 2006 (2063-6-12) and Oct. 7, 2007 (2064-6-20) in (2006/07) and 2007/08 respectively. Butachlor was sprayed as pre-emergence @ 2.5 l/ha within 3 days of seeding followed by one hand weeding. Rice thinning was done during hand weeding.

RESULTS AND DISCUSSION

Maturity

The variety NR10488-6-3-1 was 10 days earlier than Chinung 242, NR10492-7-2-2, NR10514-3-2-2 and NR10515-69-1, 20 days earlier than Khumal-4, Khumal-11, NR10490-94-3-1-3, and NR10491-57-2-1. But NR 10353 (Khumal-8) was the late matured variety in direct seeding as well as in transplanting (Table 1, Annex 1). Variety NR10488-6-3-1 matured earlier than rest of the tested varieties in the

farmer's field of Kavre Batase and Kavre Bhanjayng. So this variety was preferred by the farmers in Batase VDC, Kavre district for planting potatoes after rice (Ranjit et al 2007).

Plant height

Plant height was significantly different in both years. Two years mean highest plant height among ten different (tall and dwarf) were found in Khumal-4 variety (129 cm) and lowest plant height in variety NR 10514-3-2-2 (88 cm). Plant height of varieties Khumal -4 and NR10492-7-2-2 ranged from 125-129 cm. Plant height of varieties Chinung 242, Khumal-11, NR10515-69-1, NR10488-6-3-1, and NR10490-94-3-1-3 ranged from 104cm -117cm. But in 3 varieties namely NR10514-3-2-2, NR 1010353 and NR10491-57-2-1 plant height was less than 100 cm. Most varieties showed consistent plant height in both years Table 1.

In one of the study, most of the tall varieties performed well compared to dwarf varieties in terms of yield. Traditional variety Pokhrela masina a tall variety showed competitive ability to weeds compared to other variety (Ranjit and Suwanketnikom 2003).

Tillers/0.25m²

Tillers in both years were significantly different. Mean highest number of tillers/0.25m² were recorded in variety and NR 10490-94-3-1-3 (133) and followed by Khumal-4 (124). Lowest number of tiller was recorded in variety Chinung-242 (68). In few varieties tillers were less in 2nd year than in the 1st year (Table 1).

Seeds/panicle

Both filled and unfilled seeds /panicle were not significantly different in both the years. Mean highest filled seeds/panicle was recorded in Khumal -11 (138) and lowest (102) in NR10514-3-2-2 (Table 1).

Thousand seed weight

Thousand seed were significantly different among the varieties in both the years. Mean highest thousand seed weight 27.95g was recorded in variety NR-10514-3-2-2 followed by NR-10515-69-1 (27.6), Khumal-11 (26.55) and lowest in variety Khumal-4 (19.2gm) (Table 1).

Grain yield

In first year seed yield among the varieties were not significantly different, but in second year seed yield were found highly significant. Mean highest seed yield was recorded in variety NR-1010353 (5963 kg/ha) and followed by NR 10490-94-3-1-3 (5698 kg/ha), NR10492-7-2-2 (5694 kg/ha), Khumal-4 (5421 kg/ha) and NR10491-57-2-1 (5322 kg/ha) with lowest seed yield in variety Chinung-242 (3689 kg/ha). And four varieties yielded from 4151 - 4707 kg/ha Table-1 Low yield in the year 2007/08 might be due to weather though it is difficult to conclude. The weather data shows that there was no rain in the initial stage of crop growth in the year 2007/08. But total precipitation was higher (1053 mm) in 2007/08 than in 2006/07 (869 mm) with the variation in rainy days (Annex. 1).

CONCLUSION

Most of the varieties matured within 135-155 days except NR 10353 (Khumal-8) (168). So these varieties could be fitted in rice-wheat system. The early matured variety NR10488-6-3-1 was preferred by the farmers so this could be used in Rice –potatoes system. Rice yields were higher in the 1st year than in the 2nd year for all the varieties. It is hard to predict whether the yield reduction was due to weather pattern or something else. But the yield trend showed that there might be moisture stress during emergence due to rainfall pattern in the 2nd year. So the rice varieties in this study could be used in direct dry seeding considering proper weed management. Direct seeding could be adopted as an alternate method of rice planting. So the promising rice varieties in direct dry seeding may be used as a component of resource conservation technology in the coming days whenever necessary. Limited research has been undergoing in this aspect. So the future research should be focused in this aspect for different agro ecological environments incorporating the following components (Fig. 1).

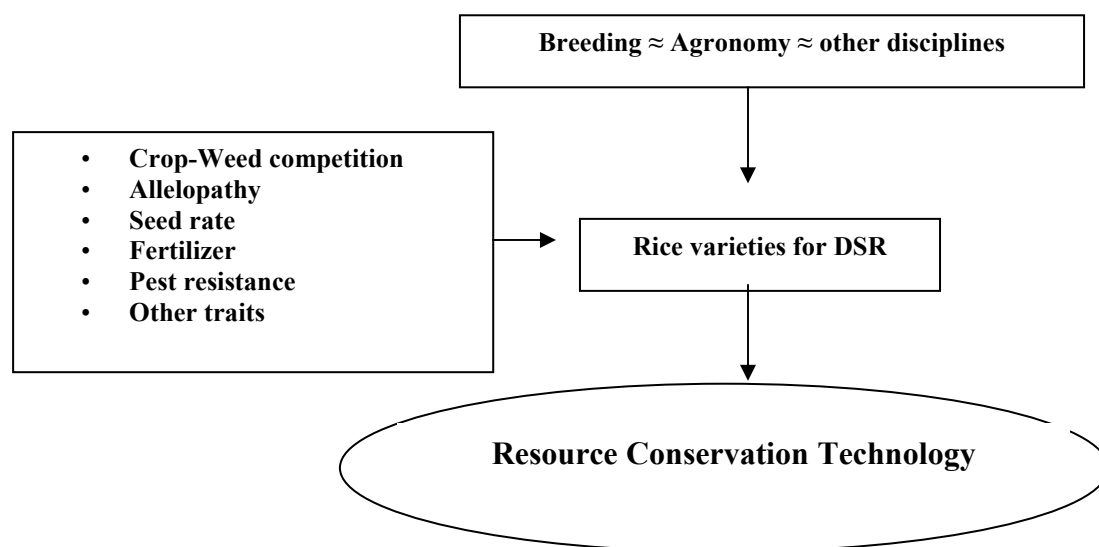


Fig. 1 Diagram showing research needs in various aspects

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Table1. Effect of direct seeding on different agronomic parameters in Rice Khumaltar, 2006/07 to 2007/08

Varieties	Plant ht.cm			Tillers/0.25 m ²			Seeds/panicle			1000 swt.gm			Yield kg/ha		
	Mean			Mean			Filled			Unfilled			Mean		
	06/07	07/08	08/07	06/07	07/08	08/07	06/07	07/08	08/07	06/07	07/08	08/07	06/07	07/08	08/07
Khumal-4	129	128	121	126	124	120	15	8	11.5	19.5	19.2	19.35	6026	4815a	5421
NR10488-6-3-1	116	106	111	92	91	139	128	133.5	15	13	20.7	21.05	5404	3345bc	4375
NR10490-94-3-1-3	114	119	117	119	146	133	131	119	125	26	21.1	21.4	6635	4761a	5698
Khumal-11	109	99	104	85	54	70	179	98	138.5	12	8	10	26.6	26.5	2195d
NR10491-57-2-1	96	101	99	104	107	106	149	108	128.5	28	21	24.5	6100	4544a	5322
NR10492-7-2-2	123	127	125	86	94	90	116	109	112.5	15	9	12	6794	4594a	5694
Chinung 242	104	103	104	64	71	68	128	132	130	13	11	12	5120	2257cd	3689
NR10514-3-2-2	86	89	88	122	72	97	115	90	102.5	16	5	10.5	6054	3359b	4707
NR10515-69-1	114	112	113	79	59	69	130	117	123.5	12	9	10.5	5325	2976bcd	4151
NR 10353 (Khumal-8)	93	96	95	116	127	122	112	111	111.5	27	21	24	6361	5565a	5963
F-Test	HS	HS	S		HS		NS	NS		NS	NS		NS	HS	HS
LSD	18	7.9	34		31		-			-			-	1094	
CV%	6.3	4.3	20		19		22	14.1		48	57		16	17	

1st year = 2006/07, 2nd year = 2007/08, swt = seed weight

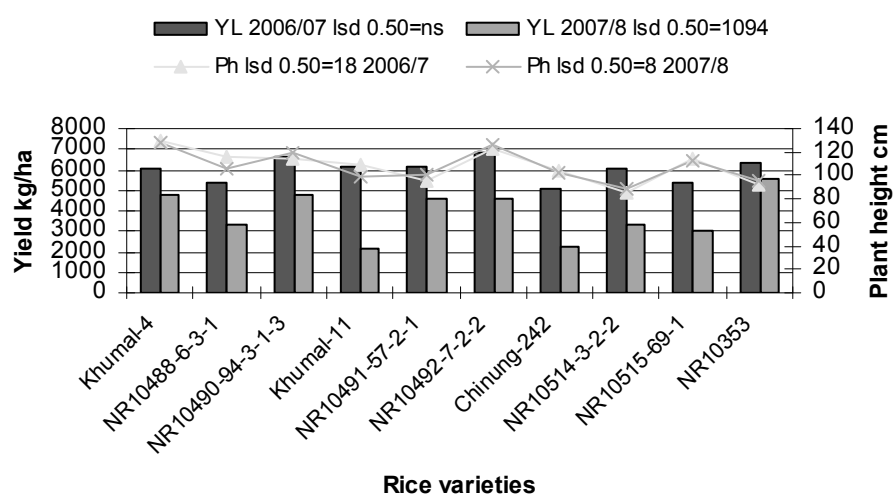
Table1.a. Effect of direct seeding in Rice varieties, Khumaltar 2005/06

Varieties	Plant height (cm)	Tillrs/0.25 m ²	1000 gwt (gm)	Yield kg/ha (14% moisture content)
Himali	69	136.5	22.7	4675.62
Khumal-4	118	146.5	17.4	5160.26
Chinung-242	100	66.5	27.4	3938.35
Khumal-11	92	83.5	27.0	4292.80
NR 10414-34	112	136.5	19.2	5092.57
NR10414-25-2	107	154.0	19.4	5351.66
NR10353	88	156.5	21.7	6452.05
NR10491-57-2-1	92	128.5	24.1	4646.76
NR10492-7-2-2	107	84.5	23.4	4474.29
NR10515-69-1	85	73.0	26.6	1067.38
IR67017-49-2-6-3	70	85.0	27.1	2056.43

Annex 1. Climatological data during the rice growing season of 2006/07 to 2007/08 at Khumaltar

Months	Maximum Temperature °C		Minimum Temperature °C		Rainfall mm	
	2006/07	2007/08	2006/07	2007/08	2006/07	2007/08
May 16-30	27.6	-	17.8	-	59.2 (7)	-
May 26-30	-	31.13	-	15.97	-	0
June	28.7	28.15	18.9	19.39	193.84 (19)	149.5(20)
July	27.97	27.24	20.28	19.65	217.2 (24)	248.1(23)
August	28.01	27.40	20.08	20.44	179.0 (22)	193.8(21)
September	26.46	26.62	18.62	19.05	186.0(16)	409.2(20)
October	25.97	25.56	13.30	14.9	32.0 (6)	39.2(4)
Nov 1-9	-	23.51	-	12.2	1.8 (1)	13.7(3)
Nov 1-15	23.73	-	10.03			
Total					869.04(95)	1053.5(91)

Numbers in bracket denotes number of rainy days



Effect of Drying and Milling on Yield of Head Rice in Paddy

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ABSTRACT

Paddy varieties were dried by three drying treatments sun, shade and oven, and milled by four mills Satake sheller with Yamamoto polisher, Otake sheller with Yamamoto polisher, commercial sheller and traditional huller. Khumal-11 had significantly higher values ($P > 0.05$) of milling recovery (73.33%) than other varieties. Out of three drying treatments, there was no significant differences in milling recovery but highest value was found in sun drying (69.13%) and lowest in oven drying (68.35%). Milling recovery was highest in Satake sheller with Yamamoto polishers and lowest in traditional huller with values of 70.57 percent and 65.18 percent, respectively. Milling recovery of traditional huller was significantly lower than other three mills, which were not significantly different to each other. Similarly, head rice percentage was highest in commercial sheller (82.33%) and lowest in traditional huller (58.29%). The highest value of head rice was found in Khumal-11 (85.41%) and lowest in NR-10353 (67.46%) representing bold and slender variety respectively. Slender varieties were not significantly different ($P > 0.05$) with each other in head rice percentage, but bold varieties were significantly different with each other and also significantly higher than slender varieties. There was significant difference in head rice percentage among drying methods and shade drying was found to be the best (78.27%) than sun and oven drying methods.

Key words: Rice milling, head rice percentage, milling recovery, milling methods

INTRODUCTION

Rice is a staple food of Nepalese people. The total cultivated land of rice is 1541729 hectare and total production is 4289827 mt (CBS, 2006). Generally the moisture content of newly harvested rice is nearly 20 percent. These grains are too wet for milling and storage. The optimum moisture content of rice is 14 percent, which is thresholds value for safe storage. For prolonged storage of grain over 6 months grain moisture should be reduced to 13 percent. The drying of rice is one of the important steps and there are number of drying methods like sun drying, electrical drying and shade drying. Sun drying is one of the most popular methods all over the world. During drying, the moisture content of the grain can be reduced more closely to the levels necessary for milling with maximum head rice recovery. The yield of head rice depends on variety, drying methods, moisture content of rice and types of mill used for milling.

Traditionally, dehulling was done by stone or abrasive disk dehullers but is now done with a rubber roll huller that minimizes damage to the surface of the brown rice. It is reported that milling actions at high pressure with low peripheral speed removes the bran layer of grains by effective friction force and cutting force of grains vigorously rubbed against the metal surface of the friction, milling unit (Satake 1990). Head rice plays key role to obtain the good price and good quality of rice. The efficiency of huller does not refer to its capacity but refers the percentage of grain actually hulled with minimum of breakage. In Engelberg type mills, dehulling and milling occur simultaneously giving a rice mill by product that is a mixture of hull, bran and polish rice (Juliano 2003). Head rice yield is usually higher for round grain japonica rice than for long- grain rice (Ruiten 1985). It is also reported that removal of the very thin grains consistently improved milling recoveries (Wadsworth and Hayes 1991). The present study mainly focused on the effect of drying and milling in the yield of head rice.

METHODOLOGY

Drying

The paddy was harvested in the month October/November (Kartik). The paddy varieties Khumal-4, NR-10353 as slender and Khumal-11 and Chainung-242 as bold were taken after threshing and winnowing from Agronomy Research Division, Khumaltar, Lalitpur. All the samples were dried in the following ways:

Sun drying: The wet paddy of different varieties was dried in the sun by spreading 2 to 3 inch thick on the jute mat. The moisture content was 12 to 13 percent in the dried paddy. The dried paddy was kept in jute bag for storage.

Shade drying: The wet paddy of different varieties was dried in the shade by spreading 1 to 2 inches thickness on the cement floor. The reduction of moisture level was very slow and taken longer time. The moisture content of dried paddy was 14 to 15 percent. The dried paddy was kept in the jute bag for storage.

Oven drying: The wet paddy of four varieties was dried in the oven at 40°C by spreading 2 to 3 inches in the tray. The moisture content of dried paddy was 13 to 14 percent. The dried paddy was kept in the jute bag for storage.

Milling

Thus, dried and stored paddy of different varieties was milled in different types of mills as given below:

Satake sheller: Rubber role huller (Lab scale) use for dehusking of paddy in the Laboratory of Food Research Unit, Khumal complex.

Otake sheller: Centrifugal huller (Lab scale) used for dehusking of paddy in the Laboratory of Food Research Unit, Khumal complex.

Commercial sheller: Rubber role huller used in community for dehusking of paddy at Lagankhel.

Traditional huller: Used for milling of paddy in community at Lagankhel.

Percentage of milling recovery, head rice and broken rice were calculated from different varieties of milled rice obtained from different mills. The head rice calculated on the basis of brown rice. The experiment was conducted as 3 Factor (variety x drying methods x milling technique). The treatments were arranged in split plot design and the data were analyzed by Statistical Software MSTATC.

RESULTS AND DISCUSSION

Table 1 presents the shelling, husk and bran percentage in slender and bold varieties of paddy. Shelling percent (brown rice) was higher in bold varieties (81%) than in slender varieties (75.4%). But husk content was higher in slender varieties (24.6%) in comparison to bold varieties (18.5%). Likewise, slender varieties gave higher amount of bran (11.17%) than the course varieties (8.8%).

Table 1. Percentages of shelling, husk and bran in slender and bold varieties of paddy

	Slender varieties	Bold varieties
Shelling % (brown rice)	75.40	81.53
Husk %	24.61	18.47
Bran %	11.70	8.78

The mean milling recovery of four varieties of paddy was 68.87 percent. The highest value was found in Khumal-11 (73.33%) and lowest in Khumal-4 (64.12%), representing bold and slender variety, respectively. There was significant difference in milling recovery of four varieties. Bold varieties had significantly higher recovery ($P > 0.05$) than slender varieties. Khumal-11 (bold) and NR 10353 (slender) had significantly higher recovery in the bold and slender variety group, respectively (Table 2).

Similarly, the mean head rice percentage of milled rice recovery of four varieties of paddy was 74.88 percent. The highest value was found in Khumal-11 (85.41%) and lowest in NR-10353 (67.46%),

representing bold and slender variety respectively. Slender varieties had significantly lower head milled percentage ($P > 0.05$) than bold varieties. Within bold varieties Khumal-11 had significantly higher values than Chainung-242 (Table 2).

Table 2. Milling analysis of different varieties of rice

Variety	Milling recovery, %	Head milled rice, %	Broken milled rice, %
Khumal -4	64.12 d	69.92 c	30.58 a
NR-10353	66.80 c	67.46 c	32.54 a
Khumal -11	73.33 a	85.41 a	14.59 c
Chainung-242	71.21 b	77.24 b	22.76 b
Mean	68.865	74.882	25.118
CV, %	4.13	7.54	22.47
SE	0.2662	2.6691	2.6691
LSD (> 0.05)	1.654	3.283	3.283

The mean milling recovery with respect to three drying treatments was 68.87%. There was no significant difference ($P > 0.05$) in milling recovery of paddy dried by different drying treatments (Table 3).

There was significant difference ($P > 0.05$) in head rice percentage among various drying methods. Shade drying had significantly higher value (78.27%) than other drying methods whereas oven drying gave lowest value (71.26%) (Table 3). The yield of head rice increases with both an increase in the number of passes and decreases in the temperature of the drying air (Araullo 1985) and shade drying improves head rice yield probably due to higher grain moisture content of the rough rice (Juliano 2003).

Table 3. Effect of drying on milling recovery, head and broken rice

Treatment	Milling recovery, %	Head milled rice, %	Broken milled rice, %
Sun drying (SD)	69.13 a	75.11 b	24.89 b
Shade drying (SHD)	69.11 a	78.27 a	21.73 c
Oven drying (OD)	68.35 a	71.26 c	28.74 a
Mean	68.865	74.882	25.118
CV, %	4.13	7.54	22.47
SE	0.5025	0.9976	0.9976
LSD (> 0.05)	1.432	2.843	2.843

With respect to the mills used for milling during experiment, milling recovery was highest in Satake sheller with Yamamoto polisher combination (70.57%) and lowest in traditional huller (65.18%). Milling recovery of traditional huller was significantly lower ($P > 0.05$) than other mills (Table 4).

With respect to the mills used for milling during experiment, head rice percentage was highest in commercial sheller (82.33%) and lowest in traditional huller (58.29%). The head rice percentage of traditional huller was significantly lower ($P > 0.05$) than other three mills. However, commercial Sheller and Satake Sheller were not significantly different but both had significantly higher value than Otake Sheller (Table 4).

Table 4. Effect of different milling techniques on milling recovery, head and broken rice

Mills	Milling recovery, %	Head milled rice, %	Broken milled rice, %
SSHYP	70.57 a	80.65 ab	19.35 bc
OSHYP	70.55 a	78.25 b	21.75 b
CSH	69.15 a	82.33 a	17.67 c
TH	65.18 b	58.29 c	41.71 a
Mean	68.865	74.882	25.118
CV, %	4.13	7.54	22.47
SE	0.5802	1.1519	1.1519
LSD (> 0.05)	1.654	3.283	3.283

SHYP, Satake sheller Yamamoto polisher. OSHYP, Otake sheller Yamamoto polisher. CSH, Commercial sheller. TH, Traditional huller.

Combine effect of variety, mills and drying methods

The highest milling recovery was found of sun-dried paddy of Khumal-11 milled in commercial sheller (77.19%) and lowest of sun-dried paddy of Khumal-4 milled in Traditional Huller (55.19%). Similarly, the mean head rice percentage of milled rice recovery of four varieties of paddy was 74.88 percent. The highest value was found in Khumal-11 dried by shade drying and milled by commercial sheller (90.11%) and lowest in Khumal-4 dried by oven drying milled by traditional huller (30.33%), representing bold and slender variety, respectively (data not presented).

CONCLUSION

Paddy varieties slender and bold dried in shade were found higher percentage of head rice milled in each mills. Hence, quality of the rice (head rice) can be improved by slow drying of paddy.

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Food Security: Contribution and Vision of Sustainable Maize Production in Nepal

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ABSTRACT

There has been a huge demand of maize for both feeds and seeds. Seed supply by the formal sectors is less than 10 percent of the total requirement. The rest demands are fulfilled by an age-old system called farmers to farmers seed flow system. Similarly, more than 40 percent of maize demand for feeds is dependant on maize, which is mainly import from India. Production of maize in Nepal could not be increased significantly only cultivating open pollinated varieties owing to their limited yield potentials. Production can only be increased growing with hybrids along with OPVs. Hybrid maize and hybrid maize technology is therefore, a new hope for the Nepalese maize farmers to improve their livelihoods through increased maize production. Malnutrition problem for the children particularly in the hills could be improved to some extent through the cultivation of Quality Protein Maize (QPM), which contains double amount of lysine and tryptophane than in normal maize. The main challenges for maize R & D Nepal are meeting the demands of maize for feed requirements and fulfilling the demand of improved seeds. To overcome the challenges, we need to promote recently released varieties; *Deuti*, *Shitala* and *Manakamana-3* in the hills through participatory varietal selection, informal research and development kits, various on farm testing and front line demonstrations. To improve the access of improved seeds to the wider areas, existing Community Based Seed Production (CBSP) groups should be strengthened through various trainings and need to replicate to the wider areas. Experiences have shown that cooperative model is found effective and appropriate model for carrying out of seed production and marketing of the seeds produced by the CBSP groups. Efforts must be focused on towards converting the CBSP groups into a cooperative so that seed production and marketing of the seeds could be done in a sustainable way. Similarly, we need to promote and popularize the QPM varieties for wider dissemination. There should be perfect isolation for the QPM seed production. Recessive genes control opaque -2 genes. If there is crossing between the QPM and non-QPM varieties, the gene will be breakdown resulting to deficient in Lysine and Tryptophane. In addition, we need to develop non-conventional hybrids for short term and conventional hybrids for the longer term.

INTRODUCTION

Maize is a wonderful and strategic crop with immense genetic diversity. It is a very important crop from food security point of view. If the maize crop fails, there will be a shortage of food leading to a severe famine particularly in the hills. Maize is cultivated in 870,401 hectares in Nepal and harvested 1,819,925 mt of maize in 2006/07 with average national productivity of 2.09 mt/ha. Maize contributes about 25.87 percent of the total food requirements in Nepal. The productivity of maize in Nepal is even quite low as compared to India and China. This low productivity could be due to both biotic and abiotic factors. At the same time, there is big yield gap between the experimental and actual crop yield at the farmers fields.

Ever increasing population is a great challenge for those who are engaged and involved in agricultural research and development in Nepal. Food security is also a major and challenge for maize research and development in Nepal. Access of food for all could only be made available when the developed productivity enhancing technologies could be disseminated to larger section of the farmers through the concerted efforts of multi-disseminating partners.

There has been an increasing demand of maize for poultry and animal feeds in the accessible areas. The present maize production has not been able to fulfill the present maize demands. Nepal requires about 1600 metric tones of feeds per day and imports more than 40 percent of its requirements from India.

This huge demand could only be met when the present productivity of maize could significantly be increased through the cultivation of maize hybrids and high yielding OPVs. This situation well justifies the urgent need of hybrid maize development in Nepal. We need to develop different kinds of hybrids for different maize production environments. Hybrid maize and hybrid maize technology would be a new hope for the Nepalese farmers to improve their livelihoods through the increased maize production. Malnutrition problem is wide spread among children and pregnant women particularly in the hills and mountain areas. This problem could partially be improved through the cultivation and promotion of Quality Protein Maize (QPM). The QPM varieties rich are rich in lysine and tryptophane amino acids. These QPM will enrich the feed as well as food quality for human consumption. National Maize Research Program (NMRP) has tested and evaluated some QPM varieties in multi- locations, which were received from CIMMYT. Some QPM genotypes have performed well in multi- location testing. Among them is S99TLWQ-HG-AB, a QPM with white kernel performed well in all evaluation and thus will release soon as the first QPM variety in the history of the QPM in Nepal.

Maize production could not be increased cultivating only with the open pollinated varieties because there is a limitation in raising the yield potentials the OPVs. In addition, the present global food crisis should be taken into consideration seriously so that possible consequences could be addressed and minimized before the situation gets into worse. Therefore, the NMRP needs to focus its efforts and set priorities on the development of conventional as well as non-conventional hybrids in order to meet the short as well as long -term demands of maize in Nepal.

Reasons for rising price of food grains

There are several reasons for rising food prices worldwide. Among the short causes are due to the extreme weather (floods, droughts) occurred in certain parts of the world, outbreaks of pests and diseases, rising energy costs, behavior of importers and exporters' speculation. Similarly, the fuel prices have gone up in the international markets, which have affected the whole chain in crop production, processing, supply, value addition and marketing of the agricultural commodities. Speculation of importers and exporters behavior has also played a negative role in rising prices of food grains.

Food is never ending demand for both human and animals. Food is always required for living. Food demand will be continuing and would never be ending. The demand will be continued as long as the human existence remains in this universe. There has always been a high pressure on the natural resources. More and more lands were brought under cultivation. Similarly, more and more water has been exploited for the cultivation of crops. More labor has been required for crop cultivation. There had been fewer investments in agricultural research and development in the past resulting to decreased worldwide grain production. Food habit has been changing worldwide. People are consuming more and more meat and meat products than cereal grains. Due to these changed habits, more and more cereal grains have been used for animal feeds. In addition, many developed and developing countries have started ethanol production using corn and other cereal grains mainly maize, wheat and soybean. A significant amount of the produced grains has been utilized for energy production.

Big yield gap in major cereal crops

There is a big yield gap between the experimental yield (5ton/ha) and the national average productivity (2.09 ton/ha) of maize in Nepal. The range of maize yield in the farm participatory research is from 4 -4.5 ton /hectare. The on farm yield seems to be realistic and attainable. The on farm participatory research has tried to narrow down the yield gap between the experimental and on farm yields. In other cereals crops, yield gap has been found to be ranged from 1-3 ton/ha. If this yield gap were brought down by 1 ton, then total maize production in Nepal would be increased by 50 percent simply through improving management practices (application of chemical fertilization and maintaining of recommended plant populations). Similarly, there is 700 kg of yield difference between the improved and the local maize varieties. Maize production could be increased to 609280 metric ton by replacing the local seeds with the improved seeds only. This increased maize production would be about 33.47 percent of the total maize production. The statistic indicates that the present seed replacement rate of maize in Nepal is about 6 percent (991 metric tons). The informal seed sectors fulfill the rest demands. If we keep our seed

replacement target is 25 percent per year, then we need to produce about 4037 metric tons of the improved seeds. For this, we need to produce 30 tons of foundation seeds and 450 kg of breeder seeds. Maize area reported under improved maize seeds is about 86 percent. If this is the case, then the annual total seed production must be at least 5000 metric tons per year. The present seed production statistics shows that about 991 metric tons of seed has been produced in formal sector in 200/07. Seed production program is to be implemented in 2500 hectares in order to produce 5000 metric tons of the improved seeds, which is about 0.13 percent of the total maize areas. National maize Research program with the present facility and man-power can easily produce and supply the source maize seeds of the above-mentioned quantities simply with minimal additional resources in seed production.

Contribution of maize in food security

The contribution of agricultural sector to the GDP is 33.06% in Nepal. Maize contributes about 3.15 percent in the national GDP and 9.5 percent in AGDP. Maize has also contributed about 25.87 percent of the total food requirements in Nepal. During the past 23 years (1984-2007), maize area has been increased by 50 percent and production by 121 percent in the same period. Similarly, the productivity of maize is increased by 29.3 kg/ha/year. The edible cereal requirement in Nepal is 196 kg/person/year but the *current* distribution rate of consumption is 182 kg/person/year with a deficit of 14 kg/person/year. Of the total maize production in Nepal, about 79 percent of maize is produced in high and mid hills where as terai produces about 21percent in Nepal. Maize is a means of livelihood for more than 14.5 million people in the hills.

MAIZE BREEDING STRATEGIES AND APPROACHES

National Maize Research Program follows the guiding principles and priorities as set in the Three-year Interim Plan (TYIP) of the Government of Nepal, Agricultural Perspective Plan (APP), and twenty-year NARC vision paper for developing and implementing the demand driven research projects. One strategy will not be effective for each production environment in Nepal. Nepal has very high climatic micro-variations. Therefore, one breeding strategy will not work in a country like Nepal where you will find micro- environmental variations within the small areas. There should be a separate breeding strategy and approach for high, mid hills and for terai commercial environments. Maize uses and utilizations are not the same in all production environments. Maize cultivation in terai is commercial where as it is subsistence and traditional in the mid and high hills. More than 85 percent of maize produced in the hills is used for human consumption. Therefore, we must have a separate breeding strategy, approach and implement accordingly.

Mid and high hills

Maize cultivation is subsistence traditional in the high and mid hills. Maize cultivation is also marginalized in these hills. Major portion of maize production has been used for human consumption. Limited portion of maize production goes to animal feeds and other uses. Following will be the breeding strategy for the mid and high hills. The strategy should be adopted and need to be implemented accordingly.

Development of open pollinated varieties for the hills

National Maize Research Program must focus its efforts on developing full season normal maize varieties for hill production environments. Development of early maturing with white and yellow grain types is also essential in these regions. We need to consider the preferences of the farmers' preferences and it must be addressed while developing the varieties. Maize with white varieties is preferred in the mid and far western hills. This is simply because their food habits of eating Roti (chapatti), prepared from wheat and maize. There is high demand of early maturing maize varieties compared to the full season varieties. Monsoon starts late in these regions and thus planting becomes late compared to western and eastern hills. However, full season maize varieties are equally important and are in demand in these hills.

Development of QPM OPVs for mid hills

Development of Quality Protein Maize (QPM) in Nepal has been considered as one of the important breeding activity both from nutritional and food security point of view. There has been a severe malnutrition problem in children and pregnant women in Nepal and in the mid and high hills in particular. QPM contains double amount of lysine and tryptophane amino acids than in normal maize. This problem could be partially solved with the cultivation of QPM varieties. NMRP has been involved in testing and evaluation of CIMMYT developed QPM varieties since 1999 for different production environments. Four QPM genotypes; S99TLWQ-HG-AB, S01SIWQ-2, S01SIWQ-3, and S99TLYQ-B have been found promising from multi- location testing. The yield potential of these QPM genotypes is ranged from 5 to 6 ton/hectare, which is at par with the high yielding normal OPVs. In addition of high yield potential and high nutritional quality, the promising QPM genotypes have stay green character, which is farmer's preferred trait particularly in Nepal. Livestock is an integral part of Nepalese agricultural farming in Nepal. Farmers could not ignore the fodder aspect of the crops. Farmers will be benefited from the cultivation of the in three different aspects. Farmers will get equal or more grain yield than the normal maize from growing the QPM. There is double amount of lysine and tryptophane than in the normal maize and thus will have improved nutritional quality. Farmers will fulfill the fodder requirements with the QPM. QPM thus will have multiple benefits for farmers. Realizing this, National maize research program has prepared and submitted a proposal for a white kernel QPM genotype, S99TLWQ-HG-AB to the National Seed Board (NSB) for release. This proposed QPM will soon be released for cultivation in the mid hills.

Development of hybrids for mid hills

Maize production in the hills could not be increased only with the cultivation of open pollinated varieties (OPVs). There is certainly a limitation for increasing yield in the OPVs. To increase the maize production in the hill, we must go for hybrids even in the hills also. For the accessible areas, we need to develop a non-conventional hybrids; one of the parents will be an inbred line. Seeds become cheaper and affordable even for a poor farmer. Poor farmers can buy hybrid seeds of non- conventional hybrids. Farmer can grow these hybrids even for 2-3 years without seed replacement. They need not to change the seeds every year. Research findings have shown that there will be no significant yield reduction in case of top crosses hybrids. This is the best available option for us for increasing maize yield in the hills. We must utilize this option for the farmers. We can even go for conventional hybrids in the accessible areas where delivery services are relatively easy as compared to the remote areas from where maize grains produced could easily be transported to different places.

Terai and inner terai regions

Major thrust of the NMRP must on the development of hybrids for terai and inner terai production environments where maize has been cultivated commercially since two decades. Poultry enterprises and feed industries are mainly located in Terai and in the accessible. Farmers have been cultivating hybrids in Terai since many years. Many agro-vets and seed traders based in Terai and other parts of country are trading hybrid seeds in Nepal. These traders bring hybrid seeds into Nepal from India. Indian hybrid seed companies develop these hybrids. In case of Nepal, NMRP developed and released a first maize hybrid named "Gaurav" in 2003 for terai and inner terai production environments. Parents of this hybrid were given to one of the private seed company in Nepal. This private seed company could not produce seeds successfully and thus hybrid seeds could not make available to the hybrid maize growers hybrid. There is nicking problem with the parents of this hybrid. This problem could be overcome by the arrangement of planting dates.

In this context, we have to create more varietal option for maize hybrids for the commercial farmers. For this, we need to develop a separate breeding strategy for different production environments. Following will be a breeding strategy for terai environments.

Development of open pollinated varieties for terai and inner terai

Open pollinated varieties (OPVs) are also required for the farmers of Terai and Inner Terai regions despite the high demand for hybrids. Hybrids are mainly grown in the areas during the winter season where there is assured irrigation. OPVs are cultivated in rainfed condition. Development of OPVs for terai should be continued. Development of composites, synthetics and QPM OPVs are part of regular breeding activities of the National maize research program. NMRP developed genotypes and genotypes received from CIMMYT have been evaluating regularly in multi-locations across the terai environments. Yellow varieties are more preferred and are in high demand these regions. Poultry industries prefer yellow maize because of β carotene found in yellow maize. Similarly, yellow QPM varieties, which contain double amount of Lysine and Tryptophane amino acids than in normal maize, are required for the feed industries. Research results have shown that these two amino acids had significant effects on the growth rate of piglets than the feeds prepared non-QPM varieties. Considering this fact, popularization and promotion of QPM varieties are essential to the commercial areas for increasing the production of QPM maize.

Development of hybrids for terai and inner terai regions

As stated above, farmers in some Terai districts are growing maize hybrids since many years. Farmers purchase the seeds of Indian hybrids from agro-vets and seed companies. Sarlahi, Jhapa, Morang, Bara, Parsa, Chitwan, Nawalparasi, and Sunsari in terai and Kavre in the mid hills are the major hybrid maize growing districts. Statistics showed that area under hybrids was more in Kavre district in 2006/07. The highest average on farm productivity of hybrid was 3.3t/ha in Sarlahi among the hybrid growing districts. In 2007, different seed companies and agro-vets have marketed about 575 metric ton of hybrid seeds into Nepal. The estimated worth of these seeds was about NRs, 8.6 million, which is 3.59 percent of the total maize seed requirement in Nepal. Similarly, Nepal imports maize about NRs, 3.3 billion worth maize from India for poultry feeds. More than 40 percent of the maize demand for poultry feeds is imported from India. This scenario clearly indicates that there are big challenges ahead for meeting the demands of maize for feeds and seeds in Nepal. We have to reduce the dependency of maize on India by increasing production and productivity of maize in Nepal through effective implementation of production and productivity enhancing technologies.

Development of open pollinated varieties

Some of the open pollinated varieties are very popular in terai production environments. Rampur composite, a full season variety and Arun-2, an early maturing variety are still in cultivation in larger areas. Their seeds are in high demand. Farmers prefer these two varieties due to high yielding, earliness and attractive grain color. Farmers grow these varieties in the areas where there is no assured irrigation. Therefore, NMRP has been focusing its effort in developing composite, synthetics and QPM OPVs. Breeding of composites, synthetics and QPM should be continued for terai environments. Farmers preferred well adapted traits from the local landraces should be incorporated while developing these varieties.

Development of non-conventional hybrids

Hybrid oriented breeding program is ongoing at NMRP, Rampur, Chitwan with the objective of developing high yielding hybrids with yield potential of more than Indian hybrids or at par yields. Hybrid research program must be systematic and strong so that a high yielding hybrids suitable for different environments could be developed and release in a regular basis. There should be a separate hybrid research program for terai regions. Non-conventional hybrids are required in the areas where maize is grown for subsistence farming. The benefits of growing non-conventional hybrids are that seeds could be grown for 2-3 years without replacing seeds and seeds are cheaper due to involvement of non-inbred seed parent in top cross hybrids. Seed production is easy and line and more seed is produced in this case. Thus, seeds of top cross hybrids are cheaper and affordable even to the poor farmers. Development of top cross hybrids would be better off in the initial phases of hybrid development. These hybrids could be developed relatively in a shorter period of time rather than taking a long time (6-8 or more years) for developing conventional hybrids. This strategy for hybrid development would be better option in the countries where seed companies are not well developed and input delivery systems are not effective and

accessible. Keeping this into consideration, NMRP has started non-conventional hybrid research program at Rampur and its collaborating stations (ABD, Khumaltar; ARS, Belachapi; and RARS, Parwanipur). A number of top cross hybrids are being tested and evaluated at different breeding and testing stages. The yield potential of some forms of non-conventional hybrids could reach to the equal yield of three way or double cross hybrids. According to the experimental results of the top cross hybrids tested at CIMMYT showed the yield range of top cross hybrids was ranged from 7.60 - 8.30 kg/ha. Similarly, the yield was ranged from 7.20-7.80 in double top cross hybrids. This indicates that the yield of double top cross hybrids had relatively more stable than top cross hybrids. Double top cross maize hybrids are still popular in China and India. Philippines is still cultivating some varietal cross hybrids. Maize produced from these non- conventional hybrids could be utilized for human consumption and animal feeds.

Development of conventional hybrids

In the commercial maize growing areas, conventional hybrids are more suitable than the non-conventional hybrids. The yield is stable in case of conventional hybrids and relatively less stable in non-conventional hybrids. NMRP should thus focus its efforts on developing conventional hybrids for increasing the production of maize in the long run. Farmers should have varietal options between early and intermediate maturing hybrids. QPM hybrids are also needed to bring significant changes piggy enterprises for pig meat production. Similarly, there is also a high demand of hybrids with fodder types. NMRP has started its hybrid-breeding program in 1987 but the activities could not be continued due to some technical problems. The systematic hybrid research work started again in 1999 with the implementation of Hill Maize Research Project funded through SDC funds. Inbred lines were obtained from the CIMMYT and hybrids were developed from these inbred lines. These hybrids were evaluated in multi- locations. As a result, National Seed Board (NSB) had released a maize hybrid named “Gaurav” for the first time in Nepal for commercial maize growing areas. The yield potential of this variety is about 9 ton/ha, which is comparable with yield of hybrids developed in other countries.

Development of hybrids for specialty purposes (QPM & high oil content)

Hybrids suitable for fodder and other specialty purposes are essential for terai production environments. Dairy industries are also located in terai and in accessible areas. Farmers need fodder type of hybrids for animals. There is demand of hybrids and OPVs with stay green for animal fodders. In addition, we need to focus on developing QPM hybrids and OPVs, baby corn, sweet and waxy corn for different purposes.

THE WAY FORWARD

There are mainly two challenges for maize research and development in Nepal. One is to meet the demands of maize for feed requirements and another is to fulfil the demand of improved seeds. We need to promote and popularize recently released varieties; Deuti, Shitala and Manakamana-3 in the hills through enhanced participatory varietal selection, informal research and development kits, various on farm testing and front line demonstrations. This could be achieved through the effective dissemination of these recently released varieties by the disseminating partners. To improve the access of improved seeds to the wider areas, existing CBSP groups should be strengthened through various trainings and need to replicate to the wider areas. Experiences have shown that cooperative model is seen effective and appropriate for carrying out of seed production and marketing of the seeds produced by the CBSP groups. Efforts should be focused towards converting the CBSP groups into a cooperative so that seed production and marketing of the seeds could be done in a sustainable manner.

Similarly, we need to promote and popularize the QPM varieties for wider dissemination. Seed production of the QPM could be done from the selected farmers. Skilled farmers are needed for QPM seed production. There should be perfect isolation for the QPM seed production. Opaque -2 genes are controlled by recessive genes. If there is crossing between the QPM and non-QPM varieties, the gene will be breakdown resulting to deficient in Lysine and Tryptophane. In open pollinated varieties, every generation is segregating generation and seeds produced in each season should be analyzed for Lysine and Tryptophane content. In addition, we need to develop non-conventional hybrids for short term and conventional hybrids for the longer term.

Maize breeding scheme

Exotic germplasm will be introduced from different International maize research and development mainly from the CIMMYT. Landraces will be collected from different maize production environments. The collected landraces along with the exotic materials will be evaluated in multi- locations. Superior germplasm will be characterized based on quantitative and qualitative traits. These germplasm will also be characterized based on the molecular analysis. Heterotic groups will be formed based on both SCA effects for grain yield and molecular analysis. Inbred lines will be developed from these heterotic groups. Inbred lines will be evaluated for adaptability, seed yield, disease, insect, and other traits of interest. Hybrids developed using these inbred lines will be evaluated in multi-locations. Best hybrids will be released for commercial cultivation. Combining ability of the inbred lines will be studied. Inbred lines with high GCA will be used for making composite and synthetic varieties. Similarly, inbred lines with high SCA will be synthesized for making synthetic varieties. Similarly, inbred lines with high SCA will be used as parents for developing hybrids. For systematic development and evaluation of inbred lines, we must have a very strong population improvement program. In this approach, two populations are improved simultaneously in a systematic way. This program will be a continuous process for the development of products based on the needs of the farmers.

National priorities

Following table presents vital programs needed for productivity enhancement of maize

Program	Production domain	Short to medium term objectives	Medium to long term objectives	Continuing objectives
Productivity enhancement	I. High and mid hills	Developing high yielding composites and synthetics of early and full season varieties tolerant to biotic and abiotic stresses Agronomic research including maize based cropping systems Seed technology research including identification of suitable areas for seed production Plant protection research on evaluation of breeding materials against major disease and insect resistance/ tolerance Integrated management of disease and insect management for stable productivity of maize	Non-conventional to conventional hybrid development Incorporation of drought tolerant genes through biotechnology Biotechnological research on incorporation of resistance genes against biotic stresses	Popularization of new available cultivars Germplasm evaluation and characterization with increasing evaluation on rainfed conditions Maintenance breeding
	Terai and inner terai production environments	Development of OPVs and hybrids Development of hybrids for industrial uses Seed technology research	Development of diverse type of hybrids	Popularization of new hybrids Germplasm evaluation and characterization particularly biotic stresses
Production enhancement	For all maize production environments	Development of crop production technology with emphasis on cost reducing input efficient and resource Cultivar development for popcorn, sweet corn, baby corn, starch. oil etc diversified maize industrial products	Expanding winter maize cultivation	Sustainability of maize production and maize based cropping system

CONCLUSION

Productivity of maize can be enhanced through the development and cultivation of non-conventional and conventional hybrids. The productivity of inbred line must be with the tune of 2-3 tones /ha with viable seed production potential for a diversity of single cross hybrids. There is need to develop maize hybrids and OPVs suitable for different purposes in order to make maize farming more attractive and remunerative for reducing dependency corn oil and corn based products. There is also need to develop germplasm against biotic and abiotic stresses. Research on seed technology, seed production and seed processing is essential for assured seed production and seed supply

We have to meet two challenges in maize research and development in Nepal. The first challenge is to meet the demand of maize for feeds. This problem could be minimized by promoting hybrids in irrigated conditions and in the accessible areas. We need to promote winter maize cultivation in terai and inner terai regions. Doing this will reduce the dependency on importing maize from India. The demand for improved seeds could be met by promoting and popularizing the recently released maize varieties (Deuti, Shitala, and Manakamana-3) and Population 45C10, a pipeline variety for seed production under community based maize seed production programs in the mid hills for assured seed production and marketing. This will increase the access of improved seeds to the farmers at the community level and eventually ensure the food security in the country. For the sustainability of the CBSP, all the existing CBSP groups should be strengthened through various trainings and need to replicate to the wider areas. Experiences have shown that cooperative model is seen an effective and appropriate model for carrying out of seed production and marketing of the seeds produced by the CBSP groups. Efforts should be focused towards converting the CBSP groups into a cooperative so that seed production and seed marketing could be done in a sustainable manner.

Similarly, we need to promote and popularize the QPM varieties for wider dissemination. This will improve the nutritional security particularly in the hills. We need to develop OPVs and QPM hybrids for both human and animals. In addition, non-conventional hybrids are required for meeting the short-term demands and conventional hybrids for the longer-term demands.

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Varietal Study on Quality Protein Maize in the Eastern Hills of Nepal

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ABSTRACT

Maize is an important cereal crop of Nepal and is rich source of protein for resource poor farmers in the hills. It is also equally important for poultry and animals using as a major constituent in the feed. The International Maize and Wheat Research Center (CIMMYT) developed Quality Protein Maize (QPM) that holds almost two folds of lysine and triptophan essential aminoacid for protein synthesis. QPM is extensively adapted in other countries where as in Nepal it is newly introduced maize. Agriculture Research Station (ARS) Pakharibas carried out Coordinated Varietal Trials (CVT) on QPM in 2005 and 2006 in normal season in collaboration with NMRP and CIMMYT Nepal at 1470 masl to evaluate and identify high yield potential QPM genotypes suitable to bari land of mid and lower hills. Experiments were laid out in RCB design in three replications. Eight varieties including local were common in both years. The genotypes S99TLWHG"AB", SOISIWQ-3 and S99TLYQ-B in 2005 whereas S99TLYQ-B, S99TLYQ-AB, SOISIWQ-2 and Rampur SO3FQ0₂ in 2006 produced significantly higher grain yield than local variety, however, similar to nationwide popular variety Manakamana-3 and found superior to the rest genotypes in individual year analysis. In over year analysis among common entries S99TLWHG "AB" and S99TLYQ-B found promising with respect to grain yield and other phenotypic traits.

INTRODUCTION

Maize is one of main cereal crop and staple food for the resource poor hill farmers. Almost 55 percent of total population use maize in their daily diets. With high content of carbohydrate, fats, proteins, some of important vitamins and minerals, maize is reputed as a poor man's nutricereal crop (Prasamanna et al 2001). From human and monogastric nutrition point view lysine and tryptophan are most limiting aminoacids. For animal it could be made by supplementing grain with essential aminoacids produced by bacterial fermentation in feed. This process is, however, very expensive and the same time loss of protein could not be ignored during processing in feed plants but for human nutritional diet maize is limiting source for lysine and tryptophan. Protein content in the maize is higher than rice and wheat, however, protein obtained from maize in the diet is far below than body requirement and people don't have much access to meat and fruits due to poverty and expensiveness of aforementioned food materials. Maize is extensively used as main constituent in feed industries to supply protein like lysine and triptophan for poultry and animals. Evangelina Villegas and her team developed QPM at CIMMYT in Mid 1980 that looks and tastes like normal maize, produce equal or higher grain yield and shows similar resistance to diseases, pests and other factors (Cordova and Listman 2001). They stated that QPM contains about 70-100 percent more lysine and tryptophan essential aminoacids for protein synthesis in human and monogastric animals. Carlous (2004) has also pointed out that QPM has nearly double lysine and triptophan content than normal maize. Opaque 2 gene is responsible for protein in Quality Protein Maize (QPM) and it is recessive in nature. National Maize Research Program (NMRP) has released 17 OPVs and one hybrid maize variety but did not come up with any QPM variety because of newly introduced crop. Varietal selection works for QPM are in progress at different stations including NMRP. ARS Pakharibas also involved in QPM varietal development works under close collaboration with CIMMYT and NMRP to identify suitable QPM variety for general cultivation.

MATERIALS AND METHODS

Coordinated varietal trials on QPM were composed of 11 entries in 2005 and 12 entries in 2006. Trials were laid out in RCB design with three replications in both years and planted on April 29, in 2005 and April 24 in 2006 in a plot size of 4 rows of 3 meter length (3mx3m). The trials were conducted at South Farm at 1470 masl. Fertilizer was applied @ 120:60:40 $\text{NP}_2\text{O}_5\text{K}_2\text{O}$ where half dose of nitrogen and full dose of P_2O_5 and K_2O were used as basal and the rest half dose as top dressing during 2nd weeding at knee high stage in both cases. In addition to chemical fertilizer compost @ 15 ton/ ha was also applied uniformly prior to final land preparation and Malathion dust @ 20 kg/ha applied to protect sown seed and germinating plants from the soil insects. Total eight genotypes were common in both years. Observed data were analyzed by Genstat software.

RESULTS AND DISCUSSION

Grain yield

Entries of CVT evaluated in 2005 and 2006 were found significantly different ($P<0.01$) in grain yield. Genotypes S99 TLWQ-HG-AB, S01 SIWQ-3, and S99 SIWQ-B were evaluated at par with Mankamana-3, Population 44C10 and Population 45C10 in grain yield and they produced significantly higher grain yield than local check and the grain yield of the rest varieties found below than grand mean 3,933 kg/ha. The lower grain yield was due to higher number of barren plants and less number of ear at harvest per plot in the respective entries (Table 1).

Genotypes S99TLYQ-AB (6231 kg/ha), S99TLYQ-B (6226 kg/ha) and SOISIWQ-2 (6215 kg/ha) produced significantly higher grain yield than local variety (5205 kg/ha) however, found at par with std variety Deuti (6602 kg/ha), RamSO₃FQO₄ (6120 kg/ha), SOOTLYQ-B(6011 kg/ha) and S99TLWQHGHG"AB" (5956 kg/ha) in 2006 (Table 2).

Over year analysis of common varieties showed significantly ($P<0.05$) differences among treatments in grain yield. Genotypes S99TLWHG"AB" and (4911 kg/ha), SOISIWQ-2 (4944 kg/ha) produced significantly higher grain yield than local variety (3667 kg/ha) however they were not different from check (Table 3). Check variety (5881 kg/ha) produced the highest yield followed by S99TLWHG"AB" (5527 kg/ha) and their grain yields evaluated significantly higher than Celaya S91SIWQ, Corralego S99SIWQ and SOISIWQ and at par with S99TLYQ-B, SOISIWQ-2 (Sah et al 2006).

Ear and plant height

Local check was significantly ($P<0.01$) taller than Manakamna 3 and this was taller than other tested entries in ear height except S99TLYQ-B, Pop 44C10, and S99 TLWQ-HG-AB. Similarly Manakamna-3 was at par with local, Population 44C10, Pop 45C10 and S99TLWQHGHG-AB and significantly taller than the rest of others in plant height in 2005. S99TLWQHGHG-AB and SOISIWQ hold the ears in the mid portion of plants.

Local check was measured significantly taller than all other genotypes both in ear and plant height. Standard variety Deuti was measured same as SOOTLYQ-B, S99TLYQ-AB and Rampur composite both in ear height and plant height however, found alike RamSO₃FQO₄, S99TLYQ-B and Celaya S91SIWQ in ear height only in 2006. Corralego S99SIWQ was shortest in ear height followed by SOISIWQ-2 and vice versa in plant height and their ear palacement were lower than mid portion of plant whereas S99TLYQ-B, SOOTLYQ-B and S99TLYQ-AB had ears above mid portion of plants and S99TLWQHGHG"AB ", Ram SO₃FQO₄, Celaya S91SIWQ bore ears almost in the centre of plants.

Both ear height and plant height showed significance differences ($P<0.01$) among entries and in combined year analysis. Local check was measured significantly taller than all other tested entries in both ear height and plant height. Standard check was recorded statistically same as S99TLWHG"AB" both in ear height and plant height where as similar to S99TLYQ-B in ear height only. S99TLWHG"AB" and SOISIWQ had ears almost in the mid portion of the plants whereas S99TLYQ-B had little above the mid portion like Manakamna 3 (Table 1). Other entries were having ears below mid portion except local.

Tasselling and silking days

Standard variety Mankamana-3 was similar to local check, Pop 44C10, S01SIWQ-3 and S99TLWQ-HG-AB in silking and tasseling days. Corralejo S99SIWQ was the earliest in silking (80 days) and tasseling (75 days) followed by Celaya S91SIWQ (81 days silking and 75 days tasseling), however, their grain yield was below than the average (3933kg/ha) in 2005 (Table 1).

Analysis of variance showed highly significance in silking days in 2006, however, there was no much difference in many varieties. Deuti was late (76 day) in silking among all varieties followed by S99TLWQ-HG-AB (73 day) and RamSO₃FO₂ (73 day) equally in 2006 (Table 2). In over year analysis also Corralejo S99SIWQ (75 day) and Celaya S91SIWQ (76 day) were earlier in silking. Check variety was late among all other tested varieties and the rest entries were same as local check.

Disease rating

All entries were infested by Turcicum leaf blight (TLB) and banded leaf sheath blight (BLSB) in 2005. Infestation of TLB was higher than of BLSB in both years. Infection range was 3-4.5 for TLB, where maximum (4.5) was recorded in Collarejo and minimum (3) in S99TLWQ-HG-AB and in Pop 44C10.

Ear aspect, plant aspect and husk cover

S99TLWQ-HG-AB, SOISIWQ-3 and Manakamana-3 found superior with regard to ear aspect, plant aspect and husk cover rating in between 2-3 in comparison of others whereas S99TLYQ-B was rated medium in all three traits in (Table 1). S99TLYQ-B was evaluated better in ear aspect husk cover and medium in plant aspect. SOOTLYQ-B and S99TLYQ-AB were observed better with respect to ear aspect and medium in husk cover and plant aspect. Whereas, RamSO₃FO₂, SOISIWQ-2 and S99TLWQ-HG-AB were medium in all three traits SOISIWQ medium with regard to ear aspect and good in husk cover and Corralejo S99SIWQ was poor in plant and ear aspect (Table 2).

Barren plants, root lodging and shoot lodging

S99TLYQ-B and SOISIWQ-3 showed superiority in root lodging shoot lodging and barren plants per unit area, S99TLWQ-HG-AB was also observed better but having more barren plants per unit area. Variety Manakamana-3 was used as standard check in 2005 and Deuti in 2006 and they were evaluated better than any tested genotypes. S99TLYQ-B, S99TLYQ-AB, SOISIWQ-2, Ram SO₃FO₂ S99TLWQ-HG-AB and SOISIWQ-3 produced higher grain yield than local and found at par with standard check varieties in grain yield. In over year analysis as explained earlier S99TLWQ-HG-AB was good yield potential genotype and evaluated better with regard to ear aspect, plant aspect and husk cover like standard check in both years (Table 3). This genotype was identified not taller like standard check both in ear height and plant height and hold the ear in the mid portion of plant. As a result it is less prone to shoot lodging in comparison to other tested genotypes and also found tolerant to BLSB on the basis of score 1.8 in 1-5 scale. Katuwal (2006) recognized SOISIWQ 3, S99TLYQ B and S99TLWQ HG"AB" promising genotypes in his study of mother baby trials. Similar results were also obtained by Dhakal et al (2006) and Paudel (2006). Prasad (2006) recommended S99TLWQ HG "AB" for CFFT due to its high grain yield potentiality and resistant to TLB.

Open pollinated QPM and non-QPM tested varieties did not produce so far significantly higher grain yield than Mankamana-3 for the last 4 years across the country on the basis of results of trials conducted at different stations. Results showed that variety S99TLWQ HG "AB" is at par with Manakamana-3 and Deuti in many agronomical traits, however, as it is QPM maize its nutritional importance is almost doubled than normal maize because of holding more than two fold lysine and triptophan that are important for human beings and animals. Therefore, this genotype should be brought in the process of release on the basis of superior traits in comparison to other QPM varieties.

CONCLUSION

S99TLWQ-HG-AB, S0ISIWQ 3, S99TLYQ-AB, S99TLYQ-B and S0ISIWQ 2 performed better in individual year whereas S99TLWQ-HG-AB, S99TLYQ-B and S0ISIWQ 2 were identified promising concerning with grain yield, silking days, plant aspect, ear aspect and husk cover in over year analysis.

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Table 1. Summary sheet of the traits recorded in maize CVT QPM - 2005

Entry name	Tasseling days	Silking days	Ear height (cm)	Plant height (cm)	Grain yield kg/ha	Ear aspect (1-5)	Plant aspect (1-5)	Husk cover (1-5)	Harvested ears/ha	Harvested plant /ha	Root lodging plant/ha	Shoot lodging plant/ha	Barren plant/ha
S99TLYQ-B	80	87	109	199	4183	2.50	3.00	3.00	46667	51111	741	370	1852
S99TLWQ-HG-AB	81	88	102	208	5097	2.50	2.33	2.67	45556	50741	741	370	4444
Celaya S91 SIWQ	75	81	87	193	3577	3.33	3.67	3.50	48148	52222	741	3333	3333
Corralejo S99 SIWQ	75	80	72	164	2930	4.00	4.33	3.00	34444	48148	1481	1852	7037
S01SIWQ-2	77	84	70	173	3673	3.17	3.67	2.67	43704	52222	0	741	5556
S01SIWQ-3	81	88	93	201	4678	2.67	2.67	2.33	50370	53333	1111	741	2963
S01SIYQ	79	86	93	183	3224	3.17	3.33	3.17	38889	47407	1111	1481	5926
Pop45C10	76	82	93	209	4094	3.33	4.00	3.33	44815	51481	1111	1111	2222
Pop44C10	81	87	102	210	4499	2.50	3.33	3.33	40370	51481	1111	741	8519
Manakamana-3	83	90	118	225	5161	2.50	2.67	2.00	49259	52963	741	1852	4444
Local check	75	89	140	242	2148	3.17	3.67	2.33	26296	41111	3333	10370	14444
Grand mean	78	85	98	201	3933	2.99	3.33	2.85	42593	50202	1111	2088	5522
F test	**	**	**	**	*	**	*	ns	**	*	ns	**	ns
LSD	2.47	2.89	17.13	23.31	1527	0.53	1.06	0.98	10477	6838	3734	2996	7572
CV%	1.9	2.0	10.3	6.8	22.8	10.4	18.7	20.1	14.4	8.0	197.3	84.3	80.5

**= highly significant at 01. *= %

Table 2. Summary sheet of the traits recorded in CVT on QPM - 2006

Entry name	Tassel (days)	Silking (days)	Ear ht (cm)	Plant ht(cm)	Gr yld (kg/Ha)	Ear asp (1-5)	Plant asp (1-5)	Husk cov (1-5)	TLB (1-5)	SB (1-5)	Har ears/ha	Root lodg plants/ha	Shoot lod plant/ha
S00TLYQ-B	69	72	144	270	6011	1.83	3.17	2.67	3.00	2.50	50370	741	1852
S99TLYQ-AB	68	72	145	269	6231	2.00	2.67	2.67	2.50	2.17	50741	370	1111
RamS 03 FQ 02	68	73	135	263	6120	2.67	2.83	2.67	3.00	2.67	44815	2222	1852
S99TLYQ-B	69	72	143	260	6226	1.83	3.00	2.00	3.33	2.33	49630	2222	1481
S99 TLWQ-HG-AB	69	73	143	277	5956	2.83	2.67	3.00	3.00	1.83	45556	4074	1111
CorralejoS99 SIWQ	66	69	108	244	4781	3.83	4.00	2.83	4.00	2.33	48889	2963	4444
CelayaS91 SIWQ	68	71	132	259	4763	3.83	3.33	2.50	3.67	2.83	44074	3333	5556
S01SIYQ	67	70	126	256	5544	3.00	3.56	1.83	4.00	3.00	50370	2222	1111
S01SIWQ-2	69	72	113	239	6215	2.83	2.83	2.67	3.00	1.83	50370	2593	1852
Rampur Composite	67	70	143	268	5204	3.00	3.50	1.50	3.67	2.00	47037	2222	4074
Deuti	72	76	145	288	6602	2.67	3.00	2.33	2.83	2.00	45926	3704	1852
Local check	67	70	175	319	5205	2.67	3.83	1.17	3.17	1.83	41481	2593	5185
Grand mean	68	72	138	268	5738	2.75	3.19	2.32	3.26	2.28	47438	2438	2623
F test	**	**	**	**	**	**	ns	*	**	*	*	ns	*
LSD	2	3	17	22	997	0.89	0.90	1.062	0.58	0.76	5049	3537.6	2891.0
CV%	2.2	2.4	7.1	4.9	10.3	19.2	16.6	27.0	10.5	19.8	6.3	85.7	65.1

**= highly significant at 01. *= %ht= height, asp= aspect, har= harvested, lod= lodging, tassel= tasseling, gr=grain, yld= yield, pl= plant

Table 3. Summary sheet of the traits recorded in common entries of maize CVT(QPM) in the years 2005 and 2006

Entry name	Tassel days	Silking days	Ear ht (cm)	Pl ht (cm)	Gr yld kg/ha	Ear asp (1-5)	Plant asp (1-5)	Husk cov (1-5)	Har ears/ha	Har pl/ha	Root lod pl/ha	Shoot lod pl/ha
S99TLYQ-B	74.	79	119.2	224.3	4911	2.583	3.167	2.500	47778	52037	1111	1667
S99TLWQ-HG-AB	75	80	122.2	242.4	5527	2.667	2.500	2.833	45556	52037	2407	741
Celaya S91 SIWQ	71	76	109.5	225.7	4170	3.583	3.500	3.000	46111	52037	2037	4444
Corralejo S99 SIWQ	71	75	96.2	209.2	4149	3.5	4.000	2.917	42037	50741	2593	2407
S01SIWQ-2	73	78	91.7	206.0	4944	3.0	3.250	2.667	47037	52778	1296	1296
S01SIYQ	73	78	109.7	219.4	4384	3.083	3.417	2.500	44630	50370	1667	1296
Manakamana-3	78	83	131.5	256.4	5881	2.583	2.833	2.167	47593	53148	2222	1852
Local check	71	79	157.2	280.6	3677	2.917	3.750	1.750	33889	47222	2963	7778
Grand mean	73	79	117.1	233.0	4705	2.990	3.302	3	44329	51296	2037	2685.0
F pr.	**	**	**	**	**	ns	**	*	**	ns	ns	**
Entry	**	**	**	**	**	ns	ns	**	**	**	*	ns
Year	*	**	ns	ns	ns	ns	ns	ns	**	*	ns	*
Entry* Year												
LSD												
Entry	1.8	2.0	15.8	16.9	995.3	0.8	0.7	0.7	5953.5	3864.0	3028.3	2236.9
Year	0.9	1.0	7.9	8.5	497.6	0.4	0.4	0.4	2976.7	1932.0	1514.2	1118.5
Entry* Year	2.5	2.9	22.4	23.9	1407.5	1.1	1.1	1.0	8419.5	5464.5	4282.7	3163.5
CV%	2.1	2.2	11.5	6.2	17.9	22.0	19.2	24.6	11.4	6.4	126.1	70.7

**= highly significant

On-Farm Performance of Quality Protein Maize Genotypes under Rainfed Hill Environments of Nepal

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ABSTRACT

Maize (*Zea mays* L.) is the second most important staple food crop after rice and a major food crop of the resource poor people in the hills of Nepal. Prevailing normal maize (non-QPM) is deficient in two essential amino acids: lysine and tryptophan. The majority of hill farm families are suffering from protein malnutrition as their major diet is maize and cannot afford animal protein. QPM (Quality Protein Maize) contains opaque-2, a single gene mutation that alters the protein composition of the endosperm portion and nearly double the essential amino acids concentrations than the normal maize grain. Series of experiments conducted in RCBD during 2004 and 2005 summer to select and promote the superior QPM maize genotypes through Observation Nurseries to IYT, CVT, and CFFT. CFFT (Co-coordinated Farmers' Field Trial) were conducted across hills in Nepal under farmer managed condition. Two years' mean performance data of CFFT revealed that the genotype S99TLWQ- HG-AB produced the highest grain yield followed by Corralejo-S99SIWQ and Celaya S91 SIWQ. However, all the tested QPM genotypes were at par with improved check for grain yield production and significantly highest grain yielder than the farmers' variety (local check). Concluding results revealed that the genotype S99 TLWQ-HG-AB performed very well across hill environments and liked by farmers.

Key Words: Genotype environment interaction, open pollinated varieties, quality protein maize.

INTRODUCTION

Maize (*Zea mays* L.) is the second most important cereal crop after rice in Nepal, and a major food crop in the hills. The total area under maize is 870,401 hectares in Nepal. Out of this area, 70.07 percent (596,293 ha) is in mid hills and 10.42 percent (88,697 ha) is in high hills, with the productivity of 2091 kg^{-ha} and 1728 kg^{-ha}, respectively. The majority of hill farm families especially infants, pregnant women, lactating women and elderly persons are suffering from protein malnutrition. Considering this problem present study was undertaken for the identification, development, and promotion of QPM maize varieties for commercial cultivation in the hills. All the OPVs and hybrid varieties of maize released so far are normal type. Their nutritional quality is poor as it is deficient of two essential amino acids Lysine and Tryptophane. New QPM synthetics have special characteristics features such as low and uniform ear placement, resistance to ear rot and root lodging and most notably levels of tryptophan (0.11% of the whole grain), lysine (0.475% of the whole grain) and protein (11.0% of the whole grain) much higher than in normal maize (0.05%, 0.225% and 8.5%). These features make the QPM synthetics/OPVs particularly attractive to farmers (Cordova 2000). The nutritional benefits of QPM for people who depend on maize for their energy and protein intake are very significant. Several researchers have demonstrated

the superior protein quality and protein digestibility of QPM over normal maize (Paes et al 1995, Bressani 1995 and Graham et al 1980). The studies indicated that the QPM protein contains, in general, 55 percent more tryptophan, 30 percent more lysine and 38 percent less leucine than that of normal maize. QPM also provides better quality feed and fodder to poultry, cattle, swine, and fishmeal industries.

MATERIALS AND METHODS

Several exotic QPM germplasm are being tested in Nepal since 1998. Series of Observation Nurseries (requested from CIMMYT) were evaluated. Superior genotypes selected and promoted from Observation Nurseries to IYT, CVT and CFFT respectively. On farm, experiments (CFFT) conducted across hills in Nepal under farmer-managed condition in RCB Design during 2004 to 2005 summer seasons (March to September). There were 7 different environments (year-site combinations) in the two years. Each experimental plot of 13.5 m² was seeded at the standard seed rate of 20 kg ha⁻¹ and net area harvested was 9.0 m². The spaces between row-to-row and plant to plant were 75 and 25 cm. respectively. Two seeds per hill were planted and thinned to single plant per hill after first weeding. Fertilizer were applied at the rate of 120:60:40 kg ha⁻¹ N: P₂O₅: K₂O respectively in addition to 15 tons farmyard manure ha⁻¹. Half dose of N and full dose of P and K applied as basal dose. The remaining half of the N applied as a side dressing at knee-high stage. The plots were kept free of weeds manually. Data on days to 50 percent tasseling and silking (5 plants in each plot), plant and ear height 2-3 weeks after flowering, all the plants and ear in each plot counted were recorded. Data on plant aspect (plant and ear height, uniformity of plants, disease and insect damage and lodging) in each plot was recorded at the brown husk stage on a scale of 1 to 5, where 1 and 5 represents excellent and poor, respectively. At maturity, husk cover was rated on a scale of 1 to 5, where 1 represents husk tightly covering the ear tip and extending beyond it and 5 signifies clearly exposed tips. After harvest, all ears from a plot were placed in a pile and ear aspect (size, disease and insect damage, grain filling and uniformity) was recorded on a scale of 1 to 5, where 1 and 5 signify the best and poorest respectively. The plots were harvested individually. Grain yield adjusted to 80 percent shelling recovery from the de-husked cob weight /plot. Grain moisture content for each plot was recorded and grain yield was adjusted to 15 percent moisture basis. Mstatc, Excel and the GGE biplot analysis system conducted statistical analyses.

RESULTS AND DISCUSSION

Results of 2004 summer season revealed that out of 6 genotypes evaluated, the genotype S99 TLWQ-HG-AB Produced the highest grain yield (7158 kg ha⁻¹) followed by Celaya S91 SIWQ (6466 kg ha⁻¹) and Manakamana-3 (improved check normal maize) 6412 kg ha⁻¹, respectively across hill environments. These QPM genotypes were statistically at par with improved check and significantly superior ($P = > 0.01$) then the farmers' local check variety. However, all the tested QPM genotypes were significantly higher grain yielder then the farmers' variety. For days to 50 percent flowering farmers' variety was earliest followed by Corralejo-S99 SIWQ and Celaya S91 SIWQ, respectively. Genotype S99 TLYQ-B was statistically earlier and S99 TLWQ-HG-AB was at par for days to 50 percent flowering than the improved check. Genotype Corralejo -S99 SIWQ had the significantly shortest ear height (110 cm) followed by Celaya S91 SIWQ (121 cm) and farmers' variety (127 cm), respectively. Manakamana-3 had the tallest ear height (139 cm) followed by S99TLYQ-B (137 cm) and S99 TLWQ-HG-AB (135 cm), respectively. All the tested genotypes were at par for plant height (Table 1). Environment-wise grain yield performance is presented in Table 2.

Table 1. Combined analysis of farmers field trial (CFFT) at Lumle, Dailekh and Kabre during 2004 summer

S N	Genotypes	Days to 50% flowering		Plant ht. (cm)	Ear ht. (cm)	<i>E. tur.</i> (1-5)	Plant aspect (1-5)	Ear aspect (1-5)	Grain yield ha ⁻¹	
		Male	Female							
1	S99TLYQ-B	71	74	251	137	2.9	1.6	2.8	5732	bc
2	S99TLWQ-HG-AB	73	76	257	135	2.3	1.6	2.4	7158	a
3	Celaya S91 SIWQ	68	71	243	121	2.3	1.6	2.6	6466	ab
4	Corralejo -S99SIWQ	67	69	236	110	2.8	2.1	1.9	6412	ab
5	Mana-3 (Imp.Chk.)	75	78	268	139	2.7	2.5	1.8	5848	bc
6	Farmers'Var.	64	67	250	127	2.8	2.5	2.3	5457	c
	Grand Mean	70	73	251	128				6179	
	F-test	**	**	NS	**				**	
	CV%	4.04	4.3	10.4	13				15.4	
	LSD 0.05	2.3	2.5	21	14				777	
	Mean of Locations	3	3	3	3	2	3	3	3	

Note: The data summarized from 12 replications.

Table 2. Combined analysis of CFFT for grain yield kg ha⁻¹ at LAC, Dailekh and HCRP Kabre 2004 summer

SN	Genotypes	Lumle	Dailekh	Kabre	Mean of 3 Locations
1	S99TLYQ-B	5053bc	7514b	4014	5732bc
2	S99TLWQ-HG-AB	6974a	8803a	5240	7158a
3	Celaya S91 SIWQ	6242ab	8048ab	4657	6466ab
4	Corralejo -S99SIWQ	6131abc	8673ab	3798	6412ab
5	Mana-3 (Imp.Chk.)	4838c	7953ab	3975	5848bc
6	Farmers'Var.	5588bc	6171c	4465	5457c
	Grand Mean	5804	7860	4358	6179
	F- Test	*	**	NS	**
	CV %	12.4	10.5	23.5	15.4
	LSD (0.05)	251	1088	1542	777
	Environments	E₁	E₂	E₃	
	Mean of Reps.	3	5	4	12

Covariance analysis of grain yield kg ha⁻¹ by no. of plants ha⁻¹ as covariate performed.

From the results of 2005 summer season, it was found that out of 7 genotypes evaluated, the genotype S99 TLWQ-HG-AB produced the highest grain yield (5299 kg ha⁻¹) followed by Pop. 45 C₁₀ (5135 kg ha⁻¹ normal maize) and Manakamana-3 (improved check normal maize) 4961 kg ha⁻¹, respectively across hill environments. These QPM genotypes were statistically at par for grain yield. All the other 6 genotypes were statistically superior (P= > 0.01) than the farmers' local check variety. However, all the tested QPM genotypes were significantly higher grain yielder than the farmers' variety. All the tested genotypes were significantly late for days to 50 percent flowering than the farmers' variety, but at par with Pop. 45 C₁₀ (improved check). Genotypes were highly significant for plant height and ear height. Farmers' local check was the tallest genotype followed by Manakamana-3 and S 99 TLYQ-B for both plant and ear height (Table 3). Environment-wise grain yield performance is presented in Table 4.

Table 3. Combined results of CFFT QPM Hill Set (Lumle, Pakhribas, Dailekh and Kabre) during 2005 summer

Genotypes	Days to 50% flowering		PH cm	EH cm	PA (1-5)	EA (1-5)	ET (1-5)	Husk cover (1-5)	PP /ha (000)	Ears /ha (000)	Grain yield, kg ha ⁻¹
	Male	Female									
S99 TLYQ-B	77	80	230	121	1.7	2.7	2.2	2.9	39	38	4844 AB
S99 TLWQ-HG-AB	78	82	230	118	1.9	2.3	2.1	2.8	43	42	5299 A
Celaya- S-91 SIWQ	75	79	215	105	1.9	2.1	2.2	2.3	46	46	4614 BC
Corralejo-S99 SIWQ	73	78	217	108	1.8	2.0	2.4	2.2	45	43	4855 AB
Pop-45 C ₁₀ (Imp.Chk.)	75	78	222	112	2.1	2.4	2.3	2.2	46	44	5135 AB
Mana-3 (Imp. Chk.)	76	80	241	135	2.1	2.0	2.1	2.2	43	40	4961 AB
F. Local (Check)	69	73	248	136	3.0	2.4	2.4	1.1	45	44	4124 C
Grand Mean	75	79	229	119	2.1	2.3	2.2	2.2	44	42	4833
F- Test	**	**	**	**	**	NS	NS	**	**	**	**
C V %	5.5	5.4	11.1	21.4	35.2	45.95	17	37	9.51	10.27	17.1
LSD (0.05)	2.6	2.7	16	16	0.47	0.66	0.5	1.0	2.61	2.73	517
Mean of Locations	4	4	4	4	4	4	2	2	4	4	4

Covariance analysis of grain yield kg/ha by no. of plants/ha as covariate performed.

PH- Plant height, EH – Ear height, PA – Plant aspect, EA – Ear aspect, ET – *Exserohilum turticum*, PP – Plant population

Performance stability analysis of QPM maize genotypes (Fig. 1 and Fig. 2) revealed that the highest yielding QPM genotype S99 TLWQ-HG-AB produced significantly higher grain yield than the improved and local checks in 2 years. It also showed stable response across environments. The genotype Corralejo S91 SIWQ also produced significantly higher grain yield than the improved and local checks in 2 years. However, this genotype performed similar to improved check in poor environments, but produced significantly higher grain yield in rich environments. All the tested QPM genotypes were significantly higher grain yielder than the farmers' local check.

Table 4. Combined analysis of CFFT on grain yield kg ha⁻¹ at LAC, PAC, Dailekh and HCRP Kabre 2005 summer

Genotypes	Lumle	Pakhribas	DMRT Test	Dailekh	Kavre	Mean of 4 Locations	DMRT Test
S99 TLYQ-B	4612	5185	BC	5481	3573	4844	AB
S99 TLWQ-HG-AB	5053	6574	A	5797	3829	5299	A
Celaya- S-91 SIWQ	4966	4679	C	4809	3682	4614	BC
Corralejo-S99 SIWQ	4364	5434	ABC	5325	3658	4855	AB
Pop-45 c10 (Std. Chk.)	5070	6304	AB	5104	3750	5135	AB
Mana-3 (Std. Chk.)	5073	6211	AB	5067	3434	4961	AB
F. Local	4250	4515	C	4281	3081	4124	C
Grand Mean	4770	5558		5123	3572	4833	
F- Test	NS	**		NS	NS	**	
CV %	17.8	15.21		17.4	15.2	17.1	
LSD (0.05)	1111	1106		1053	806	517	
Environments	E₄	E₅		E₆	E₇		
Mean of Replications	5	5		5	5	20	

Covariance analysis of grain yield kg ha⁻¹ by no. of plants ha⁻¹ as covariate performed.

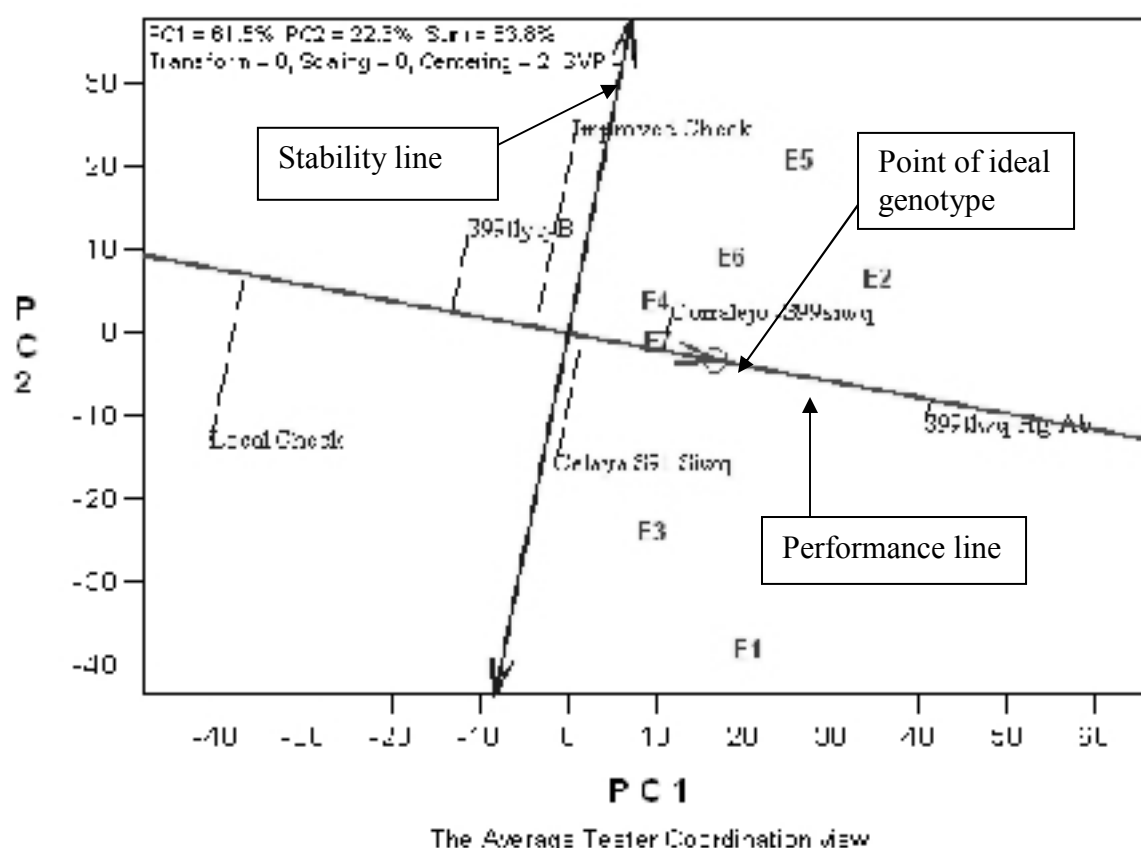
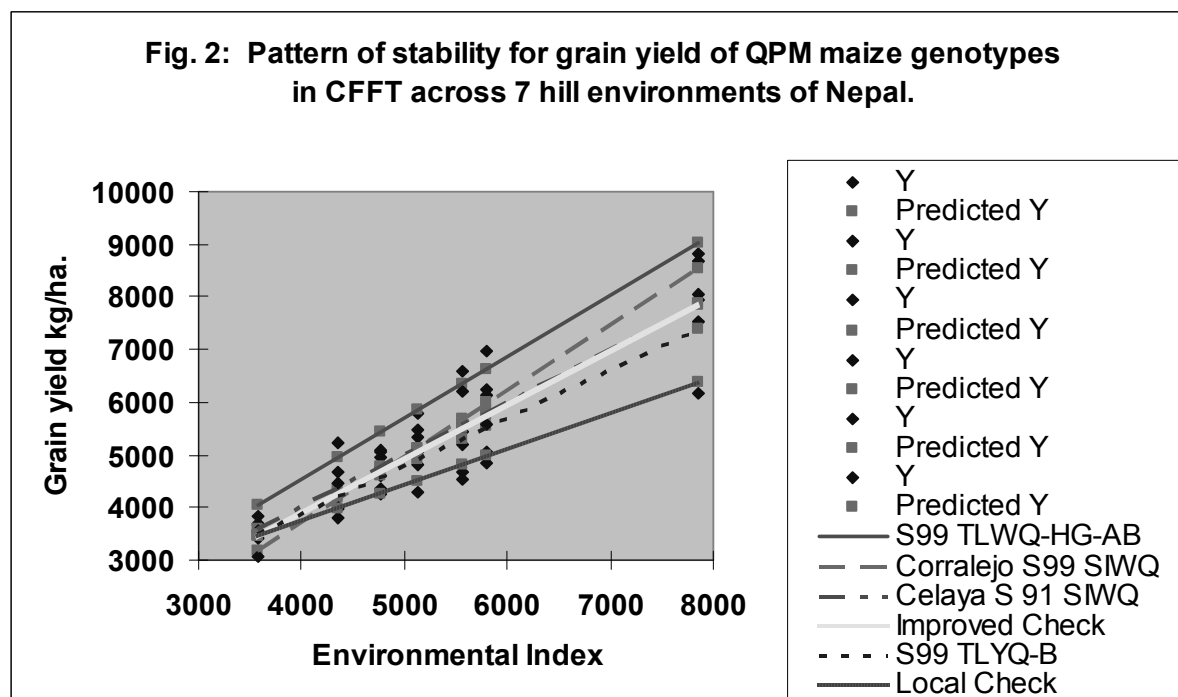


Figure. 1: GGE biplot showing comparison of 6 maize genotypes with an ideal genotype for grain yield tested on farm across 7 hill environments (E) of Nepal. For the name of specific environment, please refer tables 2 and 4.

To determine stability and identify superior genotypes across environments, genotype and genotype x environment (GGE) bi-plot analysis was conducted using GGE bi-plot software (Yan and Kang 2002). This method defines the position of an ideal genotype, which will have the highest average value of all genotypes and be absolutely stable; that is it expresses no genotype by environment interaction. The ideal genotype is used as a reference to rank the other genotypes. A performance line passing through the origin of bi-plot is used to determine mean performance of a genotype. The arrow on the performance line represents increasing mean performance. A stability line perpendicular to the performance line also passes through the origin of the bi-plot; the two arrows in opposite directions represent decrease in stability. A genotype closer to the performance line is considered more stable than the one placed farther.

Table 5. Mean grain yield and estimate of stability parameters in maize genotypes

Genotypes	Mean	b	Adjusted R ²	SE
S99 TLQ-B	5062	0.906	0.92	354
S99 TLWQ-HG-AB	6039	1.159	0.96	312
Celaya- S-91 SIWQ	5298	0.996	0.88	498
Corralejo-S99 SIWQ	5340	1.250	0.96	346
Imp. Chk. (Mana-3/RC)	5222	1.033	0.86	562
Farmers' Var. (L. Chk)	4622	0.678	0.82	429



Genotypes S99 TLWQ-HG-AB and Corralejo-S99 SIWQ Showed $b > 1.0$ and genotypic mean is higher than grand mean (Table 5). These genotypes fall under the category of "above average stability" and specifically adapted to both rich and poor conditions. Genotypes Celaya S91 SIWQ and improved checks (Manakamana-3/ Ram Composite) were at the category of "average stability" ($b = 1.0$), generally adapted to all conditions as the environmental mean changes genotypic mean (g mean) is also changes in the same direction. Here, g means is similar to grand mean.

Genotypes S99 TLYQ-B and farmers' local check were at the category of "below average stability" ($b < 1.0$), generally adapted to all conditions as the environmental mean changes genotypic mean (g mean) is also changes in the same direction, here g means are less than grand mean. However, in general, all the tested genotypes produced low grain yield in poor environments and higher grain yield in rich environments (Fig. 2).

CONCLUSION

Exotic QPM genotypes tested in seven different hill environments of Nepal showed significant variation for grain yield, days to flowering, plant and ear height, husk cover tightness and plant aspect. There were QPM genotypes out yielded the normal checks, were also highly stable. Two QPM genotypes, S99 TLWQ-HG-AB and Corralejo S91 SIWQ were higher yielder than the normal checks. Results revealed that the genotype S99 TLWQ-HG-AB performed very well across hill environments and liked by farmers. It should go to the farm of hill farm families for commercial cultivation.

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Participatory Variety Improvement and Value Addition of Nepalese Fingermillet Cultivars

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ABSTRACT

Study was undertaken on Nepalese fingermillet genotypes with the participation of the local community at Pipaltar, Nuwakot district during 2003 and 2004. This paper shades light on the major achievements on variety evaluation, production management, and value added product development and market promotion of finger millet. From household surveys carried out among 46 samples (40%), 80 HH have revealed that Mudke, Chaure and Seto Kodo are preferred fingermillet cultivars. About 70 percent farmers grow Mudke, 46 percent grow Chaure while 2 percent grow Seto Kodo (IFAD-NuS Annual Report 2005). Field experiments have also revealed that Mudke, Chaure and Jalbire are high yielding promising genotypes suited to that area. Moreover, with the collective efforts from the programme's stakeholders, local entrepreneurs and farmers were able to learn to prepare various fingermillet based products and were encouraged to sell their products. Promotion of these products among people of all walks of life was done through mass media and papers. Establishment of micro mill has also helped in reducing the hassles of flour making and has become important mean of income generation for the communities. The programme has successfully explored the potential of local fingermillet cultivars and improved rural livelihood by paving the way for their appropriate utilization.

Key words: Cultivar, finger millet market promotion, value addition, variety evaluation

INTRODUCTION

Fingermillet (*Eleusine coracana* Gaertn.), a crop of many poor and subsistent people in the hills of Nepal, is the fourth most important cereal crop in the country. It is uniquely adopted to this country and mostly grown under a maize/millet cropping system. It is cultivated in an area of 259,130 ha with the production of 282,860 ton (CBS 2061). National average productivity of fingermillet is 1.09 mt/ha. In Nepal, fingermillet is generally grown in dry and extremely marginal areas with low external inputs and little management.

Even though, fingermillet is important for the subsistence of rural farming household, its potential has not been fully realized yet by many. Farmers and the consumers are using finger millet less because this crop is not preferred over other cereals due to social reasons. Thus, it is neglected and under-utilized in the national perspective. The lack of diversity in the foods they eat often leads to micronutrient deficiencies. This dilemma can be very much true in our country case because people in rural and inaccessible areas have less choice of food items either due to scarcity or poverty. Fingermillet to some extent can mitigate this problem in rural community.

After the initiation of the project, "Enhancing the contribution of Nutritious but Neglected Crops to Food Security and to Increase income of the Rural Poor: Nepal Component of Fingermillet", during 2002 in Hill Crop Research Program, Kabre, diversified studies were carried out in fingermillet crop. The project was funded by the "International Fund for Agricultural Development" (IFAD) through the International Plant Genetic Resource Institute (IPGRI) with M.S. Swaminathan Research Foundation (MSSRF) as the main collaborator. The objectives of the project were to conserve and utilize fingermillet genetic resource

through development oriented research and to tackle major causes of it's under use by reviving the cultivation of nutritious but neglected crop. The paper highlights the finding of variety evaluation, production management, value added product development and market promotion at Pipaltar in Nuwakot during 2003 and 2004.

MATERIALS AND METHODS

Eighteen local fingermillet cultivars collected from Nuwakot, Kaski and Dolakha were sown in diversity block management in order to evaluate the performance of these landraces. These landraces were sown in rod-row with the spacing of 10 cm between rows. Plot size was 2 x 2 m. Fertilizer was applied @ 30:30:30 NPK kg/ha and FYM @ of 5 ton/ha. In the mother set trial, six fingermillet cultivars were grown in the farmer's field for selecting farmers preferred cultivars. The trial was conducted in complete randomized block design with four replications. The plot size was 6 m² with the spacing of 10 cm between fingermillet rows. Fertilizers and FYM were applied at the rate of 30:30:30 NPK kg/ha and 5 ton/ha respectively. Likewise, a total of two hundreds and forty three fingermillet cultivars and lines were evaluated at Kabre farm. Fourteen qualitative traits, eight quantitative traits and disease aspects of the fingermillet were studied. The plot size was 2 m² and spacing between the rows were 10 cm. The seed production of the demanding fingermillet cultivars like Kabre Kodo-1, GPU-25 and Mudke were carried out in an area of 250 m² for each cultivars in 2003 and in 2004 the area were expanded to 500 m² for each cultivar. In order to demonstrate farming community that improved methods of fingermillet cultivation is necessary to increase fingermillet production, the diamond trial was done in the farmer's field. Treatment details of the trial are given in table 2.

Table 1. Treatment details of Diamond Trial carried out at Pipaltar during 2004

Improved varieties/improved practice	Improved varieties/Local practice	Local varieties/Improved practice	Local varieties/Local practice
Improved fingermillet variety Kabre kodo-1	Improved fingermillet variety Kabre kodo-1.	Farmer local Mudke cultivar	Farmer local Mudke cultivar
30:30:30 NPK kg/ha	Urea (small amount)	30:30:30 NPK kg/ha	Urea (small amount)
Spacing between rows 10cm	No line maintenance	Spacing between rows 10cm	No line maintenance

RESULTS AND DISCUSSION

Fingermillet contributed 22 percent on the total food sharing in Tallo Pipaltar (Survey Report, IFAD-Nus 2005). Large numbers of Nepalese fingermillet cultivars have been assessed in terms of their yield performance as well as agro morphological characteristics, and superior genotypes like Mudke Kodo, GPU-25 and Chaure Kodo have been identified as promising fingermillet cultivars. Farmers were able to assess and select these promising genotypes with their own participation. seed production of promising fingermillet genotypes like Kabre Kodo-1, GPU- 25 and Mudke were carried out which helped in the distribution and conservation of these cultivars. Summery of findings of various activities carried out at Pipaltar, Nuwakot during 2003 and 2004 are presented in Table 2 to 8.

Identification of Superior Fingermillet cultivars

Various qualitative and quantitative traits of different fingermillet genotypes were evaluated in Diversity Block and Mother Set Trial (PVS) during 2003 and 2004. Crop yield, its performance and farmer's remarks on the performance of the cultivars were the key focus of data recording. Summery of diversity block management and Mother set Trial (PVS) are given in Table 2. Farmers were able to get active participation during the evaluations process.

Table 2. Summary of Diversity Block Management at Pipaltar, Nuwakot during 2003 and 2004

SN	Cultivars	Days to 75% maturity**	Plant height (cm)	Plant stand/m2**	No. of fingers/head	Grain yield, kg/ha	Remarks
1	Seto kodo	128	99.7	72	6	1248	Good bread
2	Seto dale	123	115.3	74	8	1570	
3	Kalo dale	126	114.2	96	7	1552	
4	Kalo jhyape	120	100.3	86	7	1792	Ist preference
5	Mudke kodo	126	111.8	88	7	1886	
6	Paheli Mudke	116	108.2	82	8	1860	
7	Chaure kodo	123	104.1	88	8	1502	
8	Paheli Kodo	129	105.0	64	7	1336	
9	Kukurkane	123	102.0	58	7	1530	
10	Chaure Kodo	123	106.0	88	7	2040	
11	Chitwane Loc.	123	102.8	102	8	1924	
12	Jalbire	129	104.5	82	8	1896	
13	Seto Jhyape	128	109.3	100	7	1772	
14	Kabre Kodo-1	121	106.9	76	6	1447	
15	Paheli*	-	111.9	-	8	1136	
16	Dalle	124	110.7	62	7	1202	
17	F Loc (Mudke)	125	117.0	96	8	1541	
	Mean	124	107.6	82	7	1602	
	Maximum	129	117	102	8	2040	
	Minimum	116	99.7	58	6	1136	
	SD	3.5	5.3	13.5	0.69	275.4	

NB: * and ** 2004 year only

Table 3. Summary of Mother set (PVS) at Pipaltar, Nuwakot during 2003 and 2004

SN	Cultivars	Days to 75% maturity	Plant height (cm)	Plant stand/m2	No. of fingers/head	Grain yield kg/ha
1	Kabre kodo-1	135.2	117.4	84.3	6	2588.9
2	GPU-25	133.8	99.0	90.7	6	2786.1
3	GE-5177	137.2	111.7	92.2	7	1911.1
4	GE-0122	132.5	117.1	92.2	6	1844.4
5	Acc#523-1	135.3	113.0	89.8	6	2077.8
6	Mudke kodo	133.8	110.8	97.3	8	2755.6
	Mean	134.6	111.1	91.1	6	2327.3
	CV%	3.59	10.58	17.55	13.3	58.8
	F-test	NS	NS	NS	**	NS
	LSD	5.7	-	17.55	0.8	1360

Seed Production of promising cultivars

With an aim to supply quality seed and effort to conserve superior finger millet local genotypes in-situ, seed production of elite finger millet cultivars were carried out. The estimated yield of different finger millet cultivars under seed production program is presented in table 4. Using crop cutting sampling method, yield estimation was done. At least four samples were taken for each variety after fully matured stage. Each sample was dried, threshed, weighted and yield was calculated by reducing 12 percent moisture.

Table 4. Estimated yield of Finger millet from seed production activities at Pipaltar during 2003 and 2004

SN	Cultivars	Year 2003		Year 2004	
		Farmers	Yield, kg/ha	Farmers	Yield, kg/ha
1	Kabre kodo-1	Birman Kumal	2420	Bishwo Kumal	2928
2	GPU- 25	Bishwo Kumal	3300	Bishwo Kumal	3725
3	Mudke	Resham Kumal	2530		

Farmer's field verification trials

Study carried out on the cost benefit analysis on finger millet cultivation by farming community showed in the ratio of 1:1.08. Thus, the need was felt to demonstrate the farming community the improved method of finger millet cultivation that will help them in getting optimum profit from the crop produced. This experiment has helped to demonstrate farming communities the importance of improved production practice and their effect on crop yield.

The performance of local finger millet cultivars, Mudke under improved practice of production gave the highest yield followed by improved variety Kabre Kodo-1 under improved production practice. Local finger millet cultivar was popular in this area as it was better performing over other local or improved varieties.

Table 5. Results from the Diamond trial conducted at Pipaltar during 2004

Trt No.	Treatment	Grain yield, kg/ha	Plant height, cm	Maturity days 75%	No. of plants/m ²	No. of head/ M ²	No. of finger/ head
1	Imp var./ imp. Practice	2950	111	131	100	103	7
2	Imp. var./ Local practice	2650	106	131	108	110	6
3	Local var./ imp. Practice	3575	97	125	112	114	6
4	Local var / Local practice	2850	96	125	89	95	7
Mean		3006.2	102.5	128	102.25	105.5	6.5

Characterization and documentation of finger millet genotypes

As a part of this project, agro morphological characterization of 243 finger millet genotypes and lines were evaluated at Kabre, Dolakha during 2004. Summary of the results from the evaluation are given in table 6 and 7. High variations in both the qualitative as well as in the quantitative characteristics on the studied genotypes were observed that could be useful in the selection of lines for future breeding programs.

Table 6. Few qualitative characteristics of 243 finger millet lines assessed at Kabre during 2004

SN	Characteristics	Diversity (Categories in number and percent)				
1	Plant pigmentation at flowering	Non-pigmented: 167 (69%)			Pigmented: 76 (31%)	
2	Ear Shape	Droopy 0(0%)	Open 25 (10%)	Semi-compact 127 (53%)	Compact 83 (34%)	Fist-like 6 (3%)
3	Ear Size	Small: 40(16%)	Medium: 82(34%)	121(50%)	Large:	
4	Finger Branching	Absent : 242 (99.6%)	Present: (0.4%)		Entry No. 136	
5	Discontinuity of Spikelet	Yes : 5 (2%)	No: 238 (98%)			
7	Lodging Susceptibility	No: 238(97%)	Low: 4(2%)	Intermediate: 0(0%)	High: 1(0.4%)	
8	Spikelet Shattering	Absent : 236(97%)	Present: 7(3%)			

Table 7. Quantitative characteristics of 243 finger millet lines assessed at Kabre during 2004

SN	Traits	Minimum	Maximum	Mean	CV%	SE of mean
1	Plant Height (cm)	27	107	80	17	0.87
2	Flag L/W Ratio	8.7	3.4			
3	Culm Branching	1	3	1.3	36.3	0.03
4	Culm Thickness (mm)	5	15	8	16.1	0.07
5	Productive Tillers	1	3	1.3	36.3	0.03
6	Finger L/W Ratio	6.4	8			
7	Disease Scoring	1	7	1.3	61	0.05

Utilization of fingermillet

Household surveys carried out among 46 samples (40%) out of total 80 HH have revealed that Mudke, Chaure and Seto Kodo are popular. About 70 percent grow Mudke, 46 percent grow Chaure while 2 percent grow Seto Kodo I. From the experiment results, personal interviews with the farmers and field inspection it was known that this local fingermillet cultivar Mudke is not only high yielding but also less disease susceptible and meets desirable fodder criteria of the farmers.

Fingermillet contribute 22 percent of the total food availability in Pipaltar. Households themselves often utilize most of the crop produced. However, 41 percent of the farming families sell their produce at cheaper rate immediately after thrashing and the quantities they sell are widely fluctuated (5-35%). Sixty percent of the crop produced is utilized in beverage production, 28% as food items (Dhindo, roti) and about 5 percent as seed and feed. Economic analysis of local beverage preparation was 1:1.1 to 1:1.6. Finger millet cultivars like Mudke, Chaure and Dalle are popular among the farming community not only from yield and fodder perspectives but also due to their taste and desirable qualities.

Value addition

Finger millet is good source of nutrient and is a high-energy crop. Compared with other cereal crops, nutrients like carbohydrate, fiber, minerals, calcium and phosphorous are higher in millet (Table 8). Chemical analyses of different fingermillet genotypes done at Food Research Unit in NARC have shown variations in the nutrient contents among them (Table 9). Samdhi kodo, white grained cultivars have more thiamine and protein than brown seeded cultivars.

Table 8. Nutrient content of fingermillet in comparison to other cereal crops

SN	Nutrients	Per 100 grams			
		Millet	Maize	Wheat flour	Rice
1	Water (g)	13.1	12	12.2	13.7
2	Protein(g)	7.3	9.2	12.1	6.8
3	Fat(g)	1.3	3.9	1.7	0.5
4	Carbohydrate(g)	72	73.7	69.4	78.2
5	Fiber(g)	3.6	1.6	1.9	0.2
6	Minerals(g)	2.7	1.2	2.7	0.6
7	Calcium(mg)	344	20	48	10
8	Phosphorous(mg)	283	256	355	160
9	Iron(mg)	6.4	2.4	11.5	3.1
10	Thiamine(mg)	0.42	0.38	0.49	0.06
11	Calorie	328	355	341	345
12	Carotene(mg)	42	90	29	0

Source: Food Research Unit under NARC, 2005

Table 9. Chemical composition of Nepalese Finger millet cultivars

Traits	Finger millet varieties			
	Kabre kodo-1	Okhale kodo-1	Dalle kodo	GE-5016
Density g/ml	1.48	1.38	1.38	1.26
Moisture %	13.94	14.25	13.50	14.67
Protein %	7.64	7.35	7.32	7.03
Total Ash %	2.2	2.25	2.17	2.19
Acid insoluble ash %	0.221	0.211	0.197	0.211
Fat %	1.41	1.34	1.32	1.38
Crude fibre %	1.82	1.79	1.74	1.64
Calcium mg/100g	390.30	386.48	3.96.81	379.33
Phosphorous mg/100g	330.19	286.19	314.76	257.82
Iron mg/100g	4.68	4.64	3.66	4.26

Source: Food Research Unit under NARC, 2005

Two types of food products were developed at Food Research unit for its value addition.

- **Nutrient supplement protein rich food** based on fingermillet and legumes
- **Biscuits**, using different percentage composition of fingermillet flour and wheat flour.

Protein energy snacks food formulation was made by mixing fingermillet and legumes in different ratios; 1:2, 2:1, 3:1 and 4:1. Likewise, optimum quality of biscuit was found for up to 30 percent millet flour. Whole millet flour failed to form biscuits (during dough making and backing) due to lack of gluten in millet flour. Central food research laboratory, prepared different millet based products like bread (millet flour 30 parts by wt.), doughnut (millet flour 20 parts by wt), cakes (millet flour 40 parts by wt), cookies (millet flour 35 parts by wt) and noodles (millet flour 30 parts by wt).

Micro-mill establishment

Pearling machine was handed over to the farmer groups. The machine had the capacity of 24 kg/hr with pearling efficiency of 99.4 percent (Shrestha, 2005). This has drastically reduced the hassles of female farmers for flouring and farmers in and around the community were able to flour their millet at the reasonable price. The mill itself became a source of income generating activities.

CONCLUSION

To increase the value of any local crop diversities, experts working in this area must understand the different values that the local crops hold for farmers as well as the ways in which changing social and technological conditions will affect those values. The project has been successful in collecting resource of information on the local fingermillet cultivars in respect to social setting. Large numbers of Nepalese fingermillet cultivars have been assessed in terms of their yield performance as well as agro morphological characteristics, and Superior genotypes like Mudke Kodo, GPU-25 and Chaure Kodo have been identified as promising fingermillet cultivars. Moreover so, the project has helped in the utilization, promotion and in the conservation of the countries rich fingermillet resources.

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Jute Research and Development in Nepal: Status and Future Strategies

Bedanand Chaudhary

Jute Research Program, NARC, Itahari

ABSTRACT

Jute (*Corchorus* spp.) is a traditional commercial crop of eastern terai of Nepal. Nepal introduced JRC 321, JRC 212, JRO 632, JRO 524 and JRO 7835 jute genotypes in 1970s. In 1993, Nepal Agricultural Research Council (NARC) obtained facilities of jute and established Jute Research Program (JRP) at Itahari, Nepal for jute research and development. In 1999, JRP released Itahari 1 and Itahari 2 jute varieties for general cultivation. The present area, production and yield of jute are nearly 12000 ha, 17000 MT and 1.43 mt/ha, respectively. Nine jute mills require 100 thousand MT of raw jute. Jute plays a significant role in national economy by exporting jute products and providing employment to nearly 100 thousand people. However, rot complex disease, insects and weeds are biotic factors lowering production and productivity. Others are lack of quality seeds, labor shortage, scarcity of water for retting. Issues like low and unstable price of jute fibre; higher cost of production; drudgery in cultivation and processing; and weak coordination among millers, traders and growers have caused decline in area and production. JRP has developed profitable production technologies and has been promoting among the growers. The report describes achievement in varietal development, integrated pest management, cropping system and retting techniques. Considering its variable uses and environment-friendly nature; investment on jute research and development works needs to be doubled and collaborative works demand to be strengthened. In addition, policies for improved marketing system, subsidies and developing entrepreneurship need to be formed to encourage jute growers and processors for increased and sustainable production.

INTRODUCTION

Jute (*Corchorus* spp.) is an important fibre crop which is traditionally grown as cash crop in eastern terai of Nepal. Development activities on jute crop were started in 1970 with establishment of Jute Development Board. The board established research station in 1971 for testing of jute materials. It also began seed production program in 1973 for distribution of quality jute seed among the growers. In 1974, it was further strengthened and Jute Development and Trading Corporation (JDTC) was formed. JDTC enhanced the programs regarding jute research and development activities. It introduced JRC 321 and JRC 212 of *C. capsularis*; and JRO 632, JRO 524 and JRO 7835 of *C. olitorius* jute varieties for cultivation in eastern terai. Promotion of jute cultivation and marketing of jute was improved through extension. In 1993, JDTC was terminated, and facilities and responsibilities related to jute research and development were handed over to Nepal Agricultural Research Council (NARC). NARC established Jute Research Program at Itahari giving mandate to lead on jute research and development activities in the country and establish linkage with national and international organization abroad for promotion of jute and allied fibre.

The crop is a means of cash earning for people of eastern terai. About 20000 people are employed in 9 jute industries and 0.1 million people are directly involved in jute production and processing. Nearly 2760.0 million rupees is earned annually from the export of jute products (MICS 2007). The crop is well fitted in existing cropping system without hampering main food grain crop especially rice and wheat. It adds organic matter to soil that is beneficial to succeeding crops. It is grown not only for fibre but also for farm fuel and fencing and saves forest resources. Rural poor earn their livelihood from jute farming

from casual labor. Small farmers are inclined towards jute cultivation as they earn cash for household expenses and engage their surplus household's labor.

TREND IN AREA, PRODUCTION AND PRODUCTIVITY

Jute area and production were recorded up to 56714 ha and 67514 mt, respectively, during 1979/80. However, situation has changed over the years and annual area under jute remains around 12000 ha with total fibre production of 17000 mt (Figure 1). The area and production under jute has increased by 6 and 4 per cent, respectively, during the last 5 years. The current productivity of jute is 1434 kg/ha (MOAC 2006/07). The productivity is low as compared to neighboring country India (2.2 mt). It can be attributed to uncertainty of raw jute price, higher cost of production, shortage of quality jute seed, labor and retting water. The remunerative crops such as sugarcane and spring rice are replacing jute.

DEMAND AND SUPPLY

At present, 9 jute industries are in operation. Their annual requirement of jute fibre is about 100 thousand metric tones while the domestic supply is about 17,000 mt. About 65 percent of raw jute is imported from India and Bangladesh (MICS 2007). Million of rupees is spent in importing raw jute from India and Bangladesh. On the other hand, only 10 percent of the jute products of the industries is consumed within the country and 90 percent jute products are exported to India (MICS 2007). To meet the raw jute requirement for jute industries, productivity level has to be increased from 1.43 to 2.0 mt and area to be extended up to 50000 ha.

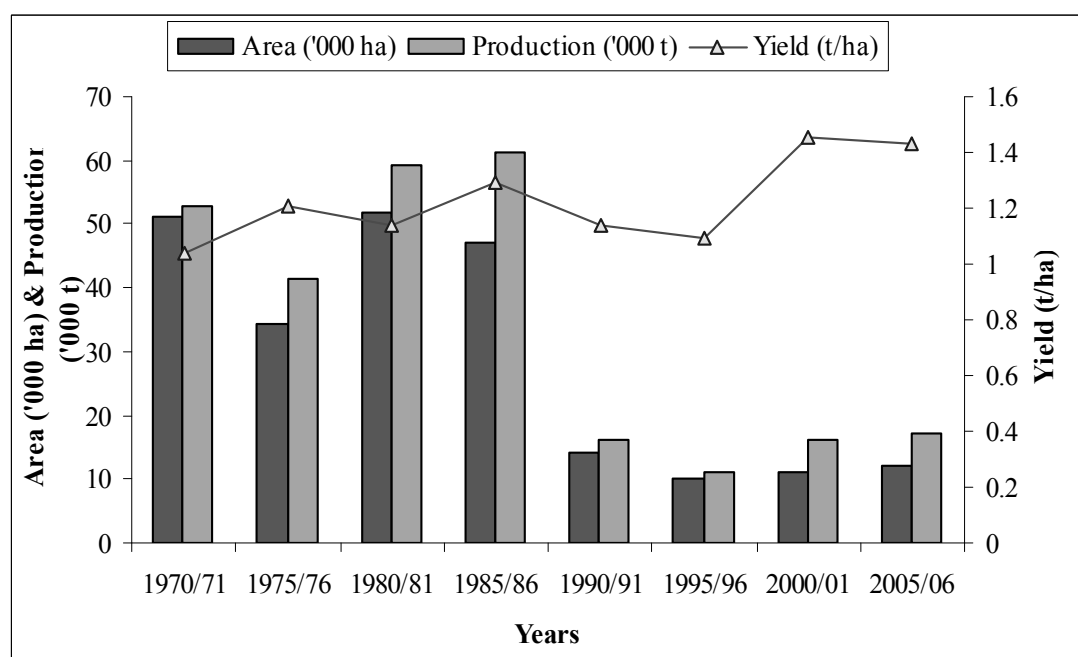


Figure 1. Trend in area, production and productivity of jute fibre over the years

PRODUCTION DOMAINS

Ecologically Jhapa, Morang, Sunsari, Saptari, Siraha and Udayapur are the main jute growing districts. District wise area, production and productivity of jute in Nepal is shown in Table 2. The climate is quite suitable for jute cultivation in this region. The *Corchorus capsularis* (Sada jute) and *Corchorus olitorius* (Tossa jute) are the two important fibre species grown in Nepal. Out of total jute area, tossa jute occupies about 76 percent of land and mainly grown in upland and mid-high land mostly under rainfed conditions.

Table 1. District wise area, production and productivity of jute during 2006/07

District	Area (ha)	Production (mt)	Productivity (mt/ha)
Jhapa	1200	1152	0.96
Morang	8200	12300	1.50
Sunsari	2075	3112	1.50
Saptari	75	75	1.0
Siraha	136	136	1.0
Udaypur	40	40	1.0
Total	11726	16815	1.434

Source: MOAC, 2006/07.

PRODUCTION CONSTRAINTS

Abiotic constraints

The crop is exclusively grown under rainfed conditions and suffers often from moisture stress in the early stage and occasionally from floods before harvest. Acidic soil in eastern terai is also one of the constraints for growing jute. Retting water and pond are also scarce for extraction and washing of jute.

Biotic constraints

Diseases like stem rot, collar rot, root rot and yellow mosaic cause considerable damage in the field. Insect pests like hairy caterpillar, semi-looper and mite infest the crop. Weeds severely invade the crops at the beginning and weeding and thinning operations become tedious and costly.

Socio-economic constraints

Cost of cultivation is high. Quality seed of jute is not available in time, place and required quantity. Extension services/ activities in jute are negligible. Price of raw jute is often low and not stable.

Technological constraints

High yielding, quality fibre producing and diseases tolerant varieties are not available.

Low investment

Trained man power for jute research and development is not sufficient. Research facilities in terms of infrastructure, building, laboratories etc are inadequate. Funding for jute research and development is also low. Irrigation facilities for research and seed production programs are also inadequate.

RESEARCH HIGHLIGHTS

Varietal development

(1) **Itahari-1 (IJO/LISA):** *Corchorus capsularis* (Sada jute) originated from Brazil, was recommended, in 2056 BS, for Jute-rice-wheat, Jute-vegetables and Jute-rice-fallow system in eastern terai of Nepal. It bears fewer branches and has tolerance to moisture stress at early stage, water logging condition, diseases and insects. It becomes ready for harvest at 120 days after sowing (DAS). The variety has quick retting ability with fine fibre quality (proper length and low breakage character) and produces an average yield of 1665 kg/ha (1120-3439 kg/ha).

(2) **Itahari-2 (IJO/T-86):** *Corchorus olitorius* (Tossa jute) originated from Taiwan is highly suitable for moisture stress areas at the time of sowing. It was recommended, in 2056 BS, for Jute-rice-wheat, Jute-vegetable and Jute-rice-fallow systems under upland and mid-lowland condition of eastern terai in the country. It has less branching habit and tolerance to water logging conditions. The variety has quick retting ability and good fibre quality (proper length and low breakage) with an average fibre yield of 1575 kg/ha (916-3254 kg/ha).

(3) **Promising Genotypes:** KEN/DS/058, DS/066, JRO 044, JRO 524, F 6 OLI and O-4 are promising genotypes with productivity of more than 3.0 t/ha fibre and more than 6.0 t/ha reeds.

Pre-harvest technologies

- Planting of jute on 30th Chaitra to 15th Baisakh for Sada jute is optimum for fibre production. Tossa performs better if sown after 15th of Baisakh (JRP, 2054/55; 2055/56 and 2056/57).
- De-topping twice at 30 and 40 days after sowing in Sada jute and thrice at 30, 45 and 60 days after sowing in Tossa jute has been found beneficial for higher seed production (JRP, 2054/55)
- 60:30:60 NPK kg/ha for Sada jute (*Corchorus capsularis*) and 40:20:40 NPK kg/ha for Tossa jute (*Corchorus olitorius*) has been recommended.
- Harvesting of jute at the stage of 90-120 days after sowing for *Corchorus capsularis* and 105-135 DAS *Corchorus olitorius* is found optimum for fibre production (JRP, 2055/56 and 2056/57).
- Jute-potato and Jute-gobhi sarson cropping sequences are profitable in partially irrigated condition of eastern terai (Ghimire et al 2007a).
- Mulching with straw @ 10.0 ton/ha and application of Targa super @ 2.0 ml/L at 20 DAS are effective against grassy weeds (Ghimire et al 2007b). Mix cropping with red amaranthus also suppresses weeds and seems to be economical.

Post-harvest technologies

- Jute bundle covered by rice straw and water hyacinth during retting are equally good for quality fibre production (JRP 2054/55).
- Jute fibre quality can be improved by one grade if jute bundles are pressed with plastic bag filled with sand or gravel.
- Jute ribbon retting treated with 0.02% Urea (20 g/L of water) or 0.2% EM (200 ml/L of water) results in superior fibre quality in Itahari-1.
- Ribbon retting fibre fetches higher quality price in the market as it has minimum root content and foreign materials.
- Ribbon retting fibre is more suitable and economical for manufacturing handy craft.
- Jute ribbon extraction method (fresh water extraction with the help of "V" shape notched bamboo pole) was found economical and best for quality fibre production.

Scaling-up activities

- Three day training on entrepreneurship development was conducted at Vokraha, Sunsari during 2003/04.
- One day training on jute cultivation (25 participants) and 3-month training on jute carpet weaving (10 participants) were completed during 2004/05.
- One day training on jute cultivation techniques and one day training on jute retting techniques were organized during 2005/06.
- One day training on jute cultivation techniques and one day training on jute retting techniques were organized during 2006/07.
- One day seed production training on jute was conducted in Siraha and community based seed production program was completed with production of 3000 kg quality jute seeds in collaboration with ADO Siraha, local NGO and Nepal Seed Company during 2006/07. This partially replaced Indian jute seeds during the last season.

FUTURE STRATEGIES

- High yielding jute varieties need to be identified/ developed especially of *Corchorus olitorius* suited for multiple cropping systems. Attention should also be given to select varieties with fine quality fibre; drought, flood and lodging tolerance; and diseases and insects resistance.

- Weed management is one of the expensive activities for jute cultivation and processing. Therefore, economic weed management technique has to be popularized among the jute growers to reduce cost of cultivation.
- Research on retting techniques should also be given top priority to reduce extraction cost and improve fibre quality. Introduction of extractor machine for mechanical cum retting technique is required to save time and water while improving fibre quality.
- Quality seed production and distribution should be strengthened for timely planting and increasing yield. For this community based jute seed production needs to be promoted.
- Research works also need to be concentrated on development and promotion of economic integrated pest management practices for increased fibre and quality seed production of jute.
- Increased collaboration with GOs/NGOs for scaling up of jute cultivation and processing techniques are required through community groups in potential jute growing districts where area under jute is negligible. Bridging among growers, traders and industrialists may accelerate technology adoption and increment in jute area.
- Investment on jute research and development activities is not adequate. Infrastructure development, trained man power, laboratories facilities and other physical facilities are required to accelerate the program.
- Policy for subsidies on inputs i. e. seeds, fertilizers and irrigation are needed to provide to curtail cost of cultivation so that the jute growers can compete with the growers of the neighboring countries. Also fluctuation and low price of jute fibre needs to be reviewed and managed.
- Development of jute entrepreneurship is pertinent to capture and mobilize rural youth force.

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Role of Legume Intercropping in Sustainable Farming in Mid Hills of Nepal

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ABSTRACT

Legumes are one of the important sources of cheap nitrogen fertiliser for soil as well as protein in human and animal diets and they are prominent crops under subsistence agricultural economy of Nepal. These crops are even much important in mid hills where large chunk of lands are sloppy by nature and needs proper conservation practices particularly with the use of legume crops. The study has been carried out to monitor status of legume intercropping in maize based cropping pattern and its role in sustainable farming in mid hills of Nepal. Nitrogen contribution by legume intercropping in the soil fertility maintenance has been found modest than under mono cropped maize fields. Although productivity of sole cropped maize is higher than that of legume intercropped, farmers have perceived that weed problem is lesser in legume intercropped area. Practice of cutting legume plants at the soil surface leaving root portion in the soil with a hope of enhancing soil fertility is still to be learnt practice by majority of the farmers. Organic matter content is also found higher under legume intercropped areas (52.20% of the soil samples show high OM) as compared to mono cropped areas (only 20.0%). Farmers use legumes as the sources of green vegetables and roughages in scarce period. Lack of new available technologies and innovations in easy access for example: Rhizobium inoculation for enhancing nitrogen fixation, lack of improved seeds, less importance given to legumes in maintaining high level of fertility and productivity have substantially declined the productivity of legumes in recent years putting question on the sustainability of crop production system in the mid hills.

Keywords: Intercropping, Rhizobium inoculation, soil fertility, sustainability, yield,

INTRODUCTION

Sustainable agriculture system seeks for the components with multidimensional benefits and less harmful to present and future of agriculture. Legumes are on of the best options to make agricultural system sustainable by enhancing soil fertility, making balance diet and protein rich feed for livestock. Intercropping will probable an essential part of future agriculture because it uses environmental and other resources more efficiently than does mono-cropping. Only those types of agriculture which maintain soil fertility can survive in the long run. Mono-cropping, which often allows erosion to proceed more quickly than soil can be formed, and which allows many other kinds of environmental damage, has clearly a limited future.

Some researchers suggest addition of nitrogen fertilizer in intercropping experiments because all modern agriculture use mineral fertilizers, but addition of N reduces the benefits to be derived from the practice of intercropping. This has led to some reports that legumes are not beneficial in the maize fields. When no N was added, the land equivalent ration (LER) for maize and soybean was 1.68, but when a significant amount of N was applied, the LER was only 1.33. However, the total weight of grain is much higher when nitrogen is applied. Even so, intercropping, when fertiliser is applied, is still very worthwhile because the total yield is 33 per cent higher. In cases where the cost of fertiliser is very high or where it is

not available, intercropping is important (Innis 1997). When the yields of three and four crop mixtures are measured, in imitation of the planting methods of many traditional farmers, the yields from the same resources can be two or even three times the yield from mono-cropping. In fact, the inefficient use of resources which accompanied the change-over from indigenous intercropping to modern mono-cropping may be a major cause of world hunger.

MATERIALS AND METHODS

Sindhupalchok is one of the mid hill districts in central region where sustainable soil management projects have been implemented after establishment of SSM-P in 1999 (STSS 2001). The study was conducted at Mankha VDC situated at the distance of 9 km from the district headquarter Chautara. Araniko highway runs in the skirts of this VDC, Khadichaur. This VDC is situated at the mid eastern region of the district on the northern side of the Sunkoshi river at 2300 ft. altitude level to 8035 ft. at Buwase. For the livelihood generation, 91 percent population is dependent upon the agriculture (Nepal 2007). Household survey was conducted from March to May 2007. A total of 201 households (HHs) were selected out of 1664 residents through simple random sampling technique. To represent the whole picture of Mankha, randomization was done according to HHs number in each hamlet. A focus group discussion (FGD) was conducted in 14 July 2007 at TUKI hall, Pangretar VDC. A set of structured questionnaire was pre-tested, modified and finalized to capture soil management practices followed by the farmers in the study area. Three soil samples were collected from each ward, one soil sample representing one HH. An attempt was made to collect 28 soil samples and these samples were analyzed for physical and chemical properties.

RESULTS AND DISCUSSION

Literacy and food security

Agreeing with Paudyal and Ransom (2005) many males were found going out for off-farm activities. Females were more responsible to the field activities than male counterparts and their literacy level and knowledge can be the major back force to uplift the agricultural economy of the country. But due to lack of education (51.0%) as presented in Table 1 has set them from learning sustainable farming methods and applying them in the practice.

Table 1. Sex and literacy level of respondents

Sex of respondents	Frequency	Respondents' literacy level (in percentage)			
		Illiterate	Literate	Below SLC	SLC & above
Male	105	30.5	27.6	33.3	8.6
Female	96	51.0	26.0	14.6	8.3
Total	201	40.3	26.9	24.4	8.5

HH heads were virtually male but control over the farming activities were mainly decided by female partners. More literate the HH head, female counterparts were freer to go into the organized group activities. Food security situation was merely contributed by HH head's literacy level (Table 2).

Table 2. Household head (HH) head literacy and food security situation

Household Head's literacy level	Food security situation (%)					Total in number
	Less than 3 months	3 to 6 months	6 to 9 months	9 to 12 months	Excess	
Illiterate	4.2	20.8	16.7	23.6	34.7	72
Literate	5.6	22.5	12.7	22.5	36.6	71
Below SLC	4.8	9.5	21.4	21.4	42.9	42
SLC & Above	0	0	9.1	9.1	81.8	11
Total	9	35	31	43	78	196

Cultivation

Legumes are cheap source of nitrogen fertiliser, organic manures and protein diet for human and animal food purpose. Intercropping legumes to get extra output from fields is traditional practice in subsistence farming and all the respondents have cultivated one or other legumes in the field as a source of vegetables and forage for the scarce period (Table 3). But use of urea for top dressing maize plants has resulted into competition for nutrients between the legumes and maize. This practice has also resulted into declined productivity of legumes also contributed by lack of improved seeds and *Rhizobium* culture inoculation practices.

Table 3. Number of respondents cultivating different legumes

Legume	Frenchbean	Ricebean	Blackgram	Soybean	Cowpea	Pea
Frequency (no.)	71	23	39	79	125	14

Cropping patterns

Cereals being the staple crop in the mid hills of Nepal, less care are given to legumes which are optional in daily diet. It is now, when the commercial value of different legumes as greens and pulse have increased, few enthusiastic farmers have started cultivating pea in large scale (1.7%) and earned money (Fig 1).

FGD and survey results revealed that maize as main field crop in Mankha was followed by paddy (100%), mustard (55.06%), and wheat (47.19%) in *khet* land and finger millet (82.68%), mustard (5.05%), wheat (3.35%) in *bari* land. Paddy – mustard – maize (22.3%) was main cropping pattern in *khet* lands. Main cropping pattern followed in *bari* lands was maize – finger millet (42.3%) in upper altitudes, maize – wheat in *bari* lands in lower altitudes (Fig. 1).

Source of seed

During survey, farmers have responded higher yield by the improved seeds they got from developmental organizations than the local seeds they were using. So, to maintain the quality and quantity of production improved seeds should be used. Use of home seeds (63.8%) is one of the reasons for declined production.

Table 4. Sources of seeds

Source	Home	Neighbors	Agro-shops	Organizations
In percentage	63.8	17.5	13.8	5.0

Farmers are also unaware of the *Rhizobium* inoculation technology to improve legume productivity (Table 5). So, farmers and concerned organizations should focus on these matters for survival of sustainable agriculture.

Table 5. Know how about *Rhizobium* inoculation

Particular	Yes	No
Knowhow about <i>Rhizobium</i> inoculation	0.5	99.5

Crop residue management

Knowledge about leaving legume roots in soil had good effects on soil health was gained by 44.4 percent sustainable soil management trained farmers and 23.7 percent HHs as a whole (Table 6) but traditional practice of post harvest operation of legumes was to uplift french bean roots (72.61%) along with plants which was easier to uproot than cutting above the ground was still prevalent (Table 7). Black gram and rice bean were also cut above ground leaving root portion with reason not making soil portion attached to plant, which was not liked by animals.

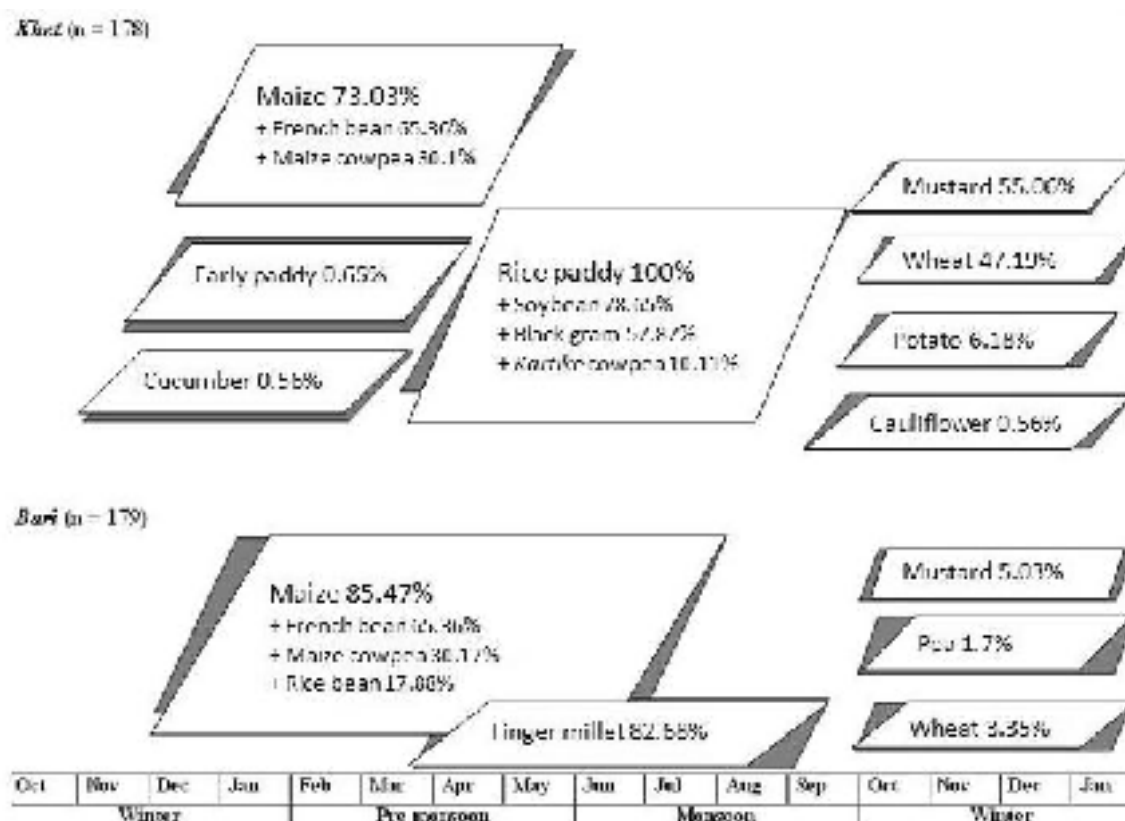


Figure 1. Cropping patterns followed

Table 6. SSM training and knowhow about leaving the legume roots improves soil fertility

Particular		SSM trained		Total
		Yes	No	
Know about leaving legume roots improves soil fertility	Yes	44.4%	55.6%	23.7%
	No	13.8%	86.2%	76.3%

Table 7. Practice of legume plants management during post harvest

Practice	Followed (in percentage)
Plant cutting leaving roots in soil	24.20
Uprooting and feeding grass portion to the animals	72.61
Both uprooting and plant cutting practice	3.20

Green manuring

Cut and carry green manuring was traditional practice in the area but was limited to cover the finger millet seed beds. *Shisoo* and *khirro* leafy twigs were used as green manure by 0.5 percent responded. This fact of not using green manures by 99.5 percent HHs confirmed Sherchan and Karki (2006) that usually farmers did not grow green manures crops on upland to enrich the soil (Table 8). Green manuring legumes with low C:N ration (below 20:1) is good practice to improve the soil organic matter is extensively used in conservation agriculture and organic farming.

Table 8. Green manuring knowledge

Particular	Yes	No
Knowhow about green manuring	0.5%	99.5%

Comparative difference in legume intercropped and mono cropped maize fields

The difference between commercial and traditional farming is the same as the difference between farming for maximum profit and farming for maximum yield. It is sometimes less profitable than mono-cropping because of extra labor involved in working with two crops in the same field at once. When hand labour is being used to produce one crop, very little extra labor is needed to intercrop (Innis 1997). It was not easier to inter-tillage in legume intercropped (89.5%) may be due to non linear sowing of legumes and maize plants (Table 9). However, legumes are the plants which protect the surface erosion in the rainy season after inter tillage.

Very few respondents (2.3%) could perceive increased productivity per unit investment in intercropped area than mono-crop maize (Table 9). This fact agreed with Innis (1997), the addition of urea as top dressing during the time when legumes are preparing for the fixation of nitrogen at their full potential whereas addition of urea results into the hindrance to nitrogen fixation and competition for the nitrogen between the main crop maize and intercropped legumes occur. Survey results show that maize productivity was 1621.90 kg ha⁻¹ in intercropped area in compare to 1619.71 kg in mono-cropped area with very least significance in yield. This is also contributed by amount of seed (average 1.5 to 2 kg) they sow and their survival after inter-culture operations. Many respondents (46.5%) thought that legumes use more soil water (Table 9). Others view was due to shade cover the place where legumes were intercropped, soils were moist. Number of respondents (28.1%) had not yet consciously checked soil moisture content in the mono-cropped and intercropped area comparatively. Early growth and ground cover by intercropped legumes suppress weeds in maize which was perceived by 3.6 percent respondents only (Table 9).

Table 9. Differences experienced by farmers in monocropping and intercropping maize

Comparative difference	In percentage		
	No difference	Sole maize crop	Intercropping legume
Inter tillage (Easier)	9.2	89.5	1.3
Productivity (Higher)	53.3	44.7	2.0
Moisture availability (Drier)	28.1	46.5	25.4
Weed problem (More)	22.3	74.1	3.6

Productivity

Farmers were worried about the productivity decline of legumes and cause may be use of urea in maize as few farmers shared their experience. Aphid problem in general and pod borer in black gram, cut worm in cowpea has also setback the yield in different legumes. Owls, Malewa feed on legumes in the field. One of the farmers quoted that 13 years before, a *ropani* land could yield 13 *pathi* ricebean but now no produce is gained (Table 10).

Table 10. Productivity of intercropped legumes

Particular	Productivity (kg ha ⁻¹)					
	French bean	Rice bean	Cowpea	Soybean	Black gram	Pea
N	77	25	41	127	79	17
Mean	322.8	824.4	644.8	1002.0	260.1	584.8
Maximum	1280.0	2400.0	3200.0	4800.0	1680.0	2400.0

Nutritive benefits

For adults, the recommended dietary intake of protein is 0.79 g per kg (0.36 g per lb) of body weight each day and this requirement is hard to fulfill by meat products in Nepalese context (Bray 2005). So, legumes can be the cheap source of protein in human diet. Most respondents (90%) mentioned that main benefit of legume is source of vegetable during dry period.

Table 11. Benefits of legume intercropping

Benefits of legume intercropping	In percentage
Vegetable source in scarce period	90.0
Vegetable plus roughage	10.0

Soil fertility status

Defending Innis (1997) when the leaves and roots of the legumes die, the recovery nutrients are returned to the surface layers of the soil. This is one of the most important ways in which intercropping can be more efficient than mono-cropping, this study had revealed that soil OM content was higher (52.2% soil samples) in the legume intercropped fields than mono-cropped area (20%). Available potash content was contributed by legume intercrops which were appreciable (39.1% soil samples) than mono-cropped area (0% soil samples) (Table 12).

The use of inorganic fertiliser to alleviate the low nitrogen content of soil is limited mainly by its high cost, untimely availability and low producer prices. As results show contribution of nitrogen by legume intercropped fields is modest to that of mono-cropped area, it is due to the untimely, uprooting of legumes for forage purpose, top dressing urea when legumes are at the stage to form maximum nodulation etc.

Table 12. Soil fertility status and legume intercropping

Soil properties	Condition	Rating#	In percentage	
			Legume intercropped (23)	Mono cropped (5)
Total Nitrogen	Low	0.05 to 0.1	21.7	20.0
	Very low	below 0.05	78.3	80.0
Soil OM	High	5.0 to 10.0	52.2	20.0
	Medium	2.5 to 5.0	34.8	60.0
	Low	1.0 to 2.5	4.3	20.0
	Very low	below 1	8.7	0.0
	Very high	above 500	39.1	0.0
Available potash	High	280 to 500	13.0	40.0
	Medium	110 to 280	39.1	40.0
	Low	55 to 110	8.7	20.0
Available phosphorus	Very high	above 110	95.7	100.0
	Medium	30 to 55	4.3	0.0
Soil pH	Acidic	Below 5.5	17.4	0.0
	Slightly acidic	5.5 to 6.5	69.6	80.0
	Neutral	6.5 to 7.5	13.0	20.0

Source: SMD 2004 and SMD 2007

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Conservation Agriculture: A System for Sustainable Food Production

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ABSTRACT

Conservation Agriculture (CA), defined as minimal soil disturbance (no-till) and permanent soil cover (mulch) combined with rotations, is more sustainable cultivation system for the future than those practiced these-days. Present tillage system is responsible for the degradation of natural resources and soils. CA can improve agriculture through improvement in water infiltration and reducing erosion, improving soil surface aggregates, reducing compaction through promotion of biological tillage, increasing surface soil organic matter and carbon content, moderating soil temperature, and suppressing weeds. CA also helps reduce cost of production, saves time, increase diversity, and reduces greenhouse gas emissions. Availability of suitable equipment is a major constraint to successful CA. National promotional program for this technology is needed in present Nepalese context.

INTRODUCTION

The demand for food is still increasing; not only to meet food security for a growing population, but also to provide more nutritious food that makes protein quality, vitamins, and some essential minerals (iron and zinc) more available. There is also increasing demand for meat products and hence the grains and fodder needed to feed livestock.

The land available to produce this extra food is shrinking because of urbanization and use of agricultural land for other purposes. The quality of this new land may be less than that already in use for agriculture. Most of the sources of productivity growth e.g. improved varieties, fertilizer and water are already being utilized. Competition for water resources, especially surface and ground water, will be more severe in future as domestic and industrial needs increase.

Costs of fossil fuels are increasing, causing higher production costs through higher diesel, fertilizer and other input costs. Greenhouse gas emissions such as carbon dioxide, methane, and nitrous oxide that have inherent warming effects on the atmosphere will increase with subsequent effects on climate causing drought and floods.

One obvious way for sustainable food production is to make more efficient use of the natural resources that are needed to produce food; this includes water, soil, air, solar radiation, inputs and labor.

MERITS AND DEMERITS OF TILLAGE

Tillage, an agricultural practice, has been used since over 10,000 years. Tillage is the act of soil manipulation with an implement powered manually or by animals or tractors. Other names for tillage include ploughing, cultivation, digging, etc. There are many reasons as given below for adopting tillage:

- It is used to incorporate the previous crop residues, weeds or amendments added to the soil, such as organic and inorganic fertilizers.

- It is the first step in the preparation of a seedbed, essentially the name for soil that is prepared to receive the seed of the planted crop.
- It helps aerate the soil organic matter (OM), which in turn helps release and make available to plants nutrients tied up in this important soil component.
- It is a recommended practice for controlling several soil- and residue-borne diseases and pests.
- It provides relief from compaction, albeit in some cases only temporarily, a physical property of soil that restricts root and water penetration and reduces yield.

Tillage has also detrimental effects on both the environment and farmers. Tillage costs money in the form of fuel for tractors, wear and tear on equipments, and the cost of the operator. If animals are used as power source, the cost of feeding and caring for the animals over a full year are also high. Greenhouse gas emissions from the burning of the diesel fuel add to global warming.

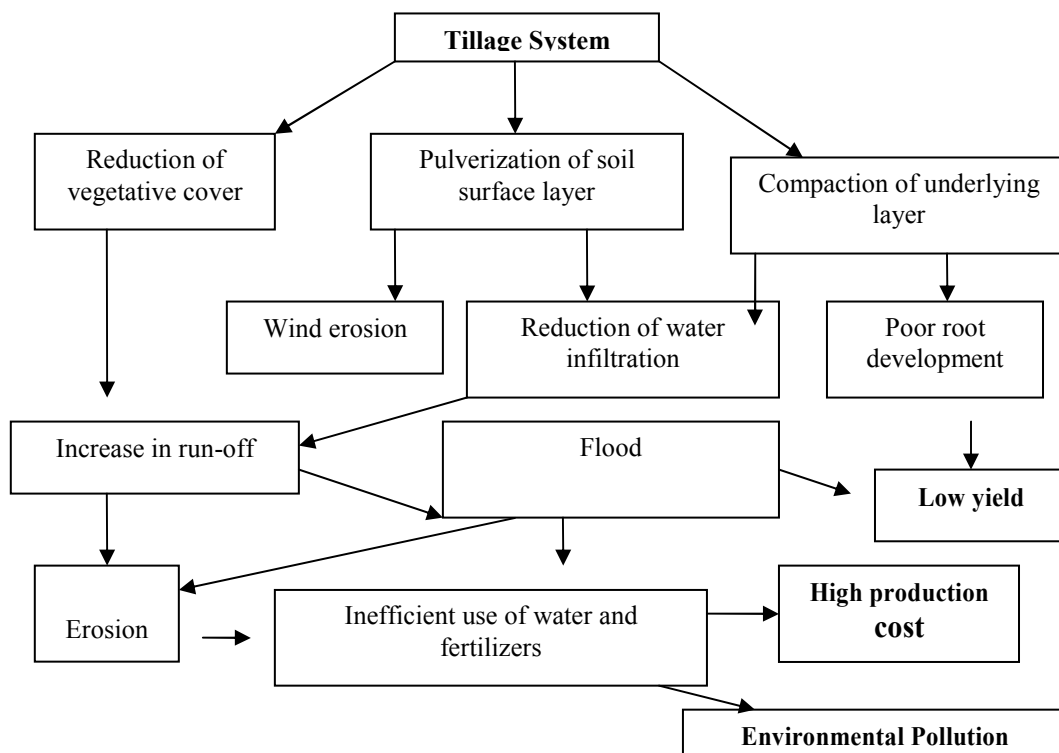


Fig.1 Effects of inappropriate tillage practices

Soil OM is oxidized when it is exposed to the air by tillage, resulting in a reduction in OM content, unless additional OM is returned to the soil as residues, compost, or other means. Tillage disrupts the pores left by roots and microbial activity. The bare surface exposed after tillage is prone to breakdown of soil aggregates as the energy from raindrops is dissipated; this results in clogging of soil pores, reduces infiltration of water and increased run-off, leading to soil erosion. When the surface dries, it crusts and forms a barrier to plant emergence. The bare surface after tillage is prone to wind erosion and tractor tires compact the soil below the surface. Figure 1 demonstrates the negative effects stemming from inappropriate tillage practices.

CONSERVATION TILLAGE AND CONSERVATION AGRICULTURE

Conservation tillage is the collective umbrella term commonly given to no-tillage, direct drilling, minimum tillage and or ridge tillage, to denote that the specific practice has a conservation goal of some nature. Usually, the retention of 0.3 surface cover by residues characterizes the lower limit of

classification for conservation tillage, but other conservation objectives for the practice include conservation of time, fuel, earthworm, soil water, soil structure and nutrients. Thus residue levels alone do not adequately describe all conservation tillage practices (Baker et al 2007).

FAO mentions “Conservation tillage is a set of practices that leave crop residues on the surface which increases water infiltration and reduces erosion”. Conservation tillage practices can be transition steps towards Conservation Agriculture (Hobbs 2006).

Where, conservation agriculture defined by FAO is as follows; “Conservation agriculture (CA) aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. It can also be referred to as resource efficient or resource effective agriculture (FAO 2006). FAO has characterized CA as follows: Conservation agriculture maintains a permanent or semi-permanent soil cover. This can be a growing crop or dead mulch. Its function is to protect the soil physically from sun, rain and wind and to feed soil biota. Therefore, zero or minimum tillage and direct seeding are important elements of CA. A varied crop rotation is also important to avoid disease and pest problem (FAO 2006).

In the rice-wheat areas of South Asia, no-till planting of wheat has increased rapidly over the past six years with more than 3.2 million ha reported in the 2005/06 wheat season in the Indo-Gangetic Plains (Rice-Wheat Consortium Research Highlights 2006). One of the major benefits of CA is that it costs less in terms of money and time (Hobbs and Gupta 2004). On an average, US\$ 55 is saved on tillage costs, 50-60 liters diesel fuel is burned and crop yields have risen 247 kg/ha compared to normal tillage systems for wheat after rice. Since planting can be accomplished in one pass of the seed drill, the time needed for planting was also reduced, thus freeing farmers to do other productive work. Surveys of farmers concerning no-till wheat systems in India (Malik et al 2004) and Pakistan (Khan and Hashmi 2004) confirm these results and show that farmers who have adopted no till planting of wheat after rice have definite economic and social benefits occurring from this technology. Similarly, according to Sah et al (2005) farmers of Nepal who are adopting wheat cultivation after rice using minimum-till technique have obtained higher yields with lower production cost (Fig.2).

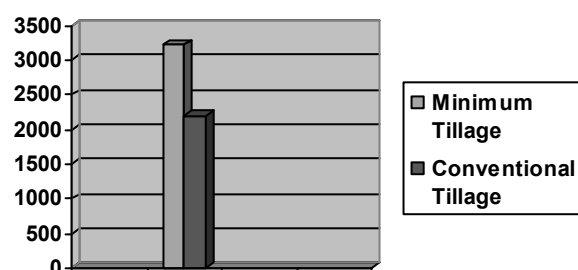


Fig. 2: Mean Wheat Grain Yield by Minimum Tillage over 1996/97-2006/07

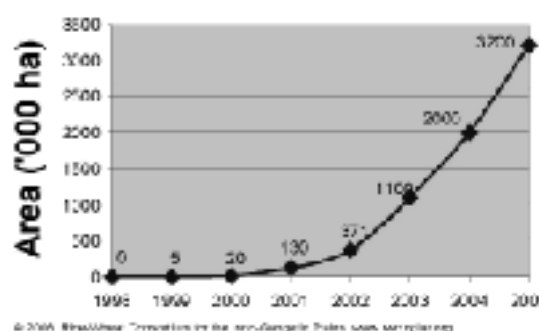


Fig.3: Adoption of Resource Conservation Technologies in the Indo-Gangetic Plains (1998-2005)

Water-use efficiency increased in the Rice-Wheat system because the first irrigation could often be eliminated, and when the first irrigation was given the water flowed faster across the field. Water savings of 15-50 percent have been calculated, with greater savings occurring when crops are planted on beds (Sayre and Hobbs 2004). Similar results were obtained in the trials at the Agricultural Implement Research Centre, Nepal (Sah et al 2007).

Mulch resulting from leftover residues is a key component of CA and helps promote more stable soil aggregates as a result of increased microbial activity and better protection of soil surface. Data from a 5-

year rice-wheat-moong bean trial at the AIRC, Nepal show higher grain yields with mulch, Table 1 (Sah et al 2007).

Table 1. Wheat grain yields (kg/ha) influenced by planting methods and mulching at AIRC, Birganj, Nepal during 2002/03-2006/07

Treatment	Year					Mean
	2002/03	2003/04	2004/05	2005/06	2006/07	
Flat + no mulch	3077	3848	4942	3192	3839	3780
Flat + mulch	3549	4189	5043	3399	4006	4037
Bed + no mulch	3220	4536	5187	3223	4013	4036
Bed + mulch	3684	4360	5324	3822	4734	4385
C. V. (%)						9.35
LSD _(0.05)						245

CA resulted in improved fertilizer efficiency (10-15%) in the RW system mainly as a result of better placement of fertilizer with the seed drill as opposed to broadcasting in the traditional system (Hobbs and Gupta 2004).

Table 2. Dry weed mass (g/m²) influenced by planting methods and mulching at AIRC, Birganj, Nepal during 2002/03- 2004/05

Treatment	2003/03			2003/04			2004/05		
	Wheat	Moong	Rice	Wheat	Moong	Rice	Wheat	Moong	Rice
Flat + no mulch	123.8	141.1	5.8	181.7	234.1	117.6	117.2	234.1	64.3
Flat + mulch	42.3	101.1	6.0	77.5	182.4	101.1	108.6	182.4	24.2
Bed + no mulch	59.1	57.0	10.7	220.3	107.1	80.2	30.5	107.1	64.8
Bed + mulch	45.8	33.4	5.8	58.1	102.7	54.4	26.4	102.7	48.9

No-till uses less diesel fuel and thus results in lower carbon dioxide emissions, one of the gases responsible for global warming. In R-W systems, 40-60 litres of diesel fuel are saved because of farmers can forego the practice of ploughing many times to get a good seed-bed following puddling-degraded rice soils (Hobbs and Gupta 2004). A reduction of 50-60 percent has been shown in the germination of weeds in CA in R-W system, This is a unique weed situation in the R-W systems, the winter annual grassy weeds *Phalaris minor*, which is buried during the soil puddling exercise for rice, does not germinate during warm summer season and the buried seeds need to be exposed to the air by tillage to germinate in the cooler wheat season. Weed pressure was substantially reduced with the application of mulch in the R-W system in the trials at the AIRC, Nepal, Table 2 (Sah et al 2007). CA increases biotic diversity in the soil as a result of the mulch and reduced soil disturbance. It also produces higher surface soil organic carbon than when soils are tilled. The surface mulch also helps moderate soil temperatures and moisture, which is favorable for microbial activity. Groundcover also promotes an increase in biological diversity below and above ground; there are more beneficial insects where there is ground cover and mulch (Kendal et al 1995, Jaipal et al 2002) and these help control insect pests.

Less lodging was seen in no-till wheat in RW systems than with conventional tillage, especially on beds (Hobbs and Gupta 2004). No-till farmers need to adjust management to control diseases through sowing date, rotations and resistant cultivars to help shift the advantage from the disease to crop (Leakes 2003). More earthworms were found in no-till treatments in Australia (Table 3).

Table 3. Earthworm Populations under various tillage treatments with and without residue mulch in Australia (Chan and Heenan 1993)

Residue Management	Direct drilling (NT)	Reduced Tillage (RT)	Conventional Tillage (CT)
Retain straw residue	17	14	4
Burn straw residue	18	7	4

EQUIPMENT ISSUES

A major requirement of CA system is the development and availability of equipment that promotes good germination of crops planted into soil that is not tilled and where residue mulch occurs on the soil surface. It should also be able to place bands of fertilizers for increased efficiency. Recently, multi-crop, zero-till-cum- fertilizer drills fitted with inverted –T openers, disk planters trash-movers or roto-disc openers, minimum till drill (PTOS) have been developed for seeding into loose residues. This range of equipment means that small- and large-scale farmers can use this technology. In south Asia where land holdings are small and many farmers do not own a tractor, a system of rental or service providers make no-till available.

FARMER ADOPTION OF CA WORLDWIDE

Data reported by Derpsch (2005) indicate that the extent of no-tillage adoption worldwide is just over 95 million ha. This figure is a proxy for CA, although not all of this land is permanently no-tilled or has a permanent ground cover. Table 4 shows the extent of no-tillage by country. Six countries have more than 1 million ha of no-till. South America has the highest adoption rate and has more permanent no-till and permanent soil cover. Both, Argentina and Brazil had significant lag periods to reach 1 million ha in the early 1990s, and then expanded rapidly to the present day figure of 18.3 and 23.6 million ha, respectively (Derpsch 2005). Derpsch (2005) estimates that Brazil increased its grain production by 67.2 million tons in 15 years, with additional revenue of US\$ 10 billion. Derpsch (2005) also estimates that at an average rate of 0.51 tons/ha/year, Brazil sequestered 12 million tons of carbon on 23.6 million ha of no-till land. Tractor use was also significantly reduced, saving millions of litres of diesel fuel. Similarly, Figure 3 shows the adoption rate of Resource Conserving Technologies in the Rice-Wheat Consortium for the Indo-Gangetic Plains (from 1998 to 2005). The adoption of this resource conservation technologies has not only produced an additional 0.5 million tons of wheat, but also saved a foreign exchange of US \$ 80 million through reduced fuel consumption in tillage and irrigation operations in the region (RWC Research Highlights 2005/06). Though very low, the area under adoption of resource conserving technologies and their benefits in Nepal are presented in Table 5 and 6.

Table 4. Extent of no- tillage adoption worldwide

Country	Area under no tillage (million ha) 2004/05
USA	25.30
Brazil	23.60
Argentina	18.27
Canada	12.52
Australia	9.00
Paraguay	1.70
Indo-Gangetic Plains*	1.90
Bolivia	0.55
South Africa	0.30
Spain	0.30
Venezuela	0.30
Uruguay	0.26
France	0.15
Chile	0.12

Colombia	0.10
China	0.10
Others (Estimate)	1.00

Total **95.48**

Source: Derpsch (2005); * includes area in India, Pakistan, Bangladesh and Nepal in South Asia.

Table 5. Adoption of Resource Conserving Technologies in Nepal, 2006/07

Technology	Area coverage (ha)
Zero- and Minimum tillage (ZTD & PTD)	678
Reduced tillage by Animal-drawn harrow (ADH)	944
Reduced tillage by Power tiller (PT)	15000
Total	16622

Table 6. Saving from different RCTs on wheat at National Wheat Research Program, Bhairahawa

Item	Percent saving /income increased
Saving in seed	10-13
Saving in land preparation and sowing cost	48-98
Saving in irrigation cost	22-44
Total cultivation cost	10-21
Production increase	5-25
Net income	33-60
Benefit cost ration against (0.95)	1.52-1.67

CHALLENGES TO ADOPTION OF CA

Probably, the first challenge faced was overcoming the mindset of the farmers in relation to changing the traditional way of farming, where tillage is considered essential. Farmers have to be convinced that it is possible to get good yields without tillage. A more practical way to convince the farmers is participatory system where they are provided with equipment and training to experiment with the technology and find out for them whether it works and what fine-tuning is needed to make it successful on their land. Other stakeholders, especially equipment manufactures, are also needed in order to modify the equipment as the farmers' requirement. Once this is done and the farmer is convinced that the CA methods are beneficial to him, he becomes the best extension agent for his village and neighboring farmers and adoption is accelerated. However, in order for accelerated adoption, farmers must also have easy access to machinery suitable for planting no-till crops into crop residues.

Since, many of the farmers in the village do not own tractor, another challenge is making equipment available to all farmers in a village once the farmers are convinced of the benefits of CA. At first, the tractor owners thought losing income from renting tractors out for plowing. Once the tractors owner was convinced to buy a no-till drill and provide the service with a fee to other farmers, this problem disappeared; whole villages were then able to adopt the technology.

Another challenge to the adoption of CA is related to the fact that the full benefits of CA take time to appear and, in fact, the initial transition years many present problems that influence farmers to abandon the technology. Weeds are the major initial problem that requires integrated weed management over time to get them under control. In the R-W system, weeds were actually fewer in the no-till wheat system than traditional tillage. In the rice phase, however, weeds are still the major constraint to using no-till or dry direct seeded rice; this problem must be solved before farmers will accept this practice for rice and allow the full benefits of CA for the entire annual cropping system. Soil physical and biological health also takes time to develop. It is hypothesized that it may take 3-7 years before physical and biological properties improve enough to be observed when the R-W system shifts from a puddle rice to a more aerobic system.

The last challenge encountered in this issue is delay in providing funds for research and development of CA and similar sustainable technology due to difficulty to convince the donors or government agencies. This means that the funding must be sustainable if CA-type technologies are to be successfully developed, introduced and adopted by farmers.

CONCLUSION

Crop production in the next decade should be increased from less land by making more efficient use of natural resources-and with minimal impact on the environment. Only by doing so can food- production keeps pace with demand, while the land's productivity is preserved for future generations. This is a significant challenge for agricultural scientists, extension personnel and farmers. Use of productive but more sustainable management practices described in the present paper can help solve this problem. Crop and soil management systems that improve soil health parameters (physical, biological and chemical) and reduce farmer's costs are essential. Development of appropriate equipment to allow these systems to be successfully implemented by farmers is a prerequisite for success. Overcoming traditional practices about tillage by promoting farmer experimentation with this technology in a participatory way will help accelerate adoption. Encouraging donors to support this long-term, applied research with sustainable funding is also urgent need.

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Effects of Nitrogen Levels and Plant Densities on the Grain Production of Maize (*Zea mays* var. Deutee) at the Acid Soils of Rampur, Chitwan

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ABSTRACT

Requirement of nitrogen by maize crop depends on the plant population. The quantity of fertilizer-N applied to the maize crop determines the yield increase or decrease and hence, profitability of the crop. To evaluate the effects of nitrogen levels (60, 90 and 120 kg N/ha) on the maize planted at varying densities (55,555; 66,666 and 83,383 plants/ha), an experiment was carried out for two consecutive years (2006 and 2007) in the farmland of National Maize Research Program, Rampur in a RCB design with three replications. A constant dose of manures and fertilizers at 10 tons of compost and 40: 30 kg/ha of P₂O₅ and K₂O was applied basally in all the experimental plots. The yield and yield parameters were analysed statistically. The results revealed that the highest grain yield of 9.71 t/ha were produced by the Deutee variety (previously known as ZM-621) when the crop was supplied with 120 kg N/ha and crop planted at the density of 66,666 plants /ha which was almost 37 percent higher than those produced by the same variety planted at the 55,555 plants/ha and crop fertilized by 60 kg/ha of N (7.09 t/ha). It is concluded that application of N at 120 kg/ha applied along with basal application of 10 t of compost and 40: 30 kg/ha of P₂O₅ and K₂O could increase the maize grain yield irrespective of the plant densities.

Key words: *Zea mays*, nitrogen levels, plant densities

INTRODUCTION

Maize (*Zea mays* L.) is the second most important food crops of Nepal but its grain yield production has been declining for the last few years as reported from many parts of the country. Lemcaff and Loomis (1986) reported that grain weight and grain numbers in maize are strongly influenced by nitrogen (N) supply. Adhikary and Sharma (1995) reported a significant response of maize varieties to plant densities and N levels at which the grain production would reach a peak. Neupane and Basnet (2002) conducted experiments on maize using 3 levels of nitrogen and 3 plant densities in the Arun-2 and Pool 15 E maize genotypes and reported a non-significant response of N and densities on those varieties; however, the highest grain yield of 2.35 t/ha was obtained in the Arun-2 variety at 120 kg N/ha and 95,000 plant population. Adhikary et al (2004) studied the effects of N levels and plant densities on the grain production of two maize varieties Gaurav (hybrid) and Hill Pool White (OPV). The highest grain yield (9,352 kg/ha) was recorded with the Gaurav variety when the crop was supplied with 120 kg N/ha and crop planted at the density of 53,333 plants /ha. Adhikary et al (2001) studied on the effects of manures and fertilizers on maize production in acid soils of Malepatan, Pokhara and reported that the highest grain yield of 4.65 t/ha was recorded when the crop was fertilized by basal application of 10 t of compost applied along with 75 : 40 kg P₂O₅ and K₂O/ha which was almost 151 percent higher yield increment over the non-treated control in the Manakamana-1 variety. Application of only 100 kg N/ha produced only 3.98 t/ha of grains which was 115 percent higher to that of the non treated control plot in this variety.

There is a gradual increase in the requirement of N by the growing maize crop, the highest N requirement being exhibited at the flowering stage, subsequently the demand for N starts declining. Therefore the adequate N supply should be ensured from germination to the flowering stage. Nitrogen level in the range of 100 - 120 kg /ha is applied with a view to obtain 4-5 t/ha of grain yield (Dayanand 2002). Therefore, this experiment was conducted with the objective to determine the optimum level of nitrogen and plant densities for increased grain yield of maize, Deutee variety in the farmland of NMRP, Rampur during the years 2006 and 2007.

MATERIALS AND METHODS

Deutee, a full season maize variety (previously known as ZM-621), was tested for 3 levels of nitrogen (60, 90 and 120 kg N/ha) and 3 plant densities of maize for 2 consecutive years (2006 and 2007). A factorial RCB design with 3 replications was employed in the experiment. The crop was fertilized with basal application of 10 tons of compost and 40:30 kg /ha of P_2O_5 and K_2O , respectively in all the experimental plots. Three levels of N was applied in the concerning plots, half as basal application and the other half as topdressing at knee high stage. The crop was planted in the month of September at a spacing of 30 cm x 60 cm (55,555 plants), 25 cm x 60 cm (66,666 plants) and 20 cm x 60 cm (83,383 plants /ha) and harvested in the month of January at full maturity. The nitrogen level and crop densities were arranged in factorial design. The crop was sown at a plot size of 12 sq. m. (3 m x 4 m). Soil samples were collected before crop planting and after crop harvest and analysed for pH, organic matter and nitrogen content. Growth and production parameters were studied and analysed statistically following LSD method (Gomez and Gomez 1984). The following treatments combination was used in the experiment.

RESULTS AND DISCUSSION

Effect of nitrogen and densities on plant characters

The results as shown in Table 1 and Table 2 indicated that non-significant effect of density on ear length, ear height and kernel numbers in the row were observed. Plant height (ht) was also not affected significantly in both of the years. However, the effect of nitrogen on ear length and kernels number per row were significantly affected during the year 2007 (Table 2) but not in the 1st year (Table 1). Effect of density on the straw production was significant during the year 2006 (Table 1). The highest straw yield of 12.89 t/ha was recorded in the year 2006 when the crop was supplied with 60 kg N and crop planted at 83,383 plants /ha. The effect of N and density on thousand grain weight (1000 grain wt.) was observed to be significant. The highest 1000 grain wt. of 470 g was recorded in the year 2007 when the crop was fertilized with 120 kg N/ha and crop planted at the density of 66,666 plants (Table 2). The lowest 1000 grain wt. of 321.7 g was recorded in the year 2006 when the crop was supplied with 90 kg N and crop planted at the density of 55,555 plants /ha (Table 1).

Effect of nitrogen and plant density on grain yield

The results revealed that the highest grain yield (12.38 t/ha) was obtained in the 1st year (2006) when the crop was supplied with 120 kg N and crop planted at the density of 66,666 plants/ha. The lowest grain yield of 8.52 t/ha was recorded in this year when the crop was planted at the high density (83,383 plants /ha) and crop supplied only with 60 kg N/ha (Table 3). Similarly, the highest grain yield of 7.04 t/ha was recorded in the 2nd year (2007) when the crop was planted at the density of 66,666 plants /ha and with highest level of N fertilization. The lowest grain yield of 4.44 t/ha was recorded in this year when the crop was fertilized with 60 kg N and crop planted at the density of 55,555 plants /ha (Table 3). The two years mean results indicated that the highest mean grain yield of 9.71 t/ha was produced when the crop was fertilized by 120 kg / and crop planted at the density of 66,666 plants/ha (D2N3) and lowest (7.09 t/ha) in the plot that received only 60 kg of N /ha and crop planted at the density of 55,555 plants /ha, ie 30 cm x 60 cm of plant spacing. The highest yield increment of 36.95 percent over D1N1 was observed when the crop was fertilized with 120 kg of N and crop planted at the density of 66,666 plants/ha (Table

3). The effect of density and nitrogen levels on grain yield was found to be significant in both years. The highest grain yield of 8.88 t/ha was recorded by the effect of density as shown in two-way table (Table 4), whereas the effect of nitrogen on grain yield was observed to be increasing with increasing levels of nitrogen irrespective of the plant population. Increased grain yield of 9.39 t/ha was recorded when the crop was supplied with 120 kg N/ha (Table 4).

Table 1. Effects of nitrogen and plant densities on the growth and yield parameters of maize during the year 2006

Treatments	Ear L (cm)	Ear ht (cm)	K/row (no.)	Pl ht (cm)	SY/ha (t/ha)	K rows/ear (no.)	Test wt. (g)
1	13.33	80	24.33	192.3	12167	12.67	396.1
2	13.67	75	28	176.3	9744	13.67	321.7
3	17	84.67	29.67	201.7	11411	13.33	405.8
4	14.33	75.67	23.33	186.3	10028	13.33	382.1
5	14.33	78.33	25	188.7	10678	14	372.1
6	14.33	76.33	27	186.3	10683	13.33	370.8
7	12.33	74.67	25.33	185	12894	13.33	347
8	14	78	28.33	198.3	10900	13.67	418.8
9	13.33	94	26.67	210.3	12189	13.33	384.8
GM	14.07	79.6	26.41	191.7	11118	13.41	377.7
F-test (D)	Ns	ns	ns	ns	*	ns	ns
(N)	Ns	ns	*	ns	ns	ns	ns
(D x N)	Ns	ns	ns	ns	ns	ns	ns
LSD							
(D)	1.189	9.84	2.092	14.19	1191	1.14	42.31
(N)	1.189	9.84	2.092	14.19	1191	1.14	42.31
(D x N)	3.151	17.05	3.624	24.57	2063	1.974	73.28
CV %	12.9	12.4	7.9	7.4	10.7	8.5	11.2

*=Significant, **= highly significant and ns= non-significant.

Table 2. Effects of nitrogen and plant densities on the growth and yield parameters of the maize during the year 2007

Treatments	Ear L (cm)	Ear ht (cm)	K/row (no.)	Pl ht (cm)	SY/ha (t/ha)	K rows/ear (no.)	Test wt. (g)
1	12.7	30	27.0	76	6.28	13.0	381.3
2	15.0	35	29.7	75	7.60	13.7	431.0
3	16.0	36	32.7	74	6.86	13.3	433.7
4	13.3	36	27.7	76	7.27	13.3	416.0
5	14.0	30	26.3	69	7.55	13.7	405.3
6	15.0	33	30.0	78	7.78	14.0	470.0
7	13.0	38	25.7	78	6.55	13.0	387.0
8	14.0	34	31.7	73	7.03	13.0	431.7
9	14.7	35	28.0	77	8.77	12.7	430.7
GM	14.2	34	28.7	75	7.30	13.0	421.0
F-test (D)	Ns	ns	ns	ns	Ns	Ns	S
(N)	**	ns	*	ns	Ns	Ns	S
(D x N)	Ns	ns	ns	ns	Ns	Ns	Ns
LSD (D)	1.07	3.58	2.57	5.84	1.235	0.83	50.3
(N)	1.07	3.58	2.57	5.84	1.235	0.83	50.3
(D x N)	1.86	6.2	4.46	10.0	2.139	1.4	90.6
CV %	7.6	10.5	9.0	7.8	16.9	6.2	21.0

*=Significant, **= highly significant and ns= non-significant.

Table 3. Response of nitrogen levels and plant densities on the grain production of Deutee maize variety

S.No.	Treatments	Grain production (t/ha)			Increment over D1N1 (%)
		2006	2007	Two years mean	
T1	D1N1	9.74	4.44	7.09	0.00
T2	D1N2	9.33	6.45	7.89	11.28
T3	D1N3	11.50	6.88	9.19	29.61
T4	D2N1	10.96	5.52	8.24	16.22
T5	D2N2	11.24	6.17	8.70	22.70
T6	D2N3	12.38	7.04	9.71	36.95
T7	D3N1	8.52	4.98	6.75	(-) 4.79
T8	D3N2	9.60	6.68	8.14	14.80
T9	D3N3	11.87	6.69	9.28	30.88
Cv (%)		10.5	9.9		
F-test (density)		*	*		
F-test (nitrogen)		**	**		
F-test (D x N)		ns	ns		
LSD (density)		1.119	0.606		
LSD (nitrogen)		1.119	0.606		
LSD (D x N)		1.939	1.049		

*= Significant, **= highly significant and ns= non-significant.

Table 4. Combined effect of plant densities and nitrogen level on maize grain yield (t/ha)

Density	Nitrogen levels (t/ha)			Density mean (t/ha)
	N1	N2	N3	
D1	7.09	7.89	9.19	8.05
D2	8.24	8.70	9.71	8.88
D3	6.75	8.14	9.28	8.05
Nitrogen mean (t/ha)	7.36	8.24	9.39	
CV (%)				
10.25				
F-test (D)				
*				
F-test (N)				
**				
F-test (DxN)				
Ns				
LSD 0.05 (D)				
1.725 t/ha				
LSD (N)				
0.898 t/ha				
LSD (NxN)				
1.494 t/ha				

*= Significant, **= highly significant and ns= non-significant.

It is noticed that the soil pH was found decreased in both years compared to those of the composite samples taken before experimentation (5.5 pH), whereas the OM was found increased (highest 2.17% OM) in the 1st year but not in the second year. Total nitrogen (N) was also found increased in the 1st year drastically but in the following the increment of nitrogen was not satisfactory (Table 5).

CONCLUSION

- The effect of N ear length and kernels per row were observed to be significantly affected in the 2nd year while the effect of N was observed to be significant only on the kernel production in the row in the 1st year. The effect of density was observed to be significantly affected in the 1st year (2006) but not in the 2nd year (2007). The highest straw yield (12.89 t/ha) was recorded in the year 2006 when the crop was planted at the density of 83,383 plants /ha and crop fertilized by 60 kg of N/ha. The lowest straw yield (6.28 t/ha) was recorded in the 2nd year when the crop was planted at the density of 55,555 plant population and crop fertilized with 60 kg N/ha only.

- The highest grain yield of 12.38 t/ha was recorded in the 1st year (2006) when the crop was planted at the density of 66,666 plants /ha and crop fertilized with 120 kg /ha of N. Only a 7.04 t/ha of grains were produced at this level of fertilization and densities in the 2nd year (2007). The two-years mean result indicated that 9.71 t/ha of grains could be produced when the crop was planted at 66,666 plants /ha and N at 120 kg/ha. The effect of N on grain production of maize was observed to be increasing with increasing levels of nitrogen.

Table 5. Soil test results of the experimental plots

Treatments	2-years mean soil test results for P and K		Soil test values of the year 2006			Soil test values of the year 2007		
	P ₂ O ₅ (kg /ha)	K ₂ O (kg/ha)	pH (units)	OM (%)	Total N (%)	pH (units)	OM (%)	Total N (%)
T1	521.2	210.5	5.00	1.85	0.085	5.18	1.40	0.073
T2	547.0	206.0	5.05	2.01	0.101	5.16	1.63	0.083
T3	582.9	215.0	4.92	2.03	0.101	5.07	1.77	0.088
T4	487.2	224.0	5.40	2.10	0.105	5.39	1.59	0.082
T5	488.9	185.9	4.90	2.17	0.109	5.26	1.66	0.085
T6	509.5	192.5	4.85	1.83	0.093	5.06	1.51	0.077
T7	567.5	250.8	5.00	2.09	0.104	5.15	1.67	0.085
T8	562.4	192.6	5.05	1.76	0.091	5.13	1.64	0.087
T9	572.5	1899.8	4.95	2.04	0.102	5.08	1.67	0.083
Composite Sample	NA	NA	5.50	1.65	0.083	5.52	1.760	0.092

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Influence of Soil PH and Initial Density of Root Lesion Nematodes (*Pratylenchus* spp.) on Their Multiplication in Maize

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ABSTRACT

Pratylenchus penetrans and *P. crenatus* often occur together in the field. The damage potential of *P. penetrans* to several field crops is well known whereas the damage caused by *P. crenatus* on the field crops is said to be minor or non-existent. An experiment was carried out in two different soil pH 5.5 and 6.5 to investigate the influence in the population of *P. crenatus* (Pc) and *P. penetrans* (Pp) when inoculated juveniles artificially in the following Pc:Pp ratios: 0:0, 100:00, 75:25, 50:50, 25:75, and 0:100 on maize in growth chamber at 20° C. The experiment was laid down in a RCBD with five treatments having eight replications. The inoculum density was fixed at 0.81 nematodes/g soil. The inoculum was inoculated simultaneously and serially. In the simultaneous inoculation, *P. crenatus* and *P. penetrans* were inoculated at the same time on 21 days seeding. In the serial inoculation, *P. penetrans* was inoculated two weeks after the inoculation of *P. crenatus*. Plants harvested 14 and 16 weeks after the first inoculation in simultaneous and serial inoculation respectively. Nematodes were extracted from soil and root. There was no influence of soil pH on the reproduction factor (Rf) of *P. penetrans*, whereas Rf of *P. crenatus* significantly influenced by soil pH. The Rf of *P. crenatus* was higher in serial than simultaneous at pH 5.5. The interaction between inoculation time and soil pH was significant on both species. Multiplication of *P. penetrans* was reduced in the serial inoculation at pH 5.5 when a higher proportion of *P. crenatus* was present.

Key words: Inoculation, maize, *Pratylenchus penetrans*, *Pratylenchus crenatus*, soil pH

INTRODUCTION

Plant-parasitic nematodes are microscopic pseudocoelomate, unsegmented worms, commonly described as filliform or thread – like multicellular invertebrates. Every cultivated plant species has at least one nematode reported to parasitize it. In turn, most agricultural sites are infested with at least one species of plant-parasitic nematodes (Luc et al 2005).

Nematodes are various and sometimes numerous nematode species can survive in the same root zone. When there are two or more nematode species present, their co-existence in the same location is possible, but never long-term stable and they tend to push out one another. The strength of competing is not exactly the same between the competitors and those who have more strength; they can survive and less competitive ones may either vanish, even extinct, or try to find another feeding site. The competition level may be inter-specific or intra-specific or both, depending on the population density with respect to the feeding area (Schoener 1983). Nematodes attempt to occupy different feeding sites and each species becomes specialized during evolution to exclude or reduce competition. Therefore, the root-feeding nematodes are differentiated into primitive vermiform to highly specialized migratory and sedentary endoparasite species.

Around 60 nematode species have been reported in maize from different parts of the world. Among them, *Pratylenchus* spp., *Meloidogyne* spp. and cyst nematode *Heterodera* spp. are significant limiting factors in maize production all over the world (Luc et al 2005).

The most encountered species of root lesion nematode, *Pratylenchus* are *penetrans*, *brachyurus*, *zeae* (De Waele and Jordaan 1988), and followed by other species such as *coffea*, *delattrei*, *goodeyi* (Prasad et al 1995), *crenatus* (Molendijk 2000), *hexincisus*, *neglectus*, *vulnus*, *sefaensis* and *thornei* (Loof 1978). In most cases, *Pratylenchus* spp. are abundant with more than one species at the same place. *P. penetrans* and *P. crenatus* occurred more frequently than *P. neglectus*, *P. thornei* and *P. vulnus* in potato and maize fields (Dickerson et al 1964). In 1991, Loof also reported that *P. crenatus* and *P. penetrans* to be commonly found together in the field. Similarly, Vaiene and Waeyenberge (2005) also recorded a high number of *P. crenatus* together with *P. penetrans* in both root and soil samples of potato and other field crops.

Although two or more species may occur together in the same field, one species usually predominates which governs by certain conditions favour to one species over the other within localized sites. Soil temperature and pH are important physical factors which influence many functions of plants and nematodes in their movement, development, reproduction, sex determination and expression of damage to plant (Jin et al 1994). The effect of the soil pH also varies with different species of *Pratylenchus*. Numbers of *P. crenatus* was more frequently found in acidic soils than in alkaline soils (Brzeski 1969). The movement of *P. penetrans* was optimum on pH 6.0, while there was no influence on the movement of *P. crenatus* (Kimpinnski and Willis 1981). Hence, this study was focused on the influence of the soil pH on the multiplication of *P. penetrans* and *P. crenatus* when inoculated in different ratios in maize.

MATERIALS AND METHODS

An experiment was performed to study the interaction of *P. crenatus* and *P. penetrans* at 5.5 and 6.5 soil pH levels. In the experiment, two aspects were addressed: ratio of inoculum, and time of inoculations (simultaneous and serial inoculation). The ratio of inoculum of *P. crenatus* and *P. penetrans* (Pc:Pp) were 100:00, 75:25, 50:50, 25:75 and 100:00. In the simultaneous inoculation, *P. crenatus* and *P. penetrans* was inoculated at same time in three weeks after seeding and in the serial inoculation, *P. crenatus* was inoculated in three weeks after seeding and *P. penetrans* was inoculated two weeks after the date of *P. crenatus* inoculation. The experiment was carried out in growth chamber for 14 and 16 weeks from the date of first inoculation in simultaneous and serial inoculation respectively.

Soil was collected from the field and plant debris and other materials were removed and sterilized. The soil was stored for 2 weeks before filling pots for the experiments. Polythene pots of 15 cm diameter and 17 cm depth were filled with 1850 g. The soil was filled up to neck level of the pot in order to prevent the dropping of the soil during handling the pot.

Soil pH was set up at two different pH levels. After sterilization, the soil pH obtained had pH 6.5, so it didn't need any treatment for the pH 6.5. Whereas for the pH 5.5, the soil pH was reduced by adding 100 ml of stock solution of 60 g Anti-mos (FeSO_4)/l of dH_2O . This concentration of the stock solution was determined by previous laboratory analysis. Five seeds of maize cultivar (Husar) were sown in each pot at 2-3 cm depth. After germination, only three plants were maintained in growth chamber. In the growth chamber, the temperature and relative humidity were adjusted at 20°C and 70 percent, respectively, for both day and night. The photoperiod of 16 hours day and 8 hours night was fixed. The intensity of light was $320\mu\text{Em}^{-2}\text{s}^{-1}$. The experiment was laid down in a randomized complete block design with five treatments having eight replications. All pots were artificially inoculated in different proportion of nematodes according to the treatments.

The inoculum density was fixed 0.81 nematode/g soil of both *P. penetrans* and *P. crenatus*. The nematode suspensions previously kept in a refrigerator, were brought at room temperature and homogenized well. Three aliquots were counted and the required nematode densities of the suspension were adjusted and maintained the coefficient of variance (cv) below 10 percent. The adult and juvenile

ratio on the suspension was also calculated. The suspension of *P. crenatus* inoculum had 63 and 37 percent female and juveniles respectively and in the inoculum of *P. penetrans* had 63, 4 and 33 percent of female, male, and juvenile respectively. *P. crenatus* inoculum density was prepared at 213 nematodes per ml of suspension and two different densities of suspension were made for *P. penetrans* for different time of inoculation ie 223 and 245 nematodes per ml of suspension for simultaneous and serial inoculation, respectively. Shallow holes were made close to the each plant and nematodes were inoculated using a glass pipette. The inoculation ratio varied with the treatments.

Watering was done every alternate day. The required amount of water was measured by weighing five pots randomly each alternate day of the week. At every end of the week, all the pots were weighed individually and added with the required amount of water to maintain moisture level according to moisture level table. The moisture level was calculated from the actual weight of soil and the approximate plant weight increase per week. At the beginning, the moisture level was kept at 10 percent for four weeks then it was increased up to 15 percent with respect to plant growth and followed by 20 percent after 8 weeks to time of harvesting.

The final population of both species was estimated from the soil and the root systems of each pot. Nematodes were counted in counting dishes at 40-50 × magnification using microscope. The number of juveniles, males and females and were counted from all the suspension. The final population (*P_f*) was calculated as the sum of nematode numbers extracted from both root and soil.

For every sample, 50 female nematodes were picked a random from freshly extracted suspension and mounted in water on glass slide. *P. crenatus* was identified by morphological characters such as oval shape swelling in the S-E duct, crenate tail without/or empty spermathecae in females, strong head skeleton with lip region slightly set off and three annules, broadly rounded basal knob, ventrally overlapping pharyngeal glands and later lines more than four insures. Juveniles (J2, J3 and J4) of *P. crenatus* were also distinguished by a swelling in the secretory-excretory duct (S-E duct) although slightly smaller compared to females (Loof 1960, Karssen and Bolk 2001). Likewise, female of *P. penetrans* were identified by a strong, head skeleton, low flat and offset lip region, rounded basal knob sometimes cupped anteriorly, ventrally overlapping pharyngeal gland, no swelling in S-E duct, a lateral field with four incisures, spherical spermatheca, round tail and smooth tip (Loof 1991). Juveniles of *P. penetrans* were also differentiated from *P. crenatus* juveniles by swelling of S-E duct.

Data analysis was performed with the STATISTICA 6.0 software (Statsoft Inc.). Homogeneity of variances and fit to normal distribution were checked for with Levene's test and Shapiro Wilk's test, respectively. Means were compared by the Tukey's HSD-test ($P < 0.05$).

RESULTS AND DISCUSSION

Replacement series for competition between two species

The relative reproduction factors of *P. crenatus* and *P. penetrans* was expected in linear and proportional to their initial inoculum levels. The relative nematode reproduction factor line predicted by the replacement series that one species inhibit or stimulate to another species when they are inoculated together.

The result of the experiment showed that the reproduction factor line for *P. crenatus* in mixed culture did not fit the reference line predicted by replacement series at both soil pH levels. Paired t-test established that the calculated relative reproduction factors of *P. crenatus* were higher than predicted values at all the ratios where *P. crenatus* and *P. penetrans* occurred together ($P < 0.05$). At pH 5.5, the relative *R_f* of *P. crenatus* was maximum at 25:75 ratio, whereas it was maximum at 50:50 ratio at pH 6.5. The apparent enhancement of *P. crenatus* did not correspond to decrease in the *P. penetrans* population in all inoculum

ratios at both pH levels (Fig 1). The calculated *Rf* line for *P. penetrans* was more or less similar to the predicted line of the replacement series. The line was only slightly lower at 25:75 ratio and slightly higher at 75:25 ratio than the predicted relative *Rf* line for *P. penetrans* at pH 6.5 and pH 5.5 respectively.

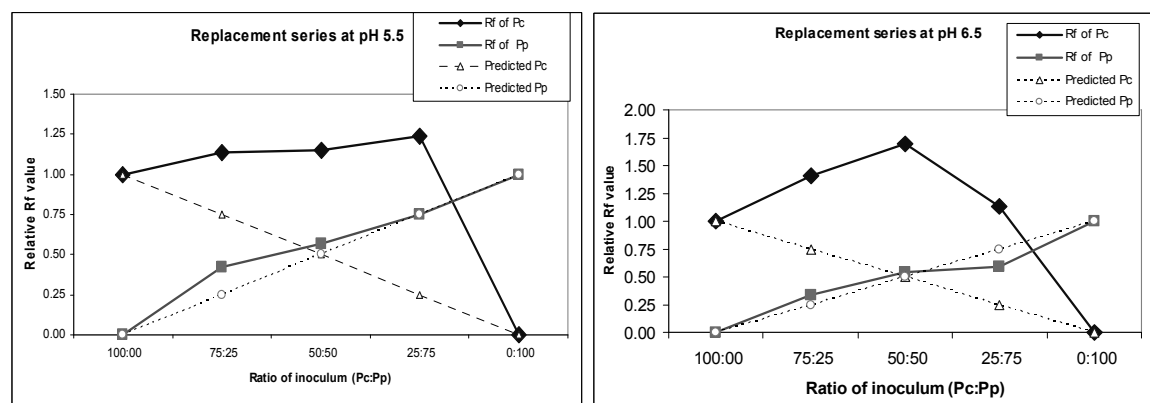


Figure 1. Relative reproduction factor of *P. crenatus* and *P. penetrans* in maize at pH 5.5 and 6.5. Predicted reference values indicate the expected response if inter and intraspecific competition are equal.

Interaction of *P. crenatus* and *P. penetrans* at soil pH 5.5 and 6.5

A relationship exists between multiplication of *P. crenatus* and *P. penetrans* on maize with respect to soil pH, time of inoculation, and different inoculum ratios. There was no influence of pH on the reproduction of *P. penetrans*, whereas the reproduction of *P. crenatus* was found to be influenced by pH. The reproduction of *P. crenatus* was higher at pH 5.5 than at pH 6.5. The data also showed the rate of multiplication of *P. crenatus* was higher after serial inoculation than after simultaneous inoculation, whereas the final population of *P. penetrans* was found to be lower after serial inoculation than after simultaneous inoculation. However, the multiplication of *P. crenatus* was not found to be differ with respect to the initial inoculation ratios but the inoculum ratios influenced the multiplication of *P. penetrans* (Table 1 and 2).

Table 1. The effect of *P. crenatus*: *P. penetrans* (Pc:Pp) inoculum ratio on their multiplication at different time of inoculation in maize at pH 5.5

Inoculum ratio (Pc:Pp)	Reproduction factor (Rf)				Total nematodes in root			
	Simultaneous		Serial		Simultaneous		Serial	
	Pc	Pp	Pc	Pp	Pc	Pp	Pc	Pp
100:00	1.6a	-	3.0a	-	2357a	-	4331c	-
75:25	2.21ab	7.22a	4.15b	6.76ab	2361a	3035a	4534c	2830a
50:50	1.99ab	10.62ab	4.47b	6.38a	1357a	9906ab	3327b	4692ab
25:75	2.88b	13.53b	4.05b	8.91ab	838a	14952bc	1325a	9769b
0:100	-	18.21b	-	10.91b	-	23062c	-	16233c

Means in the same column followed by different letters are significantly different (Tukey's HSD-test $P \leq 0.05$).

Table 2. The effect of *P. crenatus*: *P. penetrans* (Pc:Pp) inoculum ratio on their multiplication at different time of inoculation in maize at pH 6.5

Inoculum ratio (Pc:Pp)	Reproduction factor (Rf)				Total nematodes in root			
	Simultaneous		Serial		Simultaneous		Serial	
	Pc	Pp	Pc	Pp	Pc	Pp	Pc	Pp
100:00	1.17a	0	1.25a	0	1829a	-	1607b	-
75:25	1.48a	7.22a	2.01ab	5.37ab	1646a	2607a	2147b	1498a
50:50	1.92a	12.72b	2.30b	7.37bc	1441a	9165b	1722b	4341a
25:75	1.34a	18.88c	1.48ab	3.24a	504a	19997c	554a	3105a
0:100	-	18.67c	-	9.70c	-	25096c	-	10702b

Means in the same column followed by different letters are significantly different (Tukey's HSD- test $P \leq 0.05$).

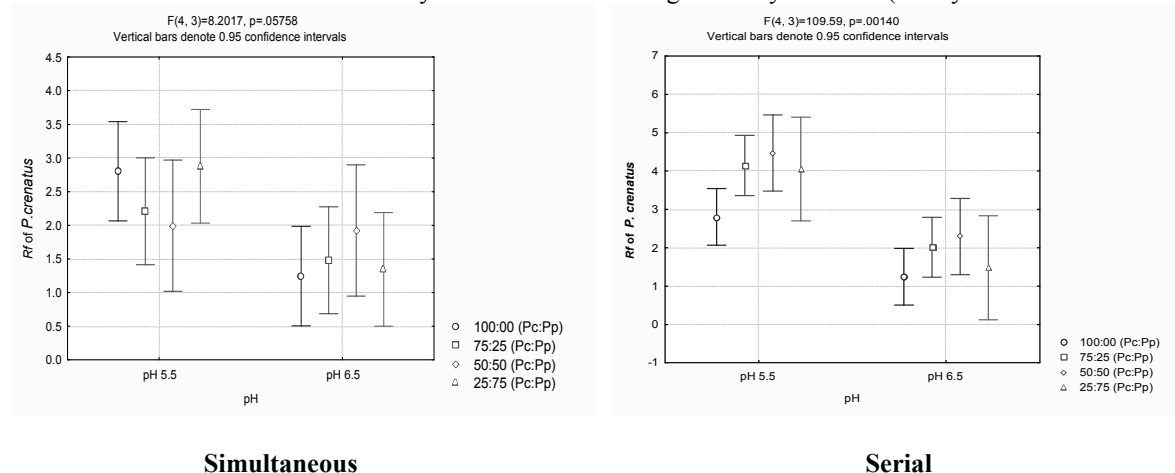


Figure 2 Reproduction factor (Rf) of *P. crenatus* in different time and ratios of inoculum in maize at both pH levels.

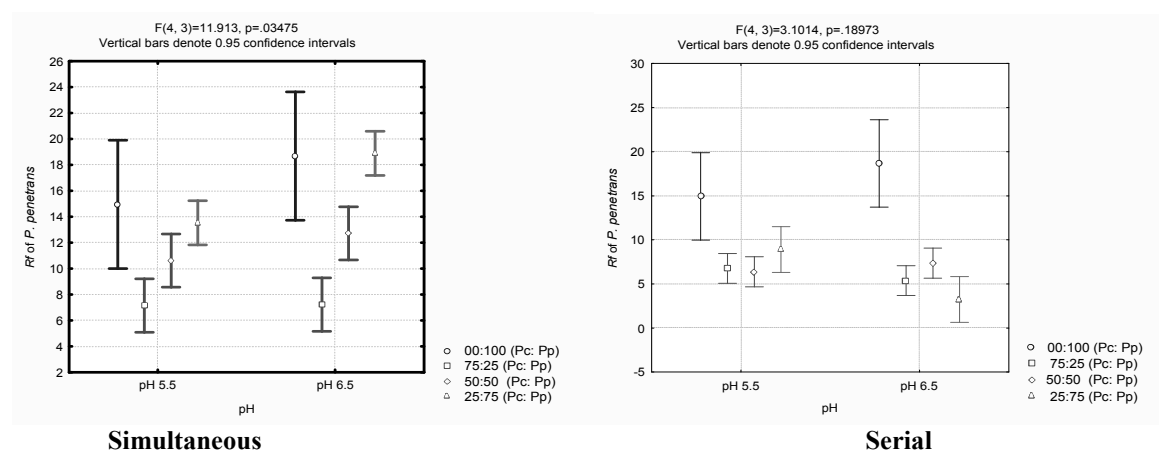


Figure 3. Reproduction factor (Rf) of *P. penetrans* in different times and ratios of inoculums in maize at both pH levels.

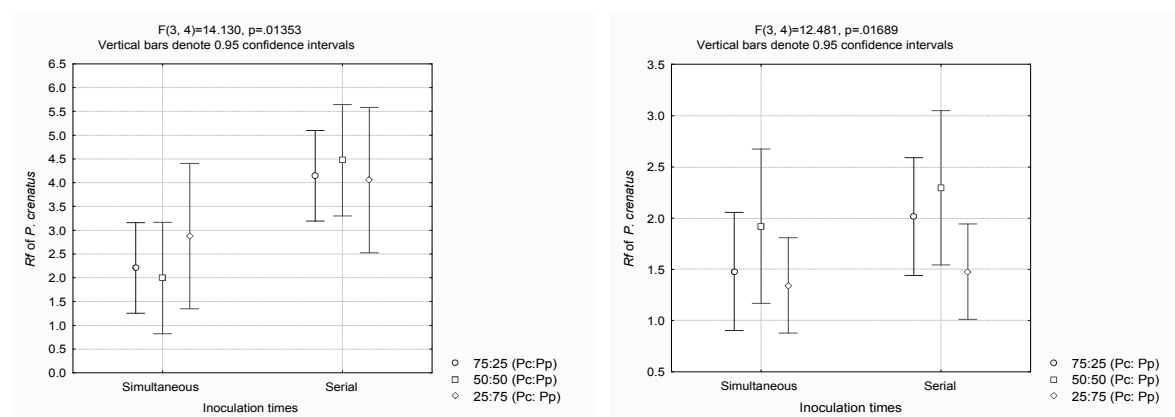


Figure 4 Comparison of reproduction factor (Rf) of *P. crenatus* in different times of inoculation in maize at soil pH 5.5 and 6.5 respectively.

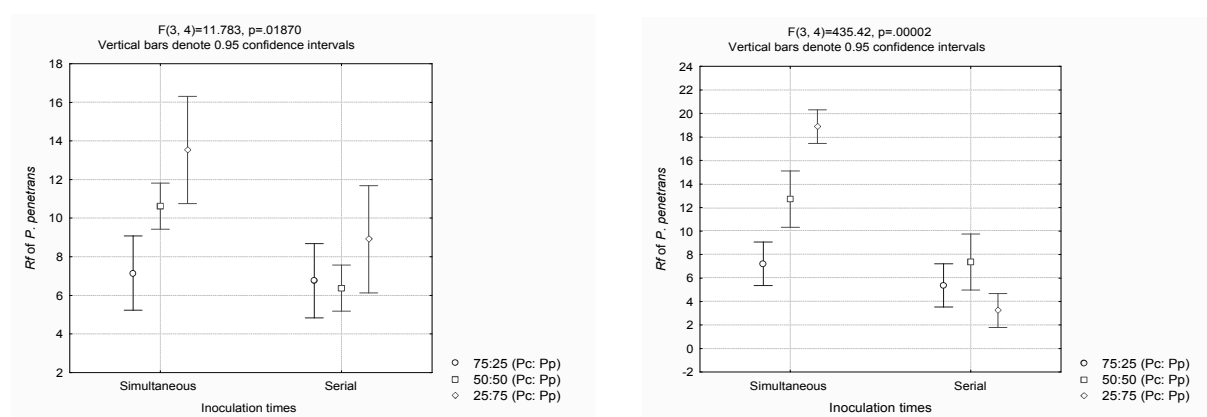


Figure 5. Comparison of (Rf) of *P. penetrans* in different times of inoculation in maize at soil pH 5.5 and pH 6.5 respectively Interaction among the parameters

The analysis of variance of the reproduction factors (Rf) of *P. crenatus* and *P. penetrans* confirms the influence of the three parameters, viz. time of inoculation, pH and inoculum ratios (Table 3). There was a significant effect of inoculation time on the Rf of *P. crenatus* and *P. penetrans*. Soil pH significantly influenced multiplication of *P. crenatus* but not of *P. penetrans*. The inoculum ratio significantly influenced the Rf of *P. penetrans*, but not of *P. crenatus*. The interaction between inoculum time and soil pH was significant on the reproduction factors of both *P. crenatus* and *P. penetrans*. There was no significant interaction between soil pH and ratio of inoculum on the Rf of both species. However, there was significant interaction between inoculation time and inoculum ratio on the Rf for *P. penetrans*, but not for *P. crenatus*. Similarly, the interaction among these three parameters was not significant for the Rf of *P. crenatus* whereas it was significant for the Rf of *P. penetrans*.

Table 3. Analysis of variance of inoculum time, soil pH and inoculum ratio on the reproduction factors (Rf) of *P. crenatus* and *P. penetrans* in maize at 20°C in growth chamber experiments.

Source of parameters	Rf value of <i>P. crenatus</i>		Rf value of <i>P. penetrans</i>	
	F - test	P - value	F - test	P - value
Time	23.03	0.000	128.62	0.000
pH	44.35	0.000	0.27	0.605
Ratio of inoculum	0.41	0.66	30.84	0.000
Time × pH	10.84	0.002	23.84	0.000
Time × Ratio of inoculum	1.02	0.37	30.76	0.000
pH × Ratio of inoculum	1.40	0.26	1.99	0.15

At pH 6.5, there was no difference on the multiplication of *P. crenatus* with respect to inoculation time, whereas the increasing trend of Rf of *P. crenatus* was significantly higher in serial inoculation than simultaneous inoculation at pH 5.5 for all inoculation ratios except for 25:75 (Fig 2 and 3). The significant different at pH 5.5 might be because of favorable conditions for multiplication of *P. crenatus* as compared to pH 6.5 and/or their late harvesting than in the simultaneous inoculation. The increasing trend of Rf of *P. penetrans* depended on the time of inoculation. At pH 6.5, the higher Rf value for *P. penetrans* in simultaneous inoculation at ratios 50:50 and 25:75 might also be due to lower multiplication of *P. crenatus* at this pH level. However, at 75:25, there was no difference of Rf of *P. penetrans* might be higher proportion initial density of *P. crenatus* (Fig 5). At pH 5.5, the Rf of *P. penetrans* did not differ in the time of inoculation in mixed ratios except at 50:50. It could be possible effect on multiplication of *P. penetrans* by the higher rate of multiplication of *P. crenatus* at pH 5.5. The impact of soil pH on

nematode population levels may be a direct effect on the nematode or an indirect effect mediated through the physiology of the host (Norton et al 1971). Potter and Olthof (1993) reported that pH deficient mineral elements may affect parasitism of vegetable crops by *Pratylenchus* species.

The significant influence of soil pH in the multiplication of *P. crenatus* corroborates the previous results by Kimpinski and Willis (1981) that the movement of *P. crenatus* was reduced when pH increased from 6.0. Melakeberhan et al (2000) found higher numbers of *P. crenatus* in acidic soil than alkaline soil. Similarly, the capacity of multiplication of *P. penetrans* at both pH levels also resembles with the previous studies by Willis (1972) in alfalfa that *P. penetrans* reproduce best between pH 5.2 to 6.4, with dropping in reproduction as pH approaches to 7. Similarly, Willis (1972) also described the reproduction rate of *P. penetrans* in alfalfa was higher at 5.2 and 6.5 than at pH 4.0 and 7.3. On vetch, Morgan and Timing of penetration of nematode is known to have an important effect on the outcome of competition between nematodes species (Eisenback 1993). In field conditions, the observed variation in the time of migration among the species of three endoparasitic nematodes (*Pratylenchus*, *Meloidogyne* and *Heterodera*) may be caused by competition (Van der Stoel 2002). As the experimental results, we found that the increase of Rf of *P. crenatus* was higher after serial inoculation than after simultaneous inoculation in both mixed and non-mixed culture at pH 5.5 than at pH 6.5 (Fig. 4). It might be due to delay harvesting (two weeks) of the serial inoculated plants than simultaneous inoculated plants, and/or *P. crenatus* had advantage of being inoculated first than *P. penetrans* thereby getting an additional time to occupy feeding area at serial inoculation. Competition for feeding sites is one of the factors that limit nematode establishment and reproduction in the plant roots (Duncan and Ferris 1983), and also migratory endoparasites can able to disturb feeding on other nematodes by disturbing plant tissue (Zunke 1990).

The reproduction factor of *P. penetrans* in this study was approximately 15 and 6 times higher than the reproduction factor of *P. crenatus* in non mixed culture at pH 6.5 and pH 5.5, respectively. Though there was higher reproductive potential of *P. penetrans* than that of *P. crenatus*, the competition appeared to favor *P. crenatus* in mixed culture in its favorable condition such as: serial inoculation, and soil pH of 5.5. Mixed-species inoculation, therefore, may permit better growth and ultimately a higher equilibrium density for *P. crenatus*. This finding suggests that reproductive potential is not only the primary attribute determining the competitive ability of these two species in maize. This research produce evidence that the interaction between *P. penetrans* and *P. crenatus*. Hence, it would be beneficial to find a rotation of crop, the level of pH and temperature that, combined with *P. crenatus* or with other *Pratylenchus* spp., would reduce population density of *P. penetrans*.

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Ethics of Agronomists: An Issue for Professionals for Agriculture Research and Development

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ABSTRACT

This paper presents about the ethical boundaries of agriculturists in general and agronomists in particular while executing different professional capacities. The paper also describes the ethical issues for agronomists that they should consider in the capacity of a researcher or extension personnel. At one time, the role of agriculture was to produce food, but now many people expect agriculture to be carried out in an environmentally friendly way that maintains the rural economy. We now speak of multifunctional agriculture. One tool sometimes used to press those demands is an appeal to ethics. This appeal can appear to suggest that agriculturalists have been ethically negligent. Given the obvious and urgent natural value of food, fiber, and forest products, if an academic ethicist so much as clears his or her throat while reviewing the basic business of farming and its allied technology and science, the inferred hint of ethical deficiency in the agricultural enterprise causes immediate hue and cry. Every agricultural ethicist knows by experience how poorly the suggestions are received. Agriculture is a vocation or profession that prides itself on the unquestionable value, even nobility, of its work. Agronomy is synonymous to agriculture, hence, agronomists should be engaged for number of works in day to day life involving social justification in farming, soil fertility and sustainability, soil conservation, rural living condition, farming and environment, healthy and nontoxic food production to the masses in an affordable manner. Above all, there is a big morale of agriculturists to save *Mother Nature* for our future generation tailored with multinational companies, engaged in agriculture, which have big say in generating and disseminating agro-technologies that are mooted to profit making and patenting agro biodiversity. This paper sheds lights in all such issues and aware agriculturists in general and agronomists in special if it is being done ethically.

BACKGROUND

Not much has been written about the ethical dimensions of agricultural professionals about their every day tasks for research and development. Most of the ideas presented here are relevant to other professionals involved for food and agriculture as well. Agriculture professionals may have not been taught about professional ethics in institutions where they have developed their careers. In this paper the readers are advised to consider agronomist as agriculturist because it is already submitted that agronomists are synonymous to agriculturists. Therefore, from ethical point of view agronomists do what they feel right personally. This article is based on review of papers presented by some renowned agriculturalists vis-à-vis agronomists who thought that without a clear-cut ethical concern it is very difficult to carry out day today works. Aside from this, the author is guided conditions of his unique genetics, cultural background, upbringing, education, cross cultural adjustment, and experiences. This paper briefly prescribes what agronomists should do as their duty ethically so that their profession is directed towards the well being of *Mother Nature* in general and living beings in particular.

Ethics as a process by which we distinguish between right and wrong behavior as well as referred to as a moral philosophy (Sparks 1997). The concept of bad and good are different from right and wrong. Thus ethical behavior and unethical behavior can also lead to both good and bad consequences. Ethical describes moral approval in accord with some approved standard or code while unethical describes behavior which does not comply with accepted standard or codes. According to Sparks (1997) ethics are categorized into following:

Personal and group ethics

Each of us has a personal code of ethics how well they conform to code of ethics and behavior of various groups with which we identify. To some extent ethical and unethical behavior are learned behaviors such as our past experiences including early childhood experiences.

Scientific misconduct

Questionable scientific practices such as failing to retain important data for a reasonable period of time, maintaining inadequate research reports, denying peers reasonable access to materials or data supporting published papers, inadequately supervising research subordinates, exploiting them, and several others. Some of the other misconduct include unethical but not unique to science such as sexual harassment, misuse of funds, and vandalism of research facilities.

Practical principle of ethical behavior

Keys of practical principle of ethical behavior include honesty, integrity, fairness, and service. Honesty is the quality of truthfulness. Seng (1990) identifies that telling the truth as a simple but profound strategy for achieving goals. Integrity broadens the concept of honesty to include the context in which honest or dishonest behavior occurs. You have integrity if you are honest when you will likely suffer bad consequences from being honest and/or you are unlikely to suffer bad consequences from being dishonest, perhaps because you will not be found out. Fairness involves treating other people fairly and not seeking to gain unfair advantages. Obviously fairness has dimension of equal treatment, equal opportunity and level playing. Agronomist generally values the science in the service of mankind (Holt 1989). The concept of service as ethical behavior seems consistent with utilitarian approach to ethical decision making and with seeking to optimize benefit.

The major objective of this paper is to share professional ethics of agronomist with peer groups however the specific objectives are as follows:

- i. To share what is ethical and unethical among agronomists while executing agricultural profession
- ii. To know what are the ethical issues for researchers and extension people and
- iii. To become aware not to do unethical jobs in the days to come

METHODOLOGY

This is a desk job carried out by consulting available literature thorough printed and electronic media. Consultation with senior professionals and experiences of the author are also included widely.

DISCUSSIONS

Discussions on ethics for agronomist consist of vast pool of subject matters. However, emphasis will be given for context most related to research and development aspect of pertinent filed concerned. These include:

Ethics of choosing research subject matter: Sustainable agriculture movement played a key role in sensitizing agronomist to ethical issues in research and development. Agronomist were criticized by people who thought they were unduly influenced by private sponsor of research, especially when such

sponsors were suppliers of inputs for production, including fertilizers, pesticides, seeds etc. Agronomists falsified or contrived data to please their sponsors and assure continued support. Such behavior would be unethical (Sparks 1997).

Ethical dimension of agricultural theme: Thompson (1988) identifies that productivity as the ethical themes of traditional/ conventional agriculture research while critics argues that new technology is developed and implemented in conventional agriculture without sufficient concern for its externalities, that is, its potential effects on environment, international justice, and agrarianism. Most researchers would agree that in many research situations it is impossible or impractical to evaluate all the possible externalities.

Resolving ethical problem: The ethical problem arises when a new technology works to improve conditions within one so called ethical theme but causes harm in the context of one or more other themes. To prevent this by having certain areas of research, however, prevents both good and bad outcomes. Often, the extent of good and bad cannot be estimated accurately until much of the research is accomplished. The appropriate response to this dilemma is to internalize as many as possible and practical of the externalities.

Ethics in the conduct of research

It is important to know how an agronomist develops and tests a hypotheses, marshals data, draws and reports inferences, engages in rational discourses, and works with colleagues and students in an ethical manner. Followings are the issues related to ethical conduct of research:

Selecting topics for research: Scientists embark on specific research efforts because they are interested in the subject matter, have expertise, wish to gain personal rewards etc. The decisions are conditioned by employment opportunities and availability of resources as well as each person letting his/her own ethical perceptions guiding these decisions.

Designing experiments: The more creative and knowledgeable scientists are the more likely they are to generate hypotheses that depart from the current paradigm. It is important for scientists to design experiments that will disprove their hypotheses if they are not true. Only if a hypothesis is not proven false by rigorous experimentation is it ethical for the scientist to promote it as a new paradigm.

Collecting and reporting data: It is generally accepted that fabrication and falsification of data constitute unethical behavior, except in special situation such as espionage. In reports data should be accurately represented so that readers are not misled. The more a scientist knows about the subject matter of an experiment, the easier to fabricate or falsify a data without being detected. It is unethical for an investigator to provide only data that support a certain hypotheses if he/she collected other data. There are statistical techniques that accommodate missing data without changing variants estimates. Statistical techniques should not be used to deal with outliers.

Analyzing data: Most agronomical data are subject to statistical analysis. With statistical information others can decide whether they think an investigator's conclusions and inferences are appropriate. Typically agronomists test hypotheses at probability of type one error which is 0.05 percent probability level of confidence. Researcher may perform various transformations so that data confirm more closely to the assumption of normality associated with many standard analytical procedures which are not unethical. Statistics can be used to misled, either intentionally or unintentionally. It is obviously unethical to use statistical anomalies to misled people deliberately.

Drawing and reporting inferences: Technically inferences drawn from an agronomic experiment only apply to the materials and conditions of that experiment. At the same time, it is usually impractical to test hypotheses with all possible materials and under all possible conditions. Generally agronomic inferences are location specific and such inferences should not be generalized thinking one size fits all.

Establishing and maintaining credibility: When a researcher is competent, professional, ethical, and intellectually honest in measuring, recording, analyzing, and presenting the results of experiments and inferences drawn from them, he/she establishes credibility and contributes to the credibility of his/her organization. Without credibility, neither scientist nor their organizations can function effectively.

Intellectual property rights

Increasingly, public institutes and agencies are expanding and improving systems to identify and protect intellectual property generated in their research operations. This presents a significant cultural as well as administrative change in many public and private institutions. Transferring intellectual property to the public domain, thus making it freely available to publics is not always in the public's best interest. It is therefore necessary to give some individual or group proprietary access to intellectual property. The management including sale and licensing, of intellectual property involves several ethical issues which are listed below:

Patent and copy right: It is illegal and unethical to commercialize patented material or duplicate, disseminate, or commercialize copy right intellectual property without the permission of the owner of the patent or copy right. This unethical behavior is similar to plagiarism.

Ethics and trade secret: When dealing with trade secrets, the ethical course of action is not always clear. The principle is simple! *Do not take things that do not belong to without permission.* To a large extent, we depend on scientist's honesty and integrity to resolve the issues.

Non-disclosure agreement: In order to enable useful exchange of proprietary information between organizations, it may be necessary for those participating in a discussion to sign nondisclosure agreements.

Ethical treatment of animals in agronomic research

Animals are used in agronomic research, especially in grazing and feeding trials, metabolism and toxicity trials, and behavioral studies involving agronomic materials. There is a need to increase productivity of animal operations and improve quality, safety, affordability, and convenience of animal product; we will no doubt continue to conduct research involving animals. The objective of most animal research conducted by or with agronomists is to improve crop as feed for animals, improve performance of animals consuming crops, or improve consumer products derived from animals that consume crops. Measures should be taken to minimize pain and discomfort and maximize animal well being in each experiment without compromising the validity of the experiment design. It definitely involves refraining from unnecessary harass treatment of animals. Animals should be treated most humanely while on the experiment.

Ethics and competition

Agronomists constantly encounter situations involving competitions. The competition is usually for resources, but may be for recognition, prestige, fame, self satisfaction, and other intangibles. We live in a hierarchy of competition in which individuals compete for resources with each other within their departments or other organizational units and even so called non profit organizations compete vigorously for resources. Competition can be very destructive, as in war and can be very constructive, as in competition to serve clients and costumers better. In a competitive framework, ethical behavior involves "playing fair" which is predetermined by rules and protocols. Ethical behavior for agronomists involves recognizing when it is appropriate to compete and when to cooperate.

Ethical issues associated with technological transfer

Many agronomic researchers are also agent of technology transfer and face various ethical issues. As technology becomes more complex, users may rely more heavily on information from various technology transfer agents and be more vulnerable to the agents' mistake. Agronomists should provide information and assistances as honestly, thoroughly, and objectively as possible. They should not portray their knowledge as being greater than it is. Agronomists should follow following guidelines with respect to technology transfer:

Transfer agents' responsibility: Technology transfer agents bear responsibility, either actual or perceived, for the outcome when clients follow their recommendations. Limitations on responsibility and liability should be discussed and agreed on before a client accepts and acts on the recommendation of an agent. Suppliers, agents, and clients should participate honestly and fully on bad outcome situation. Agronomist should be sure of the consequences of the technology. If he/she is not confidence of the technology in depth know how of the technology should be known thoroughly by going through detailed of research results of the technology in question. Without confirming technologies in a rigorous testing it is always unethical to transfer such technologies in situations where such technologies could not be delineated appropriately.

Testing and comparing product and practices: Agronomists often test and compare alternative, competing products and practices. Unbiased competition carried out under the wide range of conditions usually encountered in agricultural situations, play a very important role in helping practitioners select the best combination of product and practices for agricultural systems. Research reports should accurately and thoroughly depict the results of tests and comparisons. They should describe any circumstances that might render results unreliable or invalid. It is unethical for agronomist to falsify or fabricate test data in order to test and compare to favors one or the other of the items being examined. It is also unethical for researchers to misrepresent their ability and capacity to conduct tests and comparisons.

Advocating products and practices: It is ethical for private sector researchers to advocate their firms' products and services as long as they do not misrepresent them. It is clearly unethical for public researchers to advocate inferior products or practices in order to obtain kick back or other payments or rewards. I have personally found some of the agriculturists who are favoring for some firms' product when such products are inferior in comparison to other contemporary products available. This has led serous negative consequences for the ethics of agriculturists. Such works are utterly unethical and these should be criticized to safeguard ethics of agriculturists. It is especially important for agronomists who are professionally involved in public and community based institutions where technologies belong to public.

Ethics of consultancy

Consultants' works in the same ethical environment face the same ethical decisions and dilemmas as public sector scientists and extension people. Several of the ideas expressed in the technology transfer section apply for consultants. Consultants are obligated to function in the best interest of their clients and to provide value in return for compensation. It is also unethical for consultants to recommend that their clients engage in unethical behavior.

Ethical in research and administration

Administrative issues are important because they often directly affect people's career and life. Administrators are interested with other people's money and careers and are expected to manage them ethically. Ethics for agronomists involved in administration are as follows:

Ethical hiring and termination: It is in the best interest of both public and private institutions and organizations to attract and retain best employees. The process of attracting, hiring, and retaining

outstanding people is a competitive activity. It is ethical to compete vigorously within a system of rules and/or codes that establish the boundaries of ethical behavior. It is unethical to misrepresent a position to a potential employee or to make promises of future support or other conditions or deliberately and dishonestly undermine the efforts of competitors. It is sometimes necessary to terminate employment of an employee because of wrong doing or perceived deficiency in his/her performance. The process of termination should be as humane as possible. Harassment by employers and employees is clearly unethical.

Nurturing scientist: It is useful and practical for organizations that hire people into what are expected to be permanent positions to nurture their careers. Nurturing in agronomic research is an ongoing process in which employee becomes well informed about what they have to do to meet expectations of peers, administrators, and other decision makers.

Fair evaluation: Agronomists working as administrators often find themselves in position in which they must evaluate the performance of others or be evaluated themselves. Important decisions including hiring and termination, promotion and tenure, and salary increments, include evaluations. Subordinates should be evaluated on the basis of works not on the basis of intangible means. The important evaluations are as follows:

Activity reports: People being evaluated often are asked to submit report of their activities. They should be informed as to what criteria will be used to evaluate the reports. It is unethical to misrepresent performance on such reports or to wrongly take credit for accomplishments of others. The reports should be thorough, honest, and timely. Under our circumstance there are cases that authorships are given for persons who are not involved in the work often mentioned their involvement. This is unethical and falsification of recognition.

Letter of recommendation, support, and evaluation: Requests come from applicants and candidates for positions, promotions, and tenure, and award and from the people who are offering the positions, awards, university admission etc. Candidates hope the letter will portray their cases in the best light, emphasizing their strong points. It is unethical to deliberately misrepresent or slant information in a letter of recommendation, either to favor or disfavor the candidates or to influence a competition in favor of or against some other candidate. Author of such letter should be as honest and objective as possible, regardless of their relationship regardless with the person being evaluated. They should portray their knowledge of the person accurately, especially not claiming to know more than they know.

Promotions documents and decisions: Those who prepare promotion documents bear a heavy ethical responsibility both to candidates for promotion and to the institutions or organizations. They are obligated to present a thorough, well-documented case, which may or may not be supportive of promotion. Authors of promotion documents need to proof read carefully, adhere to format specifications, and provide clear comments, well written narrative, where such is required.

Job application: It is unethical for candidates to misrepresent their education and experiences. When there are many qualified applicants for a position, perspective employers tend to scrutinize applications more closely, looking for anything that might help them decide among candidates. Unfortunately, this scrutiny tends to focus on negative attributes which in turns should not be the selecting criteria.

Evaluating administrators/managers: Many organizations have process for evaluating administrators periodically. Those being surveyed are obligated to answer survey question as truthfully, thoughtfully, accurately, and objectively as possible. It is clearly unethical for an individual or group to use periodic review as a mechanism for launching a personal dispute against an administrator/manager. Likewise, it is unethical for a person being evaluated to provide false information or to otherwise misrepresent his/her performance.

Equity and merit: Administrators/managers are often faced with balancing consideration of equity and merit. The ethical course of action for administrators is to make sure people being evaluated know what criteria to judge merit. The criteria should be applied uniformly, fairly, and consistently. The interest of organizations' clients, customers and constituent should be taken into account.

Honest communication with constituents/institutions

Administrators often need to portray their organization to groups of constituents. Sometimes an administrator is a "true believer" i.e., really convinced that the organization is exceptionally good. This may be true or it may be that the administrator is too emotionally involved with the organization to make objective judgments about it. It is unethical to provide false or misleading information about one's organization. If there are problems within the organization or with the organizations' relationship, it is best to share those problems with clients or constituents and, whenever possible, enlist their aids in solving them. Relationships between organizations and their constituents should be characterized by ethical behavior, including honesty, fairness, and service.

CONCLUSION

Role of agronomists in war and peace is equally important. In war their role is to grow crops for feeding people not to starve of them and take care about the equity and supply of foods while in peace there comes a role of increasing productivity and boost production per unit area so that glut of production for sustaining lives and commercializing agro-products take place smoothly. There are times when agronomists should involve judging what is right and wrong with respect to evaluating agriculture inputs and products brought into markets by some multinational company and big house whose aim is centered for profit making. Such organizations, presently, are deeply mooted into patenting agro-products and at the same time they are concentrated to capture natural flora and fauna in the name of patenting rights. In such situations, agriculture professional should strongly favor for the rural masses who are conserving these agro-biodiversity from the time settled agriculture was started at the dawn of civilization. This has created a dilemma as to which is ethical and unethical so as to give professional judgments for agriculturalists. There are cases when agronomists and extension people have been advocating such commercial products without thinking of professional ethics. In some cases agriculturists are becoming mouth pieces of such big multinational companies for advertising commercial products. This holds true for agriculturists' working in Nepal as well. Such issues include commercialization of genetically modified organisms (GMOs), *Bt* variety of crops, agro-chemicals (pesticides, hormones, fertilizers), new crop varieties (hybrid, OPV, and local but modified genotypes) so on and so forth. We have experienced, in some way or other way, some time agriculture professionals have been engaged for promoting such products with a meager hope of getting some personal incentives such as kickbacks, reward or some form of other personal motivations. It is against the ethics of professionals to involve in such activities unless benefits of products from these big commercial houses have been established by scientific standards and these are largely meant for providing public interest rather than commercial one. The consequences of profit motive products to the ignorant masses can lead to grave consequences such as allergic reaction of the products, their negative effects on biodiversity conservation and soil microorganisms, underground water pollution, and sustainability of natural resources, resistance to insect pest and diseases, introduction of new pest and diseases, and above all destruction of **Mother Nature** is of unforgivable crime against nature and humanity. Agriculture professional should finally bear the impact of such devastating concerns brought about by their action without taking into consideration of scientific paradigms for such issues. Of course, in such circumstances the consequences rest for unethical decisions of agriculture professional as well.

Now because of price surge of fossil fuel and food grain many people in the developing countries are facing hunger and food crisis. Food commodities are converted into ethanol from energy rich crops in general and maize in special which are basis food of the people. These are unethical activities and

agriculturists should raise voice against such activities of the energy consuming nations. This should be taken by agriculturists as a crime against humanity as envisaged by the General Secretary of the United Nations Organization.

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Food Security: Contribution and Vision for Sustainable Potato Production in Nepal

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ABSTRACT

Potato is a wholesome and nutritious food. It is a staple food in high hills and as side dishes in other part of the country, with per capita consumption of 61.6 kg in 2007 (VDD 2007), one of the highest national rate in south Asia. In Nepal, potato production has increased more than six times since 1970s. Potatoes are grown in a wide range of altitudes, from the lowland terai, to 4000 msl above sea level. Potato is more productive than the major cereals. Small farmers grow the crop predominantly. This crop plays an important role in the country's food security and poverty alleviation because of its short vegetative cycle and high cash and food value as compared to any other major cereals. It serves as the food security crop alleviating seasonal shortage and fills food gaps. Potatoes are making a substantial contribution to meet the need for food in the hilly areas of Nepal. They are rich in carbohydrates, protein and vitamin C, making them a good source of energy. But the potential of the potato has yet to be fully realized, which has never been more evident until the recent rising prices of rice, wheat and maize.

Farmers who normally plant a hectare of potatoes using two tonnes of seed tubers can achieve the same or better results by planting as few as 150 grams of TPS and diverting it for use as food. Despite the availability of more quantity food using TPS as alternative technology of potato production, environment degradation and cost of cultivation can be reduced.

Nepal has been relying heavily on the major cereal crops to feed the ever-increasing population. Such an over dependence on cereals should end, if we have to ensure food and nutrition security in the future. We should promote a crop like potato, which is not only productive but also nutritionally balanced. Undoubtedly the food security and sustainable potato production are the major challenging issue of today and also in the future. An appropriate policy, strategy and technology are the prerequisite for sustainable potato production in achieving the food and nutrition security.

Key words: Food security, population, potato, production, true potato seed

INTRODUCTION

Nepal ranks among the poorest countries, with a per capita income of around \$386 in 2007 (NPC 2007). Based on national calorie/GNP criteria, 31 percent of the population has been estimated below the poverty line. Agriculture remains is principal economic activity, employing more than 65 percent of the population and providing 36 percent of GDP (NPC 2007).

One of the major problems faced by Nepal is the ever-increasing population. If this growth rate continues, Nepal's current population will double in the next 31 years (NPC 2007). Thus, the syndrome of food security-poverty and population may become even more acute and most serious problem for coming generations. The problem is further compounded by the concern for sustainability of high productivity and without detriment to environment.

The cultivated agricultural land is around 3091000 ha (Krishi Diary 2065 B.S.) and any further increased in areas is not visualized. A key challenge facing is to ensure food security for present and future generations, while protecting the natural resource base on which we all are depended. Therefore, in order to increase agricultural production further, the only option is to grow high productivity crops like potato.

The potato is the most important non-cereal food crop of the world. Nepal produced 19.43 million tones of potato from 153.52 thousand hectare during 2006/07 (APSD 2006/2007) thus becoming ninth position in the Asia (<http://www.potato> 2008), the status of this crop remained staple food in high hills and a major vegetable in other part of the country. The time has come now for all of us to understand and appreciate the role of potato can play in present situation and future importance.

The potato is highly adaptable to a wide variety of farming system. With its short vegetative cycle, high yield within 90 days, it fits well into double cropping system with rice and is also suitable for intercropping with maize. Potato can be grown at altitude up to 4300 m and in a variety of climates, from the barren highlight of high hills to tropical lowland of terai.

Potato is also rapidly becoming a valuable source of cash income as a primary requisite of food security for many small-scale producers.

The potato is already an integral part of the global food system. It is the world's number one non-grain food commodity. Unlike major cereals potato is not a globally trade commodity. Potato prices are determined usually by local market. It is, therefore, a highly recommended food security crop that can help low-income farmers and vulnerable consumers ride out current turmoil in national food supply and demand.

Nepal has been relying heavily on the major cereal crops to feed the ever-increasing population. Such an over dependence on cereals should end, if we have to ensure food and nutrition security in the future. We should promote a crop like potato, which is not only productive but also nutritionally balanced.

Concept of food security

The Conference of World Science Academies (1997) recognized the following dimensions of food security.

- (i) Physical, economic and environmental access to balance diets to enable individual to live a healthy and productive life.
- (ii) The food originates from efficient, effective and environmentally caring practices that conserve and enhance the nutritional base of crop husbandry, animal husbandry, and inland and marine fisheries. The food security rests on most efficient use of natural resources of land, water, energy and plant biodiversity.
- (iii) The physical dimension of food and nutritional security will involve a transition from the present chemical and mechanical intensive to knowledge intensive and co friendly practices.

The concept of food security also differs from global, regional, national and individual perceptions. Consequently the priorities and strategies also differ in the changing scenario of economic, world trade and political environments. One cannot visualize food security without taking cognizance of all those factors. The cost of production, processing, marketing and social-political conditions are equally important and cannot be ignored. Food security also cannot be separated from political security.

Sustainability

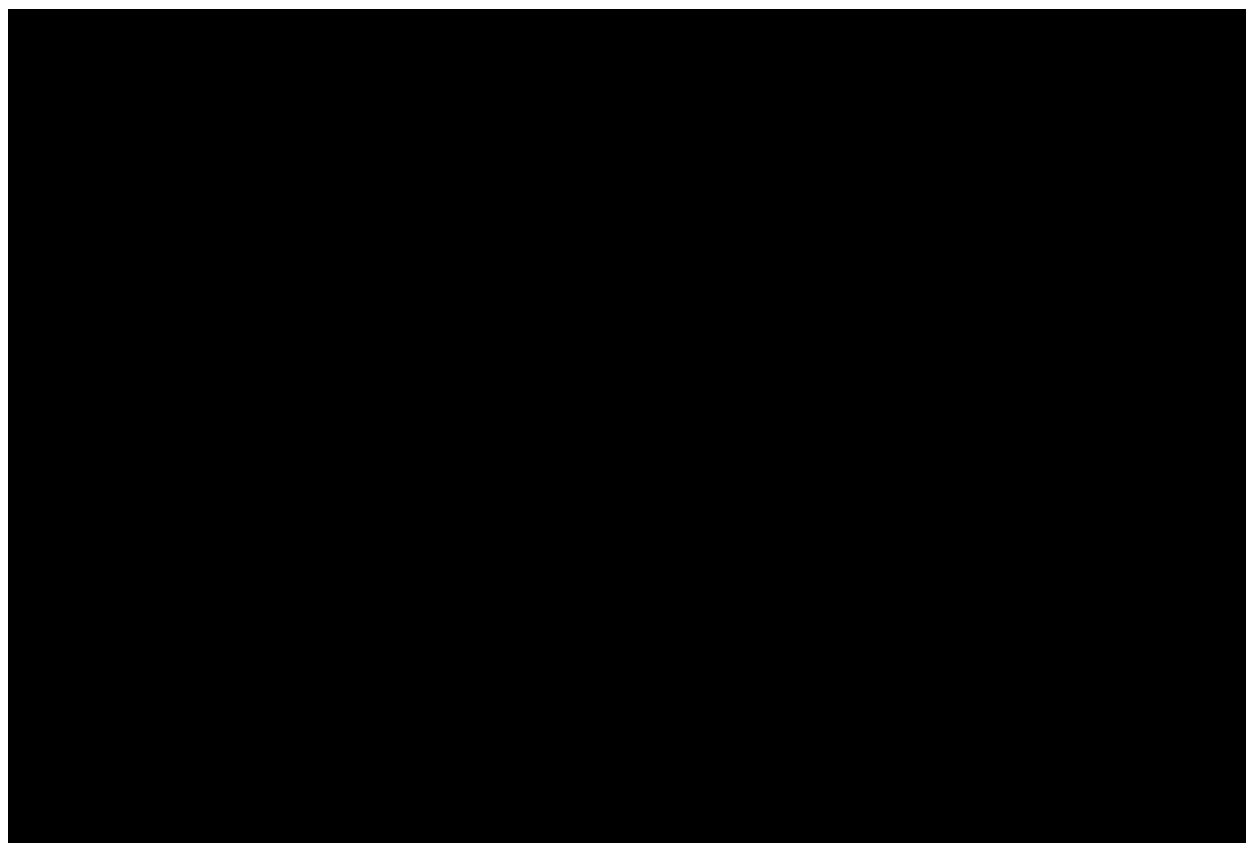
For understanding the problem of food security, the understanding of concept of sustainability is essential. There are many definitions of sustainability but the concept developed by Technical Advisory committee on International Agricultural Research (TAC, 1988) is most relevant. It states that sustainable agriculture is the successful management of resources for agriculture to satisfy the changing human needs while

maintaining or enhancing the quality of environment and conserving natural resources. Thus there are five important aspects of sustainability of agriculture.

1. Meeting the changing needs of today and tomorrow.
2. Successful management of resources internal or external, renewable.
3. Economic viability of enhanced level of productivity.
4. Maintenance, preferably enhancement of the quality of environment.
5. Conservation of natural resources viz soil, water and biodiversity.

Population growth and food security situation in the country

One of the major problems faced by Nepal in particular is the ever-increasing population. As per current trend the population in Nepal is expected to be around 34.17 million by the year 2021 (Fig.1). According to the census of 2001, the population growth rate was 2.25 percent. If this rate remains the same the population will be doubled after 31 years. The ratio of the population who are not in a position to consume the minimum calories, at the national level, is 39.9 percent (NPC 2007). This ratio for the mountain region is 45.2 percent, hill region 41.8 percent and the terai region 37.4 percent. Similarly, this ratio in the eastern, central and western development regions, the ratio is 44.3 percent and 44.9 percent, respectively (WFP 2008). In this way, in relation to geographical regions, the nutrition position in the mountains and the terai, and in relation to development regions of the Mid-west and Far-west are relatively worse. To eliminate food insecurity and poverty, it becomes necessary to take advantageous crop like potato.



Source: Ministry of population and environment 2003.

Table 1. Top ten-potato producer in Asia

S.N.	Country	Harvested area (ha)	Quantity (Tones)	Yield t/ha
1	China	5000,000	72000,000	14.4
2	India	1600,000	26280,000	16.4
3	Iran	210000	5240000	24.9
4	Bangladesh	310000	4300000	13.8
5	Turkey	158500	4280700	27.0
6	Japan	83000	2650000	31.9
7	Pakistan	131900	2622300	19.8
8	Kazakhstan	154000	2340000	15.1
9	Nepal	153524	1943246	12.6
10	North Korea	190000	1900000	10.0

Source: www.potato2008.org

POTATO IN NEPAL

Potato is the fourth in order of production and fifth in area and first in productivity among major staple food crops, rice, wheat and maize. It is grown all over the country in tropical climate of Terai to temperate climate of high hills from 65 msl to 4000 msl (Fig 2). Potato serves as staple food particularly for hilly peoples whereas it is used either as sole or mixed with other vegetables almost in every meal of Nepali people. It has important role in income generation, food production and overall poverty alleviation because it has a high cash value and short cropping duration. It provides more nutritious food from less land in less time and often under adverse condition than other cereal crops. Because of the variation in altitude, Nepal is gifted by nature with typical resources that can be gainfully utilized in producing varieties of potato. It ranks second in higher net return per ha after cauliflower as vegetable crop. Being a short duration crop, the potato fits nicely into many multiple and inter-cropping systems, thus increasing the cropping intensity and productivity of the land. Potato is also a labor-intensive crop, therefore, providing ample opportunity for employment in the rural sector and post-harvest operations.

How potato helps food security?

In the past two decades Nepal has increased production of potato 4.63, rice 1.36, wheat 2.84, maize 2.22 and millets 2.29 times as compared to 1984/85 (Table 2). Scientists believe that Nepal is capable of performing better than this in the future, as the gap between the research plot yields and farmers' plot yields is significant. The principal impact of closing the yield gap is felt on the farm, where improved potato yields can translate into income growth and greater food security. Growth in productivity can come from improved potato varieties with greater yield potential and better resistance to pests and diseases, more use of quality seed potatoes and a deeper understanding of integrated management of pests and diseases.

Table 2. Changes in area, production and productivity in cereals and potato from 1984/85 to 2006/07

Commodity	1984/85			2006/07			Ratio of increase in production
	Area (000 ha)	Production (000 t)	Yield t/ha	Area (000 ha)	Production (000 t)	Yield (t/ha)	
Potato	65.54	420.16	6.41	153.53	1943.25	12.66	4.63
Rice	1376.86	2709.43	1.97	1439.53	3680.84	2.56	1.36
Wheat	451.89	533.72	1.18	702.66	1515.14	2.15	2.84
Maize	578.72	819.85	1.42	870.40	1819.93	2.09	2.22
Millets	134.37	124.43	0.93	265.16	284.81	1.03	2.29

Source: APSD, 2006/07

Table 3 indicates that potato is an efficient and maximum potential crop. Potato being a high productive crop, it produces more dry matter per unit area and time than the major cereal crops. The dry matter production in potato

is 47.6 kg/ha/day where as in wheat, rice and maize it is 18.1, 12.4, and 9.1 kg/ha/day, respectively (Table 3). It is not enough if we are able to produce more dry matter alone. A diet rich in dry matter (carbohydrates) but deficient in nutrients will lead to nutritional imbalance. Potato rank first in dry matter as well as edible protein production (Table 3) as compared to the three major cereals. Potato also produces more nutrients per unit area and time than the major cereals (Table 4).

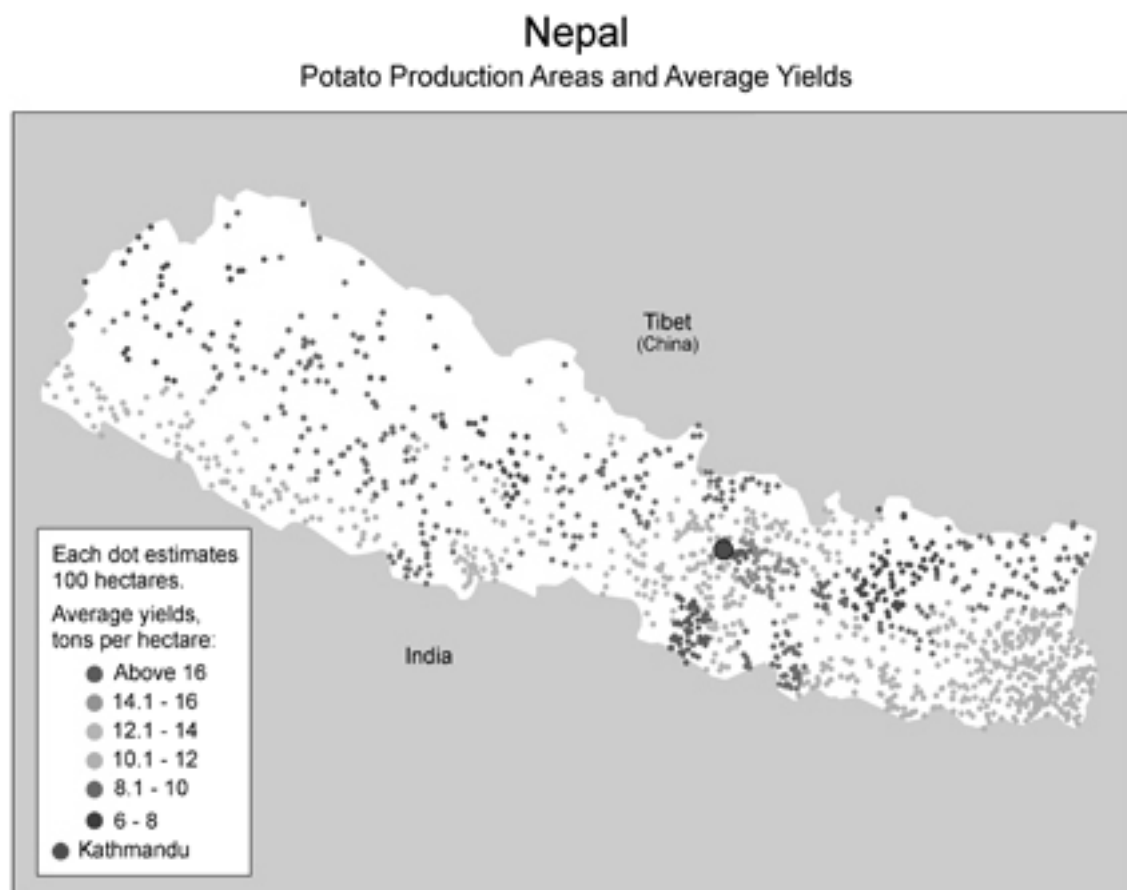


Fig 2. Potato production in Nepal

Nepal is high on the list of countries where rising food and commodity prices could have a huge impact on population. The bulk of food grains are produced in the Terai. In contrast, the hills and mountains of Nepal are mostly food deficit. Due to unavailability of transport facilities the delivery of food supply does not exists in time when they have extreme starvation. To supply food every year to these deficit areas from government side is not a permanent solution to cope with the starvation of the people. In the past, when there was no food supply from government side the local people were cultivating their local cereal as well as tuber crops and were not found vulnerable as they are found today. Potato is one of the crops, which is widely cultivated throughout the country and can solve the existing problem of food crisis.

In Nepal, the productivity of potato in the high inputs area has increased considerably due to increased inputs of fertilizer and the pesticides. Yield has increased spectacularly as result farmers have had to intensify their cropping plan in order to make a living, particularly with commercial production. The emphasis has shifted to cash crops. In Nepal, this intensification has resulted in high cropping frequencies of potatoes once per year in Terai and near by road areas and twice per year in Kathmandu

valley. However, this high cropping frequency has increased soil borne diseases and pests such as black scurf (*Rhizotonia solani*), Verticillium wilt (*Verticillium* spp.) late blight (*Phytophthora infestans*), etc and therefore farmers are using increased amounts of pesticides.

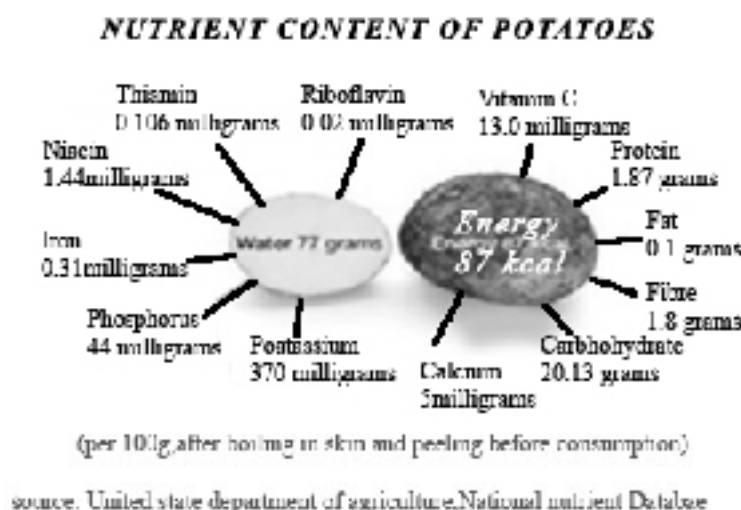
Table 3. Potato tops in dry matter and protein production (kg/ha/day)

Crop	Crop duration (days)	Dry matter	Edible protein
Potato	90	47.6	3.0
Wheat	120	18.1	2.5
Rice	130	12.4	1.0
Maize	140	9.1	1.2

Source: AICRP, Annual Report 1986-87, Directorate of Cropping System Research, Modipuram, UP, India

Potato for nutrient

Potato is a versatile, carbohydrate rich in food highly popular worldwide and prepared and served in a variety of ways. Freshly harvested, it contains about 80 percent water and 20 percent dry matter. About 60-80 percent of the dry matter is starch. On a dry weight basis, the protein content of potato is similar to that of cereals and is very high in comparison with other roots and tubers. In addition, the potato is low in fat.



Potatoes are rich in several micronutrients; especially vitamin C eaten with its skin, a single medium sized potato of 150 g provides nearly half the daily adult requirement (100 mg). The potato is a moderate source of iron, and its high vitamin C content promotes iron absorption, it is a good source of vitamin B1, B3 and B6 and minerals such as potassium, phosphorous, and magnesium and contains folic acid, pantothenic acid and riboflavin. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing, and dietary fiber, which benefit health.

True potato seed

Production of potato is increasing due to increase in area but the productivity of potato is still very low 12.6 t/ha in Nepal as compared to India (16.4 t/ha) and China (14.4 t/ha) (FAO 2007). It is mainly due to the lack of high yielding and disease resistant/tolerant varieties of potato. There has been an increasing interest in the production of potatoes from true potato seeds (TPS). TPS offers alternative technology of crop production for the regions where resource poor farmers can have quality plantation material at a reasonable cost. There are several advantages of using TPS for potato production including, the cost of true seed is cheaper than seed tubers. It can reduce total cost of potato production almost by 50 percent.

True potato seed is virtually disease-free and is much easier to transport than seed tubers. Two tones of tubers are needed to plant one hectare of potatoes, while 100 g of TPS do the same job.

Table 4. Nutrient production (/ha/day) of potato, wheat, rice and maize

Nutrients	Potato	Wheat	Rice	Maize
Carbohydrates (kg)	42.5	14.8	11.2	7.1
Minerals (kg)	1.1	0.3	0.1	0.2
Fiber (g)	752.0	249.0	29.0	287.0
Fat (g)	188.0	311.0	72.0	383.0
Phosphorous (g)	75.2	63.5	22.9	37.0
Calcium (g)	18.8	8.5	14.0	1.1
Iron (g)	1.3	1.0	0.4	0.2
Vitamin-B (g)	2.5	1.3	0.3	0.3
Vitamin-C (g)	32.0	0	0	0

Source: Bista and Sharma, 1997

Potato and food prices inflation

Prices of cereals are rising faster than those of potato and other root crops. Countries with low levels of dietary diversity and high dependency on cereal imports could benefit greatly from expanded potato cultivation. Potato flour can be blended easily with wheat flour, providing countries with a means of reducing costly wheat imports. Potato is increasingly a valuable source of cash income for low-income farm households

Intense competition for reduced international supplies of cereals and other agricultural commodities is driving worldwide food price inflation, which brings with it the risk of food shortages and social unrest in low-income countries. One strategy that could help reduce the risk is diversification of food production to nutritious and versatile staple crops that are less susceptible to the vagaries of international markets. One such crop is potato. Unlike rice, wheat and maize, the potato is not a globally traded commodity and its prices are determined usually by local supply and demand. A recent FAO survey in more than 70 of the world's most vulnerable countries found that inflation in potato prices is much lower than that for cereals. The potato is, therefore, a highly recommended food security crop that can help low-income countries ride out turmoil created by food price increases.

Potato for income and strengthening the potato 'value chain'

Potato is rapidly becoming a valuable source of cash income – a primary requisite of food security - for many small-scale producers. In Nepal growth in urban populations and incomes and the diversification of diets have led to rising demand for potatoes from the fast food, snack and convenience food industries. The structural transformation of agriculture-based economies into more urbanized societies opens up new market opportunities for potato growers

Potatoes are often sold through fragmented marketing chains with little coordination and a lack of market information, giving rise to supply disruptions and high transactions costs. Many small-scale farmers are excluded from markets owing their low yields, and inadequate storage and transport. Inefficient and unfair pricing discourages them from making on-farm investments in production.

Enhancing the value chain requires substantial public and private investment, especially in breeding programmes and in infrastructure to support and co-ordinate activities along the chain. Production initiatives can be strengthened by research focused on specific end uses, rapid multiplication of good quality planting material, and varieties with pest and disease resistance. Producers of potato seed tubers need to offer yield-improving and input-saving technologies that boost yields and reduce costs. The formation of producer groups would help farmers share expertise and strengthen their bargaining power. Production would also benefit from improvements in the supply of irrigation water and chemical fertilizers, and in cold storage and transport infrastructure.

Current status of potato research in Nepal

- Eight varieties released, 7 recommended
- True Potato Seed (TPS) technology and some promising hybrids TPS
- Agro techniques: improvement on cultural practices
- Package of practices for ware and seed potato
- Integrated crop management technology: Late blight and potato tuber moth
- Tissue culture for virus free PBS
- Soil fertility management
- Post-harvest handling and storage: Diffused light storage
- Seed production: Pre basic seed and basic seed, seed plot technique
- Technology dissemination: Farmer field school, training and visit

Strengths

- Establishment of separate research and development institute at national (NPRP and NPDP) and international level (CIP)
- Contribution to food security of marginal farmers through increased production per unit area as compared to cereals
- Potentiality to increase healthy seed through tissue culture
- High employment generation potentiality, e.g. TPS based cultivation

Weaknesses

- Limited high quality seed
- Inadequate diffusion of improved technologies
- Inadequate availability of disease resistant and processing varieties
- Lack of low-input requiring technologies
- Narrow genetic base: introduced crop
- Potential water scarcity
- Problem of marketing and storage (bulky and perishable crop)
- Lack of institutionalized seed certification scheme

Opportunities

- Being a short duration crop, the potato fits nicely into many multiple and inter-cropping systems, thus an opportunity to increase the cropping intensity and productivity of the land.
- Potato is a labor intensive crop, therefore, providing ample opportunity for employment in the rural sector and post-harvest operations.
- It provides more nutritious food from less land in less time and often under adverse condition than other cereal crops thus and opportunity of food security crop in the hills.

Threats

- Risk of importing exotic pathogen and pest e.g. PSTV
- Risk to environments: heavy use of N-fertilizers and organo-mercurial compounds

Constraints (Institutional)

- Inadequate infrastructures and human resources
- Inadequate Cold storage facility
- Maintenance of available infrastructures
- Budgetary problem

Research strategies

- Develop varieties resistant to major disease and pest, processing varieties and production technologies for different agro-ecological zones
- Encourage integrated pest, disease management concept in variety and technology generation
- Increase in productivity in Karnali and remote areas with coordination of other agencies (TPS promotion)
- Distribution of source seed distribution in coordination with extension network
- Collection and conservation of local and exotic germplasm
- Regularity and sustainability in disease free seed production through tissue culture technology
- Socio-economic research
- Post-harvest technology generation
- Participatory research on potato in collaborating with stakeholders

Future thrust

- Increase in high quality potato seed supply
- Variety development for processing and keeping quality
- Develop compatible and profitable potato based cropping system
- Modernize seed production technique e.g. virus detection methods and RMT
- Develop forecasting system for late blight disease
- Develop integrated management practices to control brown rot and PTM and leaf miner
- Agro-technique: Low input, sustainable, and environmentally friendly to reduce dependence on chemicals, trace compounds and to replace insecticides
- Seed research: Utilization of alternative multiplication techniques e.g. sprout cutting, leaf cutting, micro-tuber, minituber for multiplying disease free planting material
- Post-harvest technology: Processing and value addition, potato storage and processing, storage technology requiring minimum energy e.g. diffused light storage, varieties with superior keeping quality and processing
- Socio-economic studies: Many problem of potato in Nepal in developmental problems, need to work on socio-economic constraints, analysis in adoption of new technologies

CONCLUSION

Undoubtedly the food security and sustainability are the most challenging problems of today and. Considering the trend of population growth and consequently the increased demand of food in the country and the dwindling cultivable land area, the potato is likely to play a very important role in the future. Potato is a wholesome and nutritious food. The food security and sustainability can be achieved through the use of science base technology. Sustainable potato production is relatively inexpensive mainly because no pesticides are used and the cost of fertilization remaining low. Therefore, it is also recommended that agricultural scientists and extension workers pay attention to use of science base sustainable potato production technologies where intensive crop production systems are applied.

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Evaluation of Potato Clones at Mid and High Hills of Nepal

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ABSTRACT

Field experiments were carried out at Hattiban Research Farm, Khumaltar and Agriculture Research Station Rajikot, Jumla during 2003/04 and 2004/2005 to evaluate the morphological characters, late blight reaction, and yield and tuber characters of potato clones. Pooled analysis over the years and location revealed that clones 392637.10, 393339.242, 392657.8, 393280.64, 393077.159, 393385.39, 393280.57, 391396.96 and 393077.54 were found resistant (2 score in 1 to 9 scale) to late blight disease. Clone 393385.39 gave maximum number of tuber per plot. As compared to check varieties, clone 393077.159 gave highest (22.4 tha⁻¹) tuber yield at Khumaltar and Rajikot condition. On the basis of morphological characters, late blight infection, tuber yield and character, clones 392637.10, 392657.8, 393280.64, 393077.159, 393385.39 and 393077.54 are selected at Khumaltar and Rajikot for further evaluation in farmer's field.

INTRODUCTION

Potato is an important vegetable for farmers in mid hills and food crop for farmers in high hill of Nepal. It gives a very high income compared to any other vegetable cultivated in these domains. Climatic variation existing in the country allows potato farmers to grow this crop more than one crop in the same field in each year. Hence, high yield of potato per unit area and time has become most valuable trait especially for mid and high hill farmers. Late blight disease caused by *Phytophthora infestans* is also dependent on weather conditions and the amount of yield loss it causes depends on how early and quickly the foliage is destroyed (Hide and Lapwood, 1992). Losses in yield are generally recorded every year in Nepal, however, in terai LB appeared in epidemic form with 2-3 years intervals whereas in the hills it occurs annually (Ojha et al 1998). Most of the landraces and introduced varieties during late 70's in Nepal are susceptible to it.

Potato varieties cultivated by the farmers so far at mid and high hills are still local varieties having low yield capacity and virally degenerated. Varieties which are developed particularly for mid and high hill farmers still do not fulfill farmers' demand. High yielding, late blight resistant and medium to early bulking potato varieties are demanded by the farmers of mid and high hill. Tuber characters such as skin color, flesh color and eye depth are hardly influenced by environmental conditions but foliage development, maturity class, tuber number and size, dry matter content and yield are influenced by environmental conditions (Struik and Wiersema 1999). Haulm development, stolon growth and tuber growth are also influenced by temperature, day length, light intensity, physiological age of the seed, plant density, nitrogen supply and moisture supply.

World wide selection of resistance clone to cope with late blight is one of the most challenging tasks at present. Farmers need resistant varieties to replace traditional old varieties that are susceptible to late blight (Qunbao et al 1994). Therefore, International Potato Center (CIP) has emphasized on breeding population which is the most advanced agronomically and is derived from population A (Landeo et al 1997). National Potato Research Program (NPRP) has been testing the advanced potato clones to select the better genotype/clones in different ecological region of Nepal since 1990.

MATERIALS AND METHODS

This study was performed during 2003/04 -2004/05 at Hattiban Farm, Khumaltar (1350 masl) and ARS (Hort.) Farm, Rajikot Jumla, ecologically two distinct regions. Twelve different genotypes were used at both locations. Kufri Jyoti and Desiree were used as check varieties. This experiment was laid out in randomized complete block design (RCBD) with three replications. The plot size was maintained at 2.4 m² and net harvested area was 2.1m². Fertilizer was applied at the rate of 100:100:60 kg NPK along with 20 tons farmyard manure per hectare. Half dose of N, full dose of P, K and FYM were applied as basal dose and remaining half dose of nitrogen was given at 45 days of emergence at the time of earthing up. Weeding and irrigation was given as per the crop requirements.

Plant emergence (%), ground cover (%), late blight score, total tuber number per plot, tuber weight (kgplot⁻¹), total yield (tha⁻¹) and tuber characters were taken as important parameters. Plant emergence was taken after 30 days after planting and ground cover was measured after 7 weeks of tuber planting. Late blight score was taken in 1 to 9 CIP scale (1 = no symptom, 2 = 2.5 %, 3 = 10%, 4 = 25%, 5 = 50%, 6 = 75%, 7 =90%, 8 = 97.5 % and 9 = 100% affected, Khatri et al 1999). Likewise, total tuber number, weight, total yield and tuber characters were recorded at harvesting of the crop.

RESULTS AND DISCUSSION

Plant emergence

Tuber emergence was recorded highest (86%) in clone 392637.10 and Kufri Jyoti (100%) at Khumaltar and Rajikot (Table 1).

Table 1. Plant emergence (%) of potato clones at Khumaltar and Rajikot, Jumla

Clones	Plant emergence (%)								Mean variety x Year
	2004			2005			Loc x Variety		
	Khumal	Rajikot	Pooled	Khumal	Rajikot	Pooled	Khumal	Rajikot	
392637.10	100	72	86	83	94	89	92	83	88
393339.242	90	73	81	96	100	98	93	86	90
392657.8	94	40	67	98	96	97	96	68	82
393280.64	96	65	80	92	96	94	94	80.2	87
393077.159	96	44	70	90	98	94	93	71	82
393385.39	100	69	84	90	98	94	95	83	89
391002.6	98	44	71	75	100	88	86	72	79
393280.57	94	42	68	90	96	93	92	69	80
391396.96	100	56	78	96	100	98	98	78	88
393077.54	98	35	67	94	81	88	96	58	7
K. Jyoti (ch)	100	73	86	96	92	94	98	82	90
Desiree (ch)	100	58	79	100	90	95	100	74	87
Mean	97	56	76	91	95	93	94	75	85
F-Test	NS	**	**	NS	NS	NS			**
CV (%)	5.6	19.2	11.1	10.7	8.4	9.6			10.3
LSD	-	18.1	14.0	-	-	-			5.1
Variety			**			NS			**
Year									**
Location			**			NS			**
Var x Year									**
Var x Loc			**			NS			**
Year x Loc									**
Var x Loc x Year									**

**_ significant difference at 1% level.

In 2004, tuber emergence (%) of potato clones in Rajikot was recorded very low than Khumaltar. Poor soil moisture and less sprout development at the time of planting might be the reasons of low emergence. In 2005, tuber emergence was highest (98%) in clones 393339.242 and 391396.96 at both locations. However, plant emergence was statistically nonsignificant among the clones evaluated in 2005. The interaction of genotype and locations was found significant in 2004 but non-significant in 2005.

At Khumaltar, highest (100%) plant emergence was recorded in Desiree followed by the clone 391396.96 (98%) but at Rajikot, tuber emergence was maximum (86.4%) followed by the clone 392637.10 (83%) in both years. The mean of tuber emergence over the years at both locations were statistically highly significant (Table 1). Highest (90%) tuber emergence was recorded at Kufri Jyoti followed and clone 393339.242 (90%) and clone 393385.39 (89%) whereas lowest (77%) plant emergence was recorded in clone 393077.54. As compared to Khumaltar, tuber emergence was recorded low (74 %) in Rajikot. This might be due to lower soil temperature as well as lower soil moisture contained in soil.

Table 2. Ground cover (%) of potato clones tested at Khumaltar and Rajikot, Jumla during 2004/05 and 2005/06

Clones	Ground cover (%)								
	2004			2005			Loc x Variety		Mean Variety x Year
	Khumal	Rajikot	Pooled	Khumal	Rajikot	Pooled	Khumal	Rajikot	
392637.10	80	97	89	72	75	74	76	86	81
393339.242	67	97	82	65	65	65	66	81	74
392657.8	88	53	71	80	60	70	84	56	70
393280.64	83	86	85	68	80	74	76	83	79
393077.159	80	53	67	57	65	61	83	59	64
393385.39	77	92	84	72	85	79	74	89	82
391002.6	75	53	64	50	55	53	63	54	58
393280.57	63	56	60	70	55	63	67	56	61
391396.96	83	65	74	72	70	71	78	68	73
393077.54	82	47	65	87	55	71	84	51	68
K. Jyoti (ch)	78	97	88	80	85	83	79	91	85
Desiree (ch)	68	78	73	85	70	78	77	74	75
Mean	77	73	75	74	70	70	76	71	73
F-Test	**	**	**	**	NS	NS			**
CV (%)	7.9	18.0	13.7	13.2	8.4	10.6			12.1
LSD	10.4	22.3	16.1	16.6	15.5	-			10.6
Variety			**			NS			**
Year									**
Location			*			**			**
Var x Year									**
Var x Loc			**			**			**
Year x Loc									**
Var x Loc x Year									**

** - Significant difference at 1% level. * - Significant difference at 5% level.

Ground cover

In 2004, clone 392637.10 produced maximum (89%) ground cover followed by Kufri Jyoti (88%) but lowest (60%) ground cover was in clone 393280.57 at both locations (Table 2). In 2005, highest (83%) ground coverage was recorded in Kufri Jyoti followed by the clone 393385.39 (79%) at Khumaltar and Rajikot. The interaction of genotypes and locations over the years was statistically significant. At Khumaltar, clone 392657.8 was observed highest (84%) ground foliage followed by the clones 393077.54 (84%) and 393077.159 but in Rajikot. Maximum (91%) ground foliage was recorded in K. Jyoti followed by 393385.39 (89%). Ground foliage was also highest (76.4%) at Khumaltar than Rajikot

(70.7%). Difference in light intensity, temperature and edaphic condition exists between Khumaltar and Rajikot might vary the ground foliage development of the clones. Over the years at both locations, Kufri Jyoti produced highest (85%) ground foliage followed by the clone 393385.39 (82%) and 392637.10 (81%) where lowest (58%) ground cover was recorded in clone 391002.6.

Late blight disease infection

At Khumaltar and Rajikot, clones 393280.64, 393385.39 and 393280.57 were recorded highly resistant (1 score in CIP 1 to 9 scale) to late blight in 2004 whereas 392637.10, 392657.8, 393077.159 and 393077.54 were observed as resistant (2 score in CIP 1 to 9 scale) clones (Table 3). But in 2005, pooled late blight score among the clones were statistically significant. Clones 392637.10, 393339.242, 393280.64 and 391396.96 were found resistant genotypes in 2005. Genotypes showed variation in late blight disease development among the clones. At Khumaltar, in both the years, clones 392637.10, 393339.242, 392657.8, 393280.64, 393280.57 and 391396.96 were found resistant to late blight disease rating 2 as compared to check varieties in CIP 1 to 9 scale. Likewise, at Rajikot, clone 393280.64 was found highly resistant (ranking 1) whereas, clones 392637.10, 392657.8, 393077.159, 393385.39 and 393077.54 were least (2 score) affected by late blight disease. Pooled mean over the years and location also revealed that clones 392637.10, 393339.242, 392657.8, 393280.64, 393077.159, 393385.39, 393280.57, 391396.96 and 393077.54 were found resistant (2) to late blight. At both locations, mean of late blight disease were not much difference. Spring planting of potato at Khumaltar is not conducive for late blight disease development properly. Likewise, at Rajikot, summer planting of potato clones was not favorable conditions for late blight disease development. Because of low humidity and higher air temperature hindered the fungal growth, hence, minimum foliage blight was observed at both locations.

Table 3. Late blight (1-9) score of potato clones tested at Khumaltar and Rajikot, Jumla during 2004/05 - 2005/06

Clones	Late blight (1-9) score								Mean variety x Year
	2004			2005			Loc x Variety		
	Khumal	Rajikot	Pooled	Khumal	Rajikot	Pooled	Khumal	Rajikot	
392637.10	2.0	1.0	1.5	2.0	2.3	2.1	2.0	1.6	1.8
393339.242	2.3	2.6	2.5	1.8	2.3	2.0	2.0	2.5	2.0
392657.8	1.6	1.6	1.6	3.0	2.0	2.5	2.3	1.8	1.5
393280.64	1.0	1.0	1.0	2.0	2.0	2.0	1.5	1.0	1.5
393077.159	2.0	2.0	2.0	3.5	2.3	2.9	2.7	2.1	2.4
393385.39	1.6	1.0	1.3	2.0	3.0	2.5	1.8	2.0	1.9
391002.6	2.5	3.5	3.0	4.5	3.5	4.0	3.5	3.5	3.5
393280.57	1.3	1.0	1.1	2.8	2.3	2.5	2.0	1.6	1.8
391396.96	1.6	3.3	2.5	2.1	2.3	2.2	1.8	2.8	2.3
393077.54	2.0	1.0	1.5	4.4	2.3	3.3	3.2	1.6	2.4
K. Jyoti (ch)	2.6	6.3	4.5	4.5	4.6	4.5	3.5	5.4	4.5
Desiree (ch)	3.0	4.0	3.5	4.0	3.6	3.8	3.5	3.8	3.6
Mean	1.9	2.3	2.1	3.0	2.7	2.7	2.4	2.2	2.4
F-Test	**	**	**	**	NS	**			**
CV (%)	23.2	24.1	24.3	18.5	19.4	17.7			25.1
LSD	0.7	2.0	2.1	1.3	-	1.2			1.1
Variety			**			NS			**
Year									NS
Location			NS			**			**
Var x Year									*
Var x Loc			*			NS			*
Year x Loc									**
Var x Loc x Year									*

** - Significant difference at 1% level. * - Significant difference at 5% level.

Total tuber number

Highly significant mean difference of tuber number per plot was observed among the clones at Khumaltar and Rajikot in 2004 (Table 4). Clone 393385.39 produced highest (166) number of tubers per plot and lowest (70) tuber number in clone 393077.54. Similarly, in 2005, at both locations, clone 393385.39 yielded maximum (141) tuber number per plot followed by the clone 393077.159 (124). Highest tuber number per plot was observed in clone 393385.39 at Khumaltar and at Rajikot were 195 and 112, respectively. Mean tuber number per plot was counted highest (133) at Khumaltar than Rajikot. Besides the genetic potential of genotypes, climatic variation might be the reason of producing lower tuber number at Rajikot. Over the years and location, highest (153) tuber number was observed in clone 393385.39 followed by Kufri Jyoti (113) whereas lowest (82) tuber number in clone 393280.64.

Table 4. Total tuber number per plot of potato clones tested at Khumaltar, Lalitpur and Rajikot, Jumla during 2003/04 - 2004/05

Clones	Tuber number plot ⁻¹						Mean	
	2004			2005			variety	
	Khumal	Rajikot	Pooled	Khumal	Rajikot	Pooled	Loc x Variety	x Year
392637.10	143	93	118	113	64	89	128	103
393339.242	132	75	103	129	56	92	130	98
392657.8	142	55	98	140	54	97	140	98
393280.64	148	68	108	111	72	92	129	100
393077.159	122	53	88	164	84	124	143	106
393385.39	215	117	166	174	107	141	195	154
391002.6	137	89	113	79	40	59	108	86
393280.57	89	57	73	107	75	91	98	82
391396.96	157	53	105	157	61	109	157	107
393077.54	115	25	70	133	57	95	124	83
K. Jyoti (ch)	153	89	122	144	65	104	150	113
Desiree (ch)	91	107	99	108	63	86	100	92
Mean	137	73	105	130	66.5	98	133	102
F-Test	**	NS	**	**	*	**		**
CV (%)	18.4	22.5	27.0	18.4	28.7	22.4		24.9
LSD	42.8	-	46.7	40.6	33.4	36.1		41.2
Variety			**			**		**
Year								NS
Location			**			**		**
Var x Year								**
Var x Loc			*			NS		**
Year x Loc								NS
Var x Loc x Year								NS

** - Significant difference at 1% level. * - Significant difference at 5% level.

Tuber weight

In 2004, maximum (4.6 kg) weight per plot was harvested from clone 392637.10 followed by the clones 392657.8 (4.3 kg) and 393385.39 (4.1 kg) at Khumaltar and Rajikot (Table 5). Highest (5.5 kg) weight was obtained in clone 393077.159 followed by the clone 393077.54 (4.9 kg) and 393280.64 (4.5 kg) in 2005. Total weight per plot over the locations varied among the genotypes.

At Khumaltar, highest tuber yield (5.9 kg) per plot was harvested from the clone 393077.159 followed by the clone 392657.8 (5.6 kg) and 393077.54 (5.4 kg) but at Rajikot, clone 392637.10 gave highest (3.9 kg) followed by the clone 393077.159 (3.5 kg). Total weight per plot was also different at Khumaltar and Rajikot. Tuber emergence was low at Rajikot; hence, this might be the cause of low tuber weight per plot at Rajikot condition. In both the locations over the years, clone 393077.159 gave the highest (4.7 kg) weight per plot.

Table 5. Total weight (kg/plot) of potato clones on yield at Khumaltar, Lalitpur and Rajikot, Jumla during 2003/04 - 2004/05

Clones	Total weight (kgplot ⁻¹)								Mean Variety x Year
	2004			2005			Loc x Variety		
	Khumal	Rajikot	Pooled	Khumal	Rajikot	Pooled	Khumal	Rajikot	
392637.10	5.1	4.6	4.8	4.4	3.3	3.9	4.7	3.9	4.3
393339.242	2.7	3.2	2.9	2.6	2.3	2.4	2.6	2.7	2.7
392657.8	5.9	2.8	4.3	5.2	2.7	3.9	5.6	2.7	4.1
393280.64	4.1	2.6	3.3	5.5	3.5	4.5	4.8	3.0	3.9
393077.159	4.8	3.1	3.9	7.1	3.9	5.5	5.9	3.5	4.7
393385.39	5.4	2.9	4.1	5.2	2.9	4.0	5.3	2.9	4.1
391002.6	4.9	2.9	3.9	3.5	1.7	2.6	4.2	2.3	3.2
393280.57	2.5	2.0	2.2	4.1	2.0	3.0	3.3	2.0	2.6
391396.96	3.5	2.3	2.9	5.2	2.9	4.0	4.4	2.6	3.5
393077.54	4.6	1.7	3.2	6.6	3.2	4.9	5.6	2.5	4.0
K. Jyoti (ch)	5.1	3.1	4.1	5.2	1.6	3.4	5.2	2.4	3.8
Desiree (ch)	2.5	2.5	2.5	4.0	1.0	2.5	3.2	1.7	2.5
Mean	4.2	2.8	3.5	4.9	2.6	3.7	4.6	2.7	3.6
F-Test	**	*	**	**	*	**			**
CV (%)	13.5	30.1	21.0	18.1	22.8	23.2			22.1
LSD	0.9	1.3	1.2	1.5	1.4	1.4			1.3
Variety			**			**			**
Year									NS
Location			*			**			**
Var x Year									**
Var x Loc			**			NS			**
Year x Loc									**
Var x Loc x Year									NS

** - Significant difference at 1% level. * - Significant difference at 5% level.

Tuber yield

Pooled mean of tuber yield at Khumaltar and Rajikot in 2004 was statistically significant (Table 5). Clone 392637.10 gave highest (23.9 t ha⁻¹) tuber yield followed by clone 392657.8 (21 t ha⁻¹) and 393385.39 (20.6 t ha⁻¹). In 2005, variation in tuber yield was found among the clones. Clone 393077.159 gave highest (25.2 t ha⁻¹) yield followed by the clone 393077.54 (22.5 t ha⁻¹) and lowest (11 t ha⁻¹) in clone 393339.242. The interaction of genotype and location in expressing the yield character was also found significant. At Khumaltar, clone 393077.159 gave highest (28.3 t ha⁻¹) tuber yield followed by the clone 393385.39 (25.3 t ha⁻¹) but at Rajikot condition, clone 392637.10 performed better (18.4 t ha⁻¹) than clone 393077.159 (16.6 t ha⁻¹).

At Khumaltar, mean yield of potato clones were also higher (21.8 t ha⁻¹) than the mean yield of potato clones at Rajikot (12.7 t ha⁻¹). Poor plant emergence, less foliage development, less tuber number per plot and low weight per plot might resulted the lowest yield at Rajikot condition. But tuber yield of the clones at both locations were statistically highly significant in all the years.

Clone 393077.159 produced highest (22.4 t ha⁻¹) yield followed by the clone 392637.10 (20.5 t ha⁻¹) and lowest (12.1 t ha⁻¹) yield was recorded in Desiree. Environmental differences like photoperiod, edaphic condition and temperature etc. might be the reasons for low yield at Rajikot condition than Khumaltar.

Table 6. Yield (t/ha) of potato clones tested at Khumaltar, Lalitpur and Rajikot, Jumla during 2003/04 - 2004/05

Clones	Yield (t/ha)								Mean variety x Year
	2004			2005			Loc x Variety		
	Khumal	Rajikot	Pooled	Khumal	Rajikot	Pooled	Khumal	Rajikot	
392637.10	24.1	23.7	23.9	21.1	13.0	17.1	22.6	18.4	20.5
393339.242	13.0	16.5	14.7	12.4	9.7	11.0	12.7	13.1	12.9
392657.8	28.2	13.8	21.0	25.0	11.2	18.1	26.6	12.5	19.5
393280.64	19.4	13.8	16.6	26.3	14.5	20.4	22.8	14.1	18.5
393077.159	22.6	16.8	19.7	34.1	16.4	25.2	28.3	16.6	22.4
393385.39	25.7	15.6	20.6	24.9	12.1	18.5	25.3	13.8	19.5
391002.6	23.5	15.3	19.4	16.8	7.0	11.9	20.2	11.1	15.7
393280.57	11.7	9.9	10.8	19.8	8.3	14.1	15.7	9.1	12.4
391396.96	16.9	12.6	14.7	24.9	11.9	18.4	20.9	12.3	16.6
393077.54	22.2	9.2	15.7	31.6	13.5	22.5	26.9	11.3	19.1
K. Jyoti (ch)	24.3	16.6	20.5	25.0	6.9	16.0	24.7	11.8	18.2
Desiree (ch)	11.8	13.5	12.6	19.0	4.2	11.6	15.4	8.8	12.1
Mean	20.3	14.8	17.5	23.4	10.7	17.1	21.8	12.7	17.3
F-Test	**	*	**	**	*	**			**
CV (%)	13.6	30.2	21.1	18.2	28.6	23.1			22.1
LSD	4.6	6.5	6.1	7.2	6.1	6.5			6.2
Variety			**			**			**
Year									NS
Location			NS			**			**
Var x Year									**
Var x Loc			**			NS			**
Year x Loc									**
Var x Loc x Year									NS

** - Significant difference at 1% level. * - Significant difference at 5% level.

Crop maturity and tuber characters

At Khumaltar, clones 392637.10, 393339.242, 393280.64, 393077.159, 391396.96 and Kufri Jyoti were identified as medium maturing type but at Rajikot, these genotypes were recorded late maturing (Table 7).

Table 7. Crop maturity and tuber characters of potato clones evaluated at Khumal and Jumla during 2003/04 – 2004/05

Genotypes	Maturity		Tuber shape	Tuber characters	
	Khumal	Jumla		Tuber color	Eye depth
392637.10	M	L	O	W	M
393339.242	M	L	R	Pp	M
392657.8	L	M	R	W	M
393280.64	M	L	R	R	M
393077.159	M	L	O	W	S
393385.39	E	M	R	R	D
391002.6	E	M	R	W	M
393280.57	L	L	R	R	M
391396.96	M	L	R	Pp	M
393077.54	E	M	O	W	S
Kufri Jyoti (ch)	M	L	O	W	S
Desiree (ch)	E	E	Ob	R	M

O= oval, Ob= oblong, R= round, W= white, R= red, Pp = purple, M= medium, S= shallow, D= deep,

At Khumaltar, clone 393385.39, 391002.6 and 393077.54 were early maturing whereas these genotypes were found medium maturing type at Rajikot condition. Tuber shape, color and eye depth did not varied at both of the locations experimented. Clone 392637.10, 393077.159, 393077.54 and Kufri Jyoti were produced oval shaped tuber and rest of clones were of round shaped except Desiree. The clones 392637.10, 392657.8, 393077.159, 391002.6, 393077.54 and Kufri Jyoti were white skin and clones 393280.64, 393385.39 and Desiree were red-skinned in color. Clones 393339.242 and 391396.96 were observed purple color in tuber. Clones 392637.10, 393339.242, 392657.8, 393280.64, 391002.6, 393280.57, 391396.96 and Desiree were medium eye depth in tuber. Tubers of clone 393385.39 were found deep eyed and clone 393077.159 had shallow eye depth.

CONCLUSION

Tuber emergence, ground foliage development, maturity, total tuber number, total yield were significantly different at Khumaltar and Rajikot condition among the clones. Therefore, these characters were found unstable in different environmental conditions whereas tuber shape, tuber color and eye depth were same at both locations. Based on the evaluation of late blight, total yield and tuber characters, clones 393077.159, 392637.10, 392657.8, 393385.39, 393077.54 and 393280.64 were selected for further evaluation in different outreach sites of respective research stations. Seed tuber of selected potato clones are also recommended to multiply at on-station and conduct the research at farmer's field to validate on-station's results.

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Performance of different Generation (F_1C_1 - F_1C_4) TPS Tubers for Commercial Potato Production at Khumaltar

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ABSTRACT

In Nepal, major factors for low productivity of potato crop are poor quality seed, high seed cost and unavailability of quality seed due to which, resource poor farmers are using degenerated seed tubers. Therefore, a field study was carried out at Khumaltar, Lalitpur (1360 masl), during 2003-2006 to evaluate and compare the different generation (F_1C_1 - F_1C_4) tubers of seven hybrid true potato seed (TPS) families with basic seed tubers of Desiree and Khumal Seto-1 of 20-40 g sizes. The tubers were tested in randomized complete block design with three replications. All the tested families produced significantly higher yield by using F_1C_1 TPS tuberlets than Desiree and higher and at par as compared to Khumal Seto-1. Except Atzimba x TPS 67 all the tested TPS families significantly produced the higher yield as compared to Desiree and higher and at par yield with the high yielding potato variety Khumal Seto-1 from F_1C_2 , F_1C_3 and F_1C_4 generation TPS tubers. The research results showed that all the tested TPS families can be used for commercial potato production from F_1C_1 to F_1C_4 generation at Khumaltar condition where quality seed tubers of high yielding potato varieties are not easily available.

INTRODUCTION

In Nepal potato ranks fourth most important food crop after rice maize and wheat (APP 1995). The area under potato crop during 2006/07 was estimated 153534.ha and productivity 12.66 t/ha, respectively (APSD 2006/07). The low productivity is mainly attributed to unavailability of quality seed tubers, their high cost and late blight disease. As a result, many farmers have to use degenerated local seed. Use of poor seed tubers results to low yield, high production costs per unit of output and high potato prices at the consumers' level. Seed is a major input in potato production accounting 40-60 percent of the cost of cultivation growing of potato crop (Sadik 1983, Singh and Jaanardan Jee 1990). Because of the above-mentioned problems associated with traditional potato seed tubers, the use of true seed becomes as an alternative for the traditional methods. In Nepal, The use of true seed has been successfully practice from terai to high hills.

TPS for potato production is used in two ways; in the first method, seedling tubers are produced in nursery beds and in next season, these are used as seed tuber for raising ware potato crop. In second method, seedlings are raised in nursery beds and transplanted in field for potato production (Adhikari 2007, Adhikari 2005, Adhikari et al 2004, Sadik 1983). Potatoes produced by either approach can be used for consumption or as seed tubers, or both, depending on the specific needs and condition of the farmers. TPS seedlings as a propagating material can be used successfully in areas where farmers are well aware of the horticultural practice being applied for vegetable production, temperature are moderate at transplanting and irrigation is available (Adhikari et al 2003, Kadian et al 1988, Patel et al 1998). However, for those areas where labour availability is a problem and climatic condition are not favorable for seedlings, the seedling tubers derived from true seed during the previous season or off-season can be used as a planting material in the following season. The purpose of undertaking this study was to see the performance and comparison of first to fourth generation (F_1C_1 - F_1C_4) with well-adapted commercial potato varieties for tuber production.

MATERIALS AND METHODS

In the trial, F1C1 refers to the first potato crop planted using tubers (or tuberlets) harvested from the F1 crop. These are in effect a mixture of clones and carry considerable genetic variation. F1C2 is the potato crop planted from tubers of the F1C1 generation. Producer selection will gradually reduce the number of clones in this mixture. Similar terminology applies to the F1C3, F1C4 and subsequent generations. They are referred to as TPS, as long as a mixture of clones continues to constitute the planting material.

Potato production from F1C1 tubers

The experiment was conducted at Hattiban Research Farm, Potato Research Programme Khumaltar, Lalitpur during 2003 to 2006. TPS tuberlets from 2002 harvest of TPS families Atzima x TPS 67, LT 8 x TPS 13, LT 8 x TPS 67, MF I x TPS 67, MF II x TPS 67, Serrana x TPS 13 and Serrana x TPS 67 grown in nursery beds were kept in the cold store till the end of December 2002. Twenty-five days before planting the tuberlets of 5-40 g sizes were taken out from the cold store and kept in diffused light for sprouting. The crop was planted on Feb 2, 2003. The basic seed tubers (25-50 g size) of Desiree and Khumal seto-1 were planted as check for comparison. Planting distance for all the treatments was kept 60 cm between rows and 25 cm between plants. Pre-planting application of NPK was applied in lines at the rate of 100:100:60 kg/ha. The fertilizers were covered with well-decomposed FYM @ 20 t/ha. The experiment was laid down randomized complete block design (RCBD) with three replications. No any fungicides were sprayed. Irrigation was applied at 40 days while earthing up was done at 50 days of planting. The check variety Desiree was dehaulmed at 90 days, Khumal seto- 1 and all the TPS families were dehaulmed at 100 days and harvested at 10 days after dehaulming. Total yield was recorded in three grades (<25, 25-50 g, >50 g) at harvest. Analysis of variance was performed by using MSTATC version (MSTAT 1986). The data were analyzed as suggested by Gomez and Gomez (1984).

Potato production from F1C2 tubers

The harvested seed sized (25-50 g) TPS tubers from F1C1 were kept in cold store till the end of first week of January 2004. These tubers were kept in diffused light for sprouting. The crop was planted on February 5, 2004 and the check variety Desiree was dehaulmed at 90 days, Khumal seto- 1 and all the TPS families were dehaulmed at 100 days and harvested 10 days after the dehaulmed. The basic seeds of same cultivars were used in F1C1 also used in F1C2. Others practices were followed as described in potato production from F1C1 tubers.

Potato production from F1C3 tubers

The harvested seed sized (25-50 g) TPS tubers from F1C2 were kept in cold store till the end of the first week of January 2005. These tubers were kept in diffused light for sprouting. The crop was planted on February 3, 2004. The check variety Desiree was dehaulmed at 90 days, Khumal seto-1 and all the TPS families were dehaulmed at 100 days and harvested 12 days after dehaulmed. The basic seeds of same cultivars were used in F1C2 also used in F1C3. Others practices were followed as described in potato production from F1C2 tubers.

Potato production from F1C4 tubers

The harvested seed sized (25-50 g) TPS tubers from F1C3 were kept in cold store till the end of the first week of January 2006. These tubers were kept in diffused light for sprouting. The crop was planted on February 6, 2004. The check variety Desiree was dehaulmed at 90 days, Khumal Seto-1 and all the TPS families were dehaulmed at 100 days and harvested 10 days after dehaulmed. The basic seed of same cultivars were used in F1C3 also used in F1C4. Others practices were followed as described in potato production from F1C3 tubers.

RESULTS AND DISCUSSION

Potato production from F1C1 tubers

The yield differences among the treatments were statistically significant (Table 1). TPS family MF I x TPS 67 produced significantly higher tuber yield (39.9 t/ha) than Atzimba x TPS 15 (34.9 t/ha), Serrana x TPS 13 (33.0 t/ha) and the check Desiree (23.5 t/ha) while it was at par with other TPS families and the check variety Khumal Seto-1 (38.2 t/ha). Adhikari and Baral (2007), Adhikari et al (2003), Dubey et al (1992), and Kadian et al (1988) also reported equal or higher yield from F1C1 tubers and seedling tubers of selected TPS families than local varieties. The grading of tuber yield among the TPS families was statistically different (Table 1). The production of weight of small (25 g) size tubers was significantly highest with MF II x TPS 67 (3.3 kg/6 m²) followed by LT 8 x TPS 67 (3.1 kg/6 m²). The check variety Khumal Seto-1 produced the highest tuber weight (13.9 kg/6 m²) of seed size (25-50 g) tubers followed by Atzimba x TPS 67 (13.2 kg/6 m²). Likewise the highest tuber weight (13.5 kg/6 m²) of oversize (>50 g) tubers were recorded in LT 8 x TPS 13 followed by Serrana x TPS 67 (10.4 kg/6 m²).

Table 1. Comparative tuber yield of F₁C₁ of TPS families versus seed tubers of cv. Desiree and Khumal Seto-1 for potato production at Khumaltar in 2003

TPS families/cultivars	Tuber yield by number and weight (kg/6.0 m ²)								Yield t/ha
	<25 g		25-50 g		>50 g		Total		
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	
Atzimba x TPS 67	251bc	2.5b	381a	13.2a	59e	5.3e	691ab	21.0bc	34.9bc
LT 8 x TPS 13	168e	1.3c	224d	8.9d	124a	13.5a	516c	23.6a	39.4a
LT 8 x TPS 67	209d	3.1a	304bc	12.9a	109ab	8.0d	622b	23.9a	39.9a
MF I x TPS 67	266b	3.3a	280c	11.1bc	92bc	9.5bc	637b	23.9a	39.8a
MF II x TPS 67	271b	2.4b	293bc	10.8bc	83cd	8.7cd	647b	21.8abc	36.4abc
Serana x TPS 13	219cd	1.5c	334ab	12.2ab	66de	6.1e	620b	19.8c	33.0c
Serana x TPS 67	145e	2.3b	229d	9.6cd	90bc	10.4b	464c	22.2ab	37.1ab
Desiree (ch)	137e	1.3c	175e	6.9e	66de	5.9e	379d	14.1d	23.5d
Khumal Seto (ch)	334a	3.0c	343ab	13.9a	66de	6.1e	743a	22.9ab	38.2ab
CV %	6.64	8.04	6.86	6.42	9.03	4.79	4.77	4.31	4.36
F-test	**	**	**	**	**	**	**	**	**

** Significant difference at 1% level. Means followed by the same letter within column are not significantly different according to Duncan Multiple Range Test at P = 0.01.

Number of tubers among the families was statistically different (Table 1). The check variety Khumal Seto-1 produced the highest numbers (743/6 m²) of total tubers followed by Atzimba x TPS 67 (691/6m²). TPS families and several other factors influence tuber number. The genetic make up of the TPS family also might be responsible for these differences (Adhikari et al 2005, Adhikari et al 2003). The tuber grading results showed that the highest number of large size (>50 g) tubers was obtained from LT 8 x TPS 13 (124/6 m²) followed by LT 8 x TPS 67 (109/6 m²). The highest number of seed size (25-50 g) tubers were recorded in Atzimba x TPS 67 (381/6 m²) followed by the check variety Khumal Seto-1 (343/6 m²). The highest numbers of small (<25 g) size tubers were recorded in the check Khumal Seto-1 (334/6 m²) followed by MF II x TPS 67 (271/6 m²).

Potato production from F1C2 tubers

The yield differences among the treatments were statistically significant (Table 2). The check variety Khumal Seto-1 produced significantly maximum tuber yield (24.8 t/ha) followed by LT 8 x TPS 13 (23.1 t/ha). The production of weight of small (<25 g) size tubers was significantly highest with LT 8 x TPS 13 and Serrana x TPS 67 (1.9 kg/6 m²) followed by LT 8 x TPS 67, MF I x TPS 67, and the check variety Khumal Seto-1 (1.6 kg/6 m²). The check variety Khumal Seto-1 produced the highest tuber weight (9.3 kg/6 m²) of seed size (25-50 g) tubers followed by LT 8 x TPS 13 (8.2 kg/6 m²). The maximum weight (4.4 kg/6 m²) of oversize (>50 g) tubers were recorded in Serrana x TPS 13 followed by check variety Khumal Seto-1 (4.0 kg/6 m²).

Table 2. Comparative tuber yield of F1C2 of TPS families versus seed tubers of cv. Desiree and Khumal Seto-1 for potato production at Khumaltar in 2004

TPS families/cultivars	Tuber yield by number and weight (kg/6.0 m ²)								Yield t/ha
	<25 g		25-50 g		>50 g		Total		
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	
Atzimba x TPS 67	140def	1.0d	170d	6.6cd	15c	1.7e	326d	9.3	15.5
LT 8 x TPS 13	151cde	1.9a	195bc	8.2b	35a	3.8b	381bc	13.9	23.1
LT 8 x TPS 67	184a	1.6b	173cd	6.5cd	29b	2.9d	387abc	11.0	18.3
MF I x TPS 67	174ab	1.6b	213ab	8.0b	28b	2.9d	414a	12.4	20.7
MF II x TPS 67	162bc	1.2cd	177cd	6.8c	27b	2.8d	366c	10.8	18.0
Serana x TPS 13	122f	1.3c	179cd	6.8c	36a	4.4a	337d	12.5	20.9
Serana x TPS 67	158bcd	1.9a	192bcd	7.7b	29b	3.5c	379bc	13.1	21.9
Desiree (ch)	137def	1.0d	145e	5.9d	28b	3.0d	310d	9.9	16.4
Khumal Seto (ch)	135ef	1.6b	229a	9.3a	37a	4.0b	401ab	14.9	24.8
CV %	5.50	5.96	5.01	4.73	5.35	3.99	3.04	3.29	3.27
F-test	**	**	**	**	**	**	**	**	**

** Significant difference at 1% level. Means followed by the same letter within column are not significantly different according to Duncan Multiple Range Test at P = 0.01.

Number of tubers among the families was statistically different (Table 2). TPS family MF I x TPS 67 produced the highest numbers (414/6m²) of total tubers followed by the check Khumal Seto-1 (401/6m²). The tuber grading results showed that the highest number of large size (>50 g) tubers was obtained from the check variety Khumal Seto-1 (37/6 m²) followed by Serrana x TPS 13 (36/6 m²). The highest number of seed size (25-50 g) tubers were also counted in check variety Khumal Seto-1 (229/6 m²) followed by MF I x TPS 67(213/6 m²). The highest numbers of small (<25 g) size tubers were recorded in LT 8 x TPS 67 (184/6 m²) followed by MF I x TPS 67 (174/6 m²).

Potato production from F1C3 tubers

The yield differences among the treatments were statistically significant (Table 3). MF I x TPS 67 produced significantly maximum tuber yield (32.4 t/ha) followed by LT 8 x TPS 13 (29.7 t/ha). The grading of tuber weight among the TPS families was statistically different. The weight of small size (<25 g) tubers was significantly highest with Atzimba x TPS 67 (2.3 kg/6 m²) followed by Serrana x TPS 67 (2.1 kg/6 m²). MF I x TPS 67 produced the highest tuber weight (12.4 kg/6 m²) of seed size (25-50 g) tubers followed by Serrana x TPS 67 (12.0 kg/6 m²). The maximum weight (6.2 kg/6 m²) of oversize (>50 g) tubers were recorded in Serrana x TPS 13 followed by LT 8 x TPS 13 (5.4 kg/6 m²).

Number of tubers among the families was statistically different (Table 3). The check variety Khumal Seto-1 produced the highest numbers (587/6m²) of total tubers followed by LT 8 x TPS 67 (583/6m²). The tuber grading results showed that the highest number of large size (>50 g) tubers was obtained from the check variety Desiree (51/6 m²) followed by Serrana x TPS 13 (48/6 m²). The highest number of seed size (25-50 g) tubers were recorded in LT 8 x TPS 67 (314/6 m²) followed by MF I x TPS 67 and the check Khumal Seto-1(307/6 m²). The highest numbers of small (<25 g) size tubers were recorded in Atzimba x TPS 67 (/6 m²) followed by LT 8 x TPS 67 (243/6 m²).

The yield differences among the treatments were statistically significant (Table 4). LT 8 x TPS 13 produced significantly maximum tuber yield (28.4 t/ha) followed by the check variety Khumal Seto-1 (28.3 t/ha). The grading of tuber weight among the TPS families was statistically different. The weight of small (<25 g) size tubers was significantly highest with Atzimba x TPS 67 and MF I x TPS 67 (1.9 kg/6 m²) followed by LT 8 x TPS 13 and the check Khumal Seto-1 (1.6 kg/6 m²). The check variety Khumal Seto-1 produced the highest tuber weight (12.5 kg/6 m²) of seed size (25-50 g) tubers followed by MF I x TPS 67 (10.0 kg/6 m²).

Table 3. Comparative tuber yield of F1C3 of TPS families versus seed tubers of cv. Desiree and Khumal Seto-1 at Khumaltar in 2005

TPS families/cultivars	Tuber yield by number and weight (kg/6.0 m ²)								Yield t/ha
	<25 g		25-50 g		>50 g		Total		
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	
Atzimba x TPS 67	252a	2.3a	282b	9.2de	14e	1.3f	548b	12.9d	21.5d
LT 8 x TPS 13	169c	1.7cd	262c	10.7bcd	40bc	5.4ab	471c	17.8ab	29.7b
LT 8 x TPS 67	243ab	2.0b	314a	11.9ab	26d	2.9e	583a	16.8bc	28.1bc
MF I x TPS 67	231ab	1.9bc	307a	12.4a	40bc	5.1bc	578a	19.5a	32.4a
MF II x TPS 67	160c	1.5d	244d	10.1cd	37bc	4.5bc	441d	16.1bc	26.9bc
Serana x TPS 13	119d	1.1e	193f	8.4e	48ab	6.2a	361e	15.7c	26.2c
Serana x TPS 67	229b	2.1ab	303a	12.0ab	29cd	3.5de	562ab	17.7b	29.4b
Desiree (ch)	124d	1.0e	210e	8.2e	51a	4.9bc	386e	14.0d	23.4d
Khumal Seto (ch)	239ab	1.5d	307a	11.6abc	41b	4.4cd	587a	17.5b	29.1bc
CV %	4.34	7.07	2.34	6.03	11.64	8.96	2.40	4.17	4.20
F-test	**	**	**	**	**	**	**	**	**

** Significant difference at 1% level. Means followed by the same letter within column are not significantly different according to Duncan Multiple Range Test at P = 0.01.

Table 4. Comparative tuber yield of F1C4 of TPS families versus seed tubers of cv. Desiree and Khumal Seto-1 for potato production at Khumaltar in 2006

Seto-Flor potato production at Khumaltar in 2006									
TPS families/ cultivars	Tuber yield by number and weight (kg/6.0 m ²)								Yield t/ha
	<25 g		25-50 g		>50 g		Total		
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	
Atzimba x TPS 67	149d	1.9a	175c	7.4e	8d	0.9d	331e	10.1e	16.9e
LT 8 x TPS 13	176c	1.6ab	244ab	10.2bc	35a	5.3a	454bc	17.1a	28.4a
LT 8 x TPS 67	186bc	1.3ab	250ab	9.6bcd	28ab	3.8b	465bc	14.7bc	24.5bc
MF I x TPS 67	174c	1.9a	287a	10.9b	34ab	4.0b	495abc	16.9a	28.1a
MF II x TPS 67	147d	1.5ab	255ab	9.6bcd	33ab	4.9a	435cd	16.0ab	26.6ab
Serana x TPS 13	126d	0.9b	211bc	8.9cde	27b	4.0b	365e	13.8c	23.1c
Serana x TPS 67	147d	1.1b	212bc	8.3de	20c	2.5c	378de	12.0d	20.0d
Desiree (ch)	203ab	1.5ab	295a	9.2cd	12d	1.2d	510ab	11.8de	19.7d
Khumal Seto (ch)	211a	1.6ab	305a	12.5a	27b	2.9c	543a	17.0a	28.3a
CV %	5.87	18.72	10.31	6.84	11.02	6.56	5.73	5.04	5.00
F-test	**	**	**	**	**	**	**	**	**

** Significant difference at 1% level. Means followed by the same letter within column are not significantly different according to Duncan Multiple Range Test at P = 0.01.

The maximum weight (5.3 kg/6 m²) of oversize (>50 g) tubers were recorded in LT 8 x TPS 13 followed by MF II x TPS 67 (4.9 kg/6 m²). Number of tubers among the families was statistically different (Table 4). The check variety Khumal Seto-1 produced the highest numbers (543/6m²) of total tubers followed by Desiree (510/6m²). The tuber grading results showed that the highest number of large size (>50 g) tubers was obtained from LT 8 x TPS 13 (35/6 m²) followed by MF I x TPS 67 (34/6 m²). The maximum numbers (305/6 m²) of seed size (25-50 g) tubers were produced by the check Khumal Seto-1 followed by Desiree (295/6 m²). The maximum numbers (211/6 m²) of <25 g (under sized) tubers were recorded in the check variety Khumal Seto-1 followed by Desiree (203/6 m²).

CONCLUSION

The above results showed that F1C1 to F1C4 generation tubers of hybrid TPS family, HPS II/67 have shown the potential of giving significantly higher yield than crop grown from Dessiree and equal or higher yield compared to Khumal Seto-1 under Khumaltar condition. That's why it can be concluded that

TPS ware potatoes are produce of potato crops planted with botanical seed or with derived tuber seed selections of the first to third clonal generations. TPS ware potatoes therefore include F1C4 tubers under the agro-ecological conditions at Kathmandu valley and can be used as a alternate seed material for potato production.

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Disease Status and Generic Pest Risk Analysis (PRA) of Potato

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ABSTRACT

Generic Pest Risk Analysis (PRA) of potato was done to develop database as demanded by Sanitary and Phytosanitary (SPS) agreement. There are 135 pathogens (pests) reported on potato (*Solanum tuberosum*) globally. Out of 135 global diseases fungi, bacteria and viruses were 73, 22 and 40 respectively. Altogether 45 pathogens (diseases) have been recorded in Nepal list including potato and other than potato crops present in Nepal. Out of 45 pathogens, fungi were 24, bacteria were 7 and viruses were 14. However, only sixteen pathogens have been recorded from National reports solely on potato crop in Nepal. An economic status of the pathogen (pest) was worked out. Ninety two pathogens were recorded as potential quarantine pest (PQP) in Nepal. They were found in two economic categories. Among 92 potential quarantine pest (pathogen), 51 pathogens were of major status; 14 were in minor status and 27 were of unknown status having no information. In generic PRA altogether ninety two potential quarantine pests (fungi, bacteria, phytoplasma, virus and viroids) were recorded in Nepal. Out of 92 PQP fungi were 52, bacteria and phytoplasma were 13, virus and viroids were 27. However, detail information of 15 pests (pathogen) was not available. Out of 92 PQP for pest risk assessment, 34 were at high risk, 30 were medium risk and 13 were lower risk. Fifteen pests had no risk information. Similarly in pest management, there were 35 pests in high category, 30 pests in medium, and 12 pests in low category. Fifteen had no risk information. Out of 92 pest 61 pest (pathogen) required additional declaration, 16 do not required additional declaration while 15 had no information.

INTRODUCTION

Potato occupies the fifth position in area, fourth in total production and first in productivity compared with the main staple crops: rice, maize, wheat and millet. It is a staple food for the high hills and side dish for the people of lower elevations where potato can not be stored for longer period. Potato is grown in all 75 districts of Nepal and the yield varies from 2 to 35 tons per ha (Lama et al 1998, Amatya et al 1998). The climatic diversity of Nepal permits year-round cropping of potato from terai (plains) to high hills (4000 masl). This country exhibits a wide range of climatic variation where potato cultivation is diverse and consequently likely to enter, establish and spread, potential quarantine pest (pathogens), and cause considerable losses in production and productivity. The role of plant pathogens (fungi, bacteria and phytoplasma, viruses and viroids) in potato production is very prominent and crucial.

Sanitary and Phytosanitary (SPS) agreement stipulated by the WTO it becomes important to carry out a Pest Risk Analysis (PRA) for the material under exchange. In order to remain competitive in the international trade and commerce a comprehensive PRA needs to be developed and brought out on priority especially for the crops meant for export and import. FAO has taken the initiative to strengthen the plant quarantine service in Nepal to strengthen the institutional capacity of the plant quarantine service to undertake functions and thereby support to meet the prime goals of Government of Nepal (GON) for overall development of the agriculture sector. This is the beginning of strong quarantine service in Nepal. To meet the objective continuation of pest risk analyses of potato among priority crops has been taken into consideration. Pest Risk Analysis (PRA) is the process of evaluating biological or scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it (Mahto 2004).

Pest risk analysis involves the merging of scientific assessment, practical management and on going consultation. Not all of the components are required in all analysis. Several components may be carried out simultaneously. They are not necessarily conducted in the sequence presented. PRA is not a scientific research but it is science based.

Risk is a combination of probability of harm and the severity of impact caused by a pest. Pest risk assessment is a process of identifying plant pests as potential hazards and characterizing their risk. Risk characterization is a process within risk assessment of estimating the likelihood or probability of experiencing the adverse effects of pests and the severity of the impact or consequences of those effects. Risk assessment provides the scientific basis for analyses. Its emphasis is on biology, but it also includes a description of economic implications. The time and detail devoted to a report will vary depending on the information available and the importance of the assessment to programs.

EPPO guidelines on pest risk analysis provide detailed guidance on the analysis of risk from individual pests for a defined area, in relation to their potential status as quarantine pests or regulated non-quarantine pests. Individual guidelines concern different elements of pest risk analysis and also the different purposes for which pest risk analysis is performed.

The purpose of generic PRA in potato, is to prepare a complete and extensive list of potential quarantine pests (PQP) pathogens (fungi, bacteria, viruses and phytoplasma), its risk of entry, spread, environmental damage, risk management globally in the world, for import of potato from outside world into Nepal excluding pathogens present in Nepal.

MATERIALS AND METHODS

Crop Protection Compendium (CPC) 2006 has been used as a reference for information for global pests (pathogens) list to perform generic PRA on potato. Prepared a list of potato pests (pathogens) present worldwide (CPC, 2006). Reviewed pertinent available literatures again and prepared list of potato pathogens (diseases) present in Nepal (Table 1) and added some of more pathogens (diseases) in previous list of disease data sheet (Table 2). Different journals, proceedings, research report and books describing the pathological works done in Nepal were consulted (CPC 2006). The collected information was included further and updated existing Nepal NPD pest list (Table 3). However, in Nepalese context information on various aspects like entry, establishment, biology, epidemiology and economic impact has been inadequate. Crop Protection Compendium (CPC) 2006 has been used as a reference for information to perform generic PRA and some has been done on personal experiences and referring manual and internet also (CPC 2006).

Guidelines for rating entry potential include

Rating = low: The probability of entry is low given the combination of factors including the distribution of the pest source, management practices applied, low commodity volume, low probability of pest survival in transit, or low probability of contact with susceptible hosts given the intended use. The probability of entry is low but clearly possible given the expected combination of factors.

Rating = medium: Pest entry into in an area is likely given the combination of factors described above.

Rating = high: Pest entry is very likely or certain given the combination of factors described above.

Likewise same rating scale was used i.e. Low, Medium, High for establishment, spread, economic and environmental damage etc.

RESULTS AND DISCUSSION

Generic PRA revealed that 135 pest (pathogens) have been reported on potato crop globally round the world. Out of one hundred thirty five global pathogen fungi were 73, bacteria were 22 and viruses were forty respectively (table1). Altogether 45 pathogens have been recorded in Nepal list including potato and other than potato crops present in Nepal (Table 1). Out of 45 pathogens, fungi were 24, bacteria were 7 and viruses were 14. However, only sixteen pathogens have been recorded from National reports solely

on potato crop grown in Nepal. Economic analysis was determined to know the status of the pathogen (pest) for the PQP in context to Nepal. Among ninety two potential quarantine pathogen (pest), 51 were of major status, 14 were in minor status and 27 were of unknown status having no information (table 2).

Nepal being a member of World Trade Organization (WTO), this country needs to declare the prevailing pest (disease) status of crops which has been a major international concern. This may be serious concern regarding trade promotion scenario among the member countries of WTO (Mahto 2004; Anonymous 2005).

Nepal being a member of World Trade Organization (WTO), this country needs to declare the prevailing pest (disease) status of crops which has been a major international concern. This may be serious concern regarding trade promotion scenario among the member countries of WTO (Mahto 2004).

The perusal of data revealed that all together 92 pathogens (fungi, bacteria and phytoplasma, viruses and viroids) were recorded as potential quarantine (pathogens) pests (PQP) for pest risk analysis (PRA). Out of ninety two pathogens fungi were 52, bacteria and phytoplasma were 13 and virus and viroids were 27 (Table 2). Detail information was not available in CPC 2006 and elsewhere for fifteen pathogens (Table 2, 3). Among 15 pathogens fungi was nine, phytoplasma one and virus and viroids was five in number (Table 2, 3). Out of 92 PQP for pest risk assessment, 34 were at high risk, 30 were medium risk and 13 were lower risk. Fifteen pests had no information (table 3). Risk management revealed that thirty-five pathogens (pests) were in high category, 30 pathogens (pests) in medium, 12 pathogens (pests) in low category. Fifteen had no risk information (Table 3). Out of 92 pest sixty-one pathogen (pest) required additional declaration, 16 do not required additional declaration while fifteen had no information (Table 3).

Common pathogens (diseases) reported in Nepal are focused mainly on late blight of potato (*Phytophthora infestans*), bacterial wilt of potato caused by *Pseudomonas solanacearum*, black scurf caused by *Rhizoctonia solani*, wart caused by *Synchytrium endobioticum* and late blight caused by *Phytophthora infestans*. Some of the recommendations such as crop rotation, use of clean planting materials in minimizing bacterial wilt incidence in the infested area, selection of wart and late blight resistant clones are the major output of the research performed in the last 30 years (NARC 1995 and 1997; Anonymous 1997).

Viruses are the major yield degenerating causes in potato crop. Yield potentiality of cultivars declines due to virus diseases when same seed lot is planted year after year for many years. The yield declined as low as 80 percent of its healthy plants depending upon types of viruses. Degeneration studies conducted in eastern terai indicated that tuber yield was decreased by 3.6 percent for every 10% increase in virus infection. This quantifies for the first time the value of clean seed for potato crop in Nepal (Wells et al 1996, Khairegauli 2004, Amatya et al 1998). Mechanically transmitted virus such as PVX is more prevalent in the hills than in terai whereas aphid transmitted viruses, e.g., PVY, are more prevalent in the terai. Other viruses such as PVM and PVS are found in both the hills and terai (Shrestha 1997, Lama et al 1996, Anonymous 2003). Sanitary and phytosanitary (SPS) agreement demands developing disease database as prerequisite and it becomes important to carry out a pest risk analysis (PRA) for the material under exchange in order to remain competitive in the international trade and commerce (Anonymous 2003).

CONCLUSION

In generic PRA, altogether ninety-two potential quarantine pests (fungi, bacteria and Phytoplasma, viruses and viroids) were recorded however, detail information of 15 pests were not available. Out of 92 pests fungi were 52, bacteria and phytoplasma were 13, virus and viroids were 27, respectively. A PRA should be sufficiently documented so that when a review or a dispute arises, the PRA will clearly state the sources of information and the rationales used in reaching a management decision regarding phytosanitary measures taken or to be taken.

Table 1. Global pathogens (pest), Nepal list and potential quarantine pest (PQP) of potato

S.N.	Global pathogens (pest) Fungi, bacteria/ phytoplasma and viruses on Potato in world	Nepal pathogens list (CPC+ Potato own +Other crops)	Potential Quarantine Pest (PQP) in Nepal
1	<i>Aecidium cantense</i> (Aecidium potato rust)	<i>Alternaria alternata</i> (alternaria leaf spot)	<i>Aecidium cantense</i> (Aecidium potato rust)
2	<i>Alternaria alternata</i> (alternaria leaf spot)	Alfalfa mosaic virus (alfalfa yellow spot)	<i>Alternaria radicina</i> (black rot of carrots)
3	<i>Alternaria radicina</i> (black rot of carrots)	<i>Alternaria solani</i>	<i>Arthrinium phaeospermum</i>
4	<i>Alternaria solani</i> (early blight of potato and tomato)	<i>Alternaria tenuissima</i>	<i>Bacillus polymyxa</i> (bacterial fruit rot)
5	<i>Arthrinium phaeospermum</i>	<i>Aspergillus niger</i> (Aspergillus ear rot)	<i>Belicobasidium purpureum</i>
6	<i>Aspergillus niger</i> (Aspergillus ear rot)	<i>Cercospora concors</i>	<i>Botryotinia fuckeliana</i> (Botrytis rot)
7	<i>Bacillus polymyxa</i> (bacterial fruit rot)	<i>Cercospora solanicola</i>	<i>Burkholderia cepacia</i> (slippery skin of onion)
8	<i>Belicobasidium purpureum</i>	<i>Cercospora solani-tuberosi</i>	<i>Burkholderia gladioli</i> pv. <i>gladioli</i> (corm scab)
9	<i>Botryotinia fuckeliana</i> (Botrytis rot)	Citrus exocortis viroid (citrus exocortis)	<i>Chalara elegans</i> (black root rot)
10	<i>Burkholderia cepacia</i> (slippery skin of onion)	<i>Cladosporium tenuissimum</i>	<i>Choanephora cucurbitarum</i> (Choanephora blossom blight)
11	<i>Burkholderia gladioli</i> pv. <i>gladioli</i> (corm scab)	<i>Clavibacter michiganensis</i> subsp. <i>sepedonicus</i>	<i>Cochliobolus australiensis</i>
12	<i>Cercospora solanicola</i>	<i>Cochliobolus lunatus</i> (Cabage, Rice)	<i>Cochliobolus hawaiiensis</i> (leaf spot: maize)
13	<i>Chalara elegans</i> (black root rot)	<i>Colletotrichum capsici</i> (leaf spot of peppers)	<i>Coleosporium tussilaginis</i> f.sp. <i>senecionis-sylvati</i>
14	<i>Choanephora cucurbitarum</i> (Choanephora blossom blight)	<i>Corticium rolfsii</i> (collar rot)	<i>Colletotrichum coccodes</i> (anthracnose of tomato)
15	<i>Cladosporium tenuissimum</i>	Cucumber mosaic virus (cucumber mosaic)	<i>Didymella bryoniae</i> (gummy stem blight)
16	<i>Clavibacter michiganensis</i> subsp. <i>sepedonicus</i> (Potato ring rot)	<i>Erwinia carotovora</i> subsp. <i>atroseptica</i>	<i>Didymella lycopersici</i> (canker of tomato)
17	<i>Cochliobolus australiensis</i>	<i>Erwinia chrysanthemi</i> (in onion)	<i>Erwinia carotovora</i> subsp. <i>carotovora</i> (bacterial root rot of sweet potato)
18	<i>Cochliobolus hawaiiensis</i> (leaf spot: maize)	<i>Erwinia chrysanthemi</i> pv. <i>zeae</i> (bacterial stalk rot)Maize	<i>Erwinia chrysanthemi</i> pv. <i>chrysanthemi</i> (bacterial maize stalk rot)
19	<i>Cochliobolus lunatus</i> (black kernel of rice)	<i>Fusarium coeruleum</i> (dry rot: potato)	<i>Erysiphe orontii</i> (powdery mildew)
20	<i>Coleosporium tussilaginis</i> f.sp. <i>senecionis-sylvati</i>	<i>Leveillula taurica</i> (In onion)	
21	<i>Colletotrichum capsici</i> (leaf spot of peppers)	<i>Macrophomina phaseolina</i> (ashy stem blight)Mango	<i>Fusarium culmorum</i> (culm rot: cereals)
22	<i>Colletotrichum coccodes</i> (anthracnose of tomato)	<i>Phytophthora capsici</i> (soft rot of cucurbit fruits)	<i>Fusarium oxysporum</i> f.sp. <i>tuberosa</i>
23	<i>Corticium rolfsii</i> (collar rot)	<i>Phytophthora infestans</i>	<i>Geotrichum candidum</i> (sour rot: Citrus spp.)

24	<i>Didymella bryoniae</i> (gummy stem blight)	Potato aucuba mosaic virus	<i>Gibberella avenacea</i> (bud rot)
25	<i>Didymella lycopersici</i> (canker of tomato)	Potato leafroll virus	<i>Gibberella baccata</i> (biocontrol: velvetleaf)
26	<i>Erwinia carotovora</i>	Potato virus A (potato mild mosaic)	<i>Helminthosporium solani</i> (silver scurf)
27	<i>Erwinia carotovora</i> subsp. <i>atroseptica</i> (potato blackleg disease)	Potato virus M	<i>Hypocrea rufa</i> (fruit rot: Citrus spp.)
28	<i>Erwinia carotovora</i> subsp. <i>carotovora</i> (bacterial root rot of sweet potato)	Potato virus S	<i>Melanotus communis</i> (wireworm, common)
29	<i>Erwinia chrysanthemi</i>	Potato virus X (potato interveinal mosaic)	<i>Nectria haematococca</i> (dry rot of potato)
30	<i>Erwinia chrysanthemi</i> pv. <i>chrysanthemi</i> (bacterial maize stalk rot)	Potato virus Y (potato mottle)	<i>Pectobacterium chrysanthemi</i> (slow wilt)
31	<i>Erwinia chrysanthemi</i> pv. <i>zeae</i> (bacterial stalk rot)	<i>Pseudomonas syringae</i> (It come with other sp showacpc)	<i>Phaciidiopycnis tuberivora</i> (dryrot: potato)
32	<i>Erysiphe orontii</i> (powdery mildew)	<i>Pythium aphanidermatum</i> (damping-off)Maize	<i>Phialophora parasitica</i> (wilt: date palm)
34	<i>Fusarium</i>	<i>Ralstonia solanacearum</i>	<i>Phoma andigena</i> (black blight of potatoes)
35	<i>Fusarium coeruleum</i> (dry rot: potato)	<i>Ralstonia solanacearum</i> race 1 (in tomato)	<i>Phoma eupyrena</i>
36	<i>Fusarium culmorum</i> (culm rot: cereals)	<i>Rhizoctonia solani</i>	<i>Phoma exigua</i> var. <i>exigua</i> (leaf blotch)
37	<i>Fusarium oxysporum</i> f.sp. <i>tuberosi</i>	<i>Sclerotinia sclerotiorum</i> (collar rot) Lentil	<i>Phoma foveata</i> (potato gangrene)
38	<i>Geotrichum candidum</i> (sour rot: Citrus spp.)	<i>Septoria lycopersici</i> (leaf spot of tomato)Tomato	<i>Phytophthora citrophthora</i> (brown rot of citrus fruit)
39	<i>Gibberella avenacea</i> (bud rot)	<i>Spongospora subterranean</i>	<i>Phytophthora cryptogea</i> (tomato foot rot)
40	<i>Gibberella baccata</i> (biocontrol: velvetleaf)	<i>Streptomyces scabiei</i>	<i>Phytophthora drechsleri</i> (watermelon fruit rot)
41	<i>Gibberella zeae</i> (cobweb disease)	<i>Synchytrium endobioticum</i>	<i>Phytophthora erythroseptica</i> var. <i>erythroseptica</i> (pink rot)
42	<i>Helminthosporium solani</i> (silver scurf)	<i>Thanatephorus cucumeris</i> (Frank) Donk	<i>Phytophthora megasperma</i> (apoplexy)
43	<i>Hypocrea rufa</i> (fruit rot: Citrus spp.)	Tobacco mosaic virus (tobacco mosaic)	<i>Polyscytalum pustulans</i> (skin spot of potato)
44	<i>Leveillula taurica</i>	Tomato mosaic virus (tomato mosaic)	Potato purple-top wilt phytoplasma
45	<i>Macrophomina phaseolina</i> (ashy stem blight)	Tomato spotted wilt virus (tomato spotted wilt)	<i>Potato stolbur phytoplasma</i>
46	<i>Melanotus communis</i> (wireworm, common)		Potato witches' broom phytoplasma
47	<i>Nectria haematococca</i> (dry rot of potato)		<i>Pseudomonas fluorescens</i> (biocontrol: Damping off (cotton))
48	<i>Nectria haematococca</i> (dry rot: potato)		<i>Pseudomonas putida</i> (biocontrol: Erwinia spp.)
49	<i>Pectobacterium chrysanthemi</i> (slow wilt)	Total 16	<i>Pseudomonas syringae</i> pv. <i>garcae</i> (bacterial blight of coffee)

50	<i>Phaciidiopycnis tuberivora</i> (dryrot: potato)	Fungi	<i>Pseudomonas syringae</i> pv. <i>tabaci</i> (angular leaf spot)
51	<i>Phialophora parasitica</i> (wilt: date palm)	Bacteria	<i>Puccinia pittieriana</i> (common rust of potato)
52	<i>Phoma andigena</i> (black blight of potatoes)	Virus	<i>Pythium butleri</i>
53	<i>Phoma eupyrena</i>		<i>Pythium ultimum</i>
54	<i>Phoma exigua</i> var. <i>exigua</i> (leaf blotch)		<i>Pythium vexans</i> (damping off)
55	<i>Phoma foveata</i> (potato gangrene)		<i>Ralstonia solanacearum</i> race 3
56	<i>Phytophthora capsici</i> (soft rot of cucurbit fruits)		<i>Rhizobium radiobacter</i> (crown gall)
57	<i>Phytophthora citrophthora</i> (brown rot of citrus fruit)		<i>Rhizobium rhizogenes</i> (bacterial gall)
58	<i>Phytophthora cryptogea</i> (tomato foot rot)		<i>Rosellinia bunodes</i> (black root rot)
59	<i>Phytophthora drechsleri</i> (watermelon fruit rot)		<i>Rosellinia necatrix</i> (dematophora root rot)
60	<i>Phytophthora erythroseptica</i> var. <i>erythroseptica</i> (pink rot)		<i>Septoria lycopersici</i> var. <i>malagutii</i> (annular leaf spot of potato)
61	<i>Phytophthora infestans</i> (blight of potato)		<i>Thecaphora solani</i> (potato smut)
62	<i>Phytophthora megasperma</i> (apoplexy)		<i>Ulocladium atrum</i> (almond mould complex)
63	<i>Polyscytalum pustulans</i> (skin spot of potato)		<i>Verticillium albo-atrum</i> (verticillium wilt of alfalfa)
64	Potato purple-top wilt phytoplasma		<i>Verticillium dahliae</i> (verticillium wilt)
65	Potato stolbur phytoplasma		<i>Verticillium nigrescens</i> (seed reduction: soybean)
66	Potato witches' broom phytoplasma		<i>Verticillium tricorpus</i>
67	<i>Pseudomonas fluorescens</i> (biocontrol: Damping off (cotton))		Andean potato latent virus
68	<i>Pseudomonas marginalis</i> pv. <i>marginalis</i> (lettuce marginal leaf blight)		Andean potato mottle virus (Andean mottle of potato)
69	<i>Pseudomonas putida</i> (biocontrol: Erwinia spp.)		Arracacha virus B
70	<i>Pseudomonas syringae</i>		Beet curly top virus (curly top)
71	<i>Pseudomonas syringae</i> pv. <i>garcae</i> (bacterial blight of coffee)		Pepino mosaic virus
72	<i>Pseudomonas syringae</i> pv. <i>tabaci</i> (angular leaf spot)		Potato 14R (?) tobamovirus
73	<i>Puccinia pittieriana</i> (common rust of potato)		Potato Andean latent tymovirus
74	<i>Pythium aphanidermatum</i> (damping-off)		Potato Andean mottle comovirus
75	<i>Pythium butleri</i>		Potato black ringspot virus (calico disease of potato)
76	<i>Pythium ultimum</i>		Potato deforming mosaic virus (deforming mosaic of potato)
77	<i>Pythium vexans</i> (damping off)		Potato mop-top virus
78	<i>Ralstonia solanacearum</i> (bacterial wilt of potato)		Potato spindle tuber viroid (spindle tuber of potato)

79	<i>Ralstonia solanacearum</i> race 1	Potato virus T
80	<i>Ralstonia solanacearum</i> race 3	Potato virus V
81	<i>Rhizobium radiobacter</i> (crown gall)	Potato yellow dwarf virus (yellow dwarf of potato)
82	<i>Rhizobium rhizogenes</i> (bacterial gall)	Potato yellow vein virus (yellow vein of potato)
83	<i>Rosellinia bunodes</i> (black root rot)	Potato yellowing virus
84	<i>Rosellinia necatrix</i> (dematophora root rot)	Solanum apical leaf curling (?) bigeminivirus
85	<i>Sclerotinia sclerotiorum</i> (collar rot)	Solanum yellows luteovirus
86	<i>Septoria lycopersici</i> (leaf spot of tomato)	Southern potato latent (?) carlavirus
87	<i>Septoria lycopersici</i> var. <i>malagutii</i> (annular leaf spot of potato)	Tobacco necrosis virus
88	<i>Streptomyces scabiei</i> (potato scab)	Tobacco rattle virus (spraing of potato)
89	<i>Synchytrium endobioticum</i> (black wart of potato)	Tobacco ringspot virus (annulus tabaci)
90	<i>Thanatephorus cucumeris</i> (many names, depending on host)	Tobacco streak virus
91	<i>Thecaphora solani</i> (potato smut)	Tomato black ring virus
92	<i>Ulocladium atrum</i> (almond mould complex)	Tomato infectious chlorosis virus
93	<i>Verticillium albo-atrum</i> (verticillium wilt of alfalfa)	Tomato yellow mosaic virus
94	<i>Verticillium dahliae</i> (verticillium wilt)	
95	<i>Verticillium nigrescens</i> (seed reduction: soybean)	
96	<i>Verticillium tricorpus</i>	
97	Alfalfa mosaic virus (alfalfa yellow spot)	
98	Andean potato latent virus	
99	Andean potato mottle virus (Andean mottle of potato)	
100	Arracacha virus B	
101	Beet curly top virus (curly top)	
102	Citrus exocortis viroid (citrus exocortis)	
103	Cucumber mosaic virus (cucumber mosaic)	
104	Pepino mosaic virus	
105	Potato 14R (?) tobamovirus	
106	Potato Andean latent tymovirus	
106	Potato Andean mottle comovirus	
107	Potato aucuba mosaic virus	
108	Potato black ringspot virus (calico disease of potato)	
109	Potato deforming mosaic virus (deforming mosaic of potato)	
110	Potato leafroll virus	
111	Potato mop-top virus	

112	Potato spindle tuber viroid (spindle tuber of potato)
113	Potato virus A (potato mild mosaic)
114	Potato virus M
115	Potato virus S
116	Potato virus T
117	Potato virus V
118	Potato virus X (potato interveinal mosaic)
119	Potato virus Y (potato mottle)
120	Potato yellow dwarf virus (yellow dwarf of potato)
121	Potato yellow vein virus (yellow vein of potato)
122	Potato yellowing virus
123	Solanum apical leaf curling (?) bigeminivirus
124	Solanum yellows luteovirus
125	Southern potato latent (?) carlavirus
126	Tobacco mosaic virus (tobacco mosaic)
127	Tobacco necrosis virus
128	Tobacco rattle virus (spraying of potato)
129	Tobacco ringspot virus (annulus tabaci)
130	Tobacco streak virus
131	Tomato black ring virus
132	Tomato infectious chlorosis virus
133	Tomato mosaic virus (tomato mosaic)
134	Tomato spotted wilt virus (tomato spotted wilt)
135	Tomato yellow mosaic virus

Table 2. Potential Quarantine pest (PQP) pathogen Status of Potato

S.No.	Category	Potential Quarantine Pest (PQP) Pathogen	Status	Comments
1	Bacteria	<i>Bacillus polymyxa</i> (bacterial fruit rot)	No Information	No Information
2	Bacteria	<i>Erwinia carotovora subsp. carotovora</i> (bacterial root rot of sweet potato)	Major	The mean incidence of soft rot ranged from 10 to 100% in 34 potato varieties
3	Bacteria	<i>Erwinia chrysanthemi pv. chrysanthemi</i> (bacterial maize stalk rot)	Minor	Considerable loss
4	Bacteria	<i>Potato stolbur phytoplasma</i>	No Information	No Information
5	Bacteria	<i>Potato witches' broom phytoplasma</i>	Major	cause serious losses in potato yield
6	Bacteria	<i>Pseudomonas fluorescens</i> (biocontrol: Damping off (cotton))	Minor	weak pathogen

7	Bacteria	<i>Pseudomonas putida</i> (biocontrol: Erwinia spp.)	No Information	No Information
8	Bacteria	<i>Pseudomonas syringae</i> pv. <i>garcae</i> (bacterial blight of coffee)	Major	Losses due to BBC can be as high as 100% of the total crop
9	Bacteria	<i>Pseudomonas syringae</i> pv. <i>tabaci</i> (angular leaf spot)	Minor	substantial loss
10	Bacteria	<i>Ralstonia solanacearum</i> race 3	No Information	No Information
11	Bacteria	<i>Rhizobium radiobacter</i> (crown gall)	Major	Considerable loss
12	Bacteria	<i>Rhizobium rhizogenes</i> (bacterial gall)	Major	Considerable loss
13	Bacteria	Potato purple-top wilt phytoplasma	No Information	No Information
14	Fungi	<i>Aecidium cantense</i> (Aecidium potato rust)	Major	Considerable loss
15	Fungi	<i>Alternaria radicina</i> (black rot of carrots)	Minor	substantial loss
16	Fungi	<i>Arthrinium phaeospermum</i>	No Information	No Information
17	Fungi	<i>Belicobasidium purpureum</i>	No Information	No Information
18	Fungi	<i>Botryotinia fuckeliana</i> (Botrytis rot)	Minor	substantial loss
19	Fungi	<i>Burkholderia cepacia</i> (slippery skin of onion)	Minor	substantial loss
20	Fungi	<i>Burkholderia gladioli</i> pv. <i>gladioli</i> (corm scab)	Major	Considerable loss
21	Fungi	<i>Chalara elegans</i> (black root rot)	Minor	substantial loss
22	Fungi	<i>Choanephora cucurbitarum</i> (Choanephora blossom blight)	Minor	weak pathogen
23	Fungi	<i>Cochliobolus australiensis</i>	No Information	No Information
24	Fungi	<i>Cochliobolus hawaiiensis</i> (leaf spot: maize)	No Information	No Information
25	Fungi	<i>Coleosporium tussilaginis</i> f.sp. <i>senecionis-sylvati</i>	No Information	No Information
26	Fungi	<i>Colletotrichum coccodes</i> (anthracnose of tomato)	No Information	No Information
27	Fungi	<i>Didymella bryoniae</i> (gummy stem blight)	Major	Considerable loss
28	Fungi	<i>Didymella lycopersici</i> (canker of tomato)	Minor	weak pathogen
29	Fungi	<i>Erysiphe orontii</i> (powdery mildew)	Major	Considerable loss
30	Fungi	<i>Fusarium</i>	Major	Considerable loss
31	Fungi	<i>Fusarium culmorum</i> (culm rot: cereals)	Minor	substantial loss
32	Fungi	<i>Fusarium oxysporum</i> f.sp. <i>tuberosi</i>	No Information	No Information
33	Fungi	<i>Geotrichum candidum</i> (sour rot: Citrus spp.)	No Information	No Information
34	Fungi	<i>Gibberella avenacea</i> (bud rot)	Major	cause considerable yield losses.
35	Fungi	<i>Gibberella baccata</i> (biocontrol: velvetleaf)	Major	Considerable loss
37	Fungi	<i>Helminthosporium solani</i> (silver scurf)	Major	Considerable loss
38	Fungi	<i>Hypocrea rufa</i> (fruit rot: Citrus spp.)	No Information	No Information
39	Fungi	<i>Melanotus communis</i> (wireworm, common)	Major	Considerable loss
40	Fungi	<i>Nectria haematococca</i> (dry rot of potato)	No Information	No Information
41	Fungi	<i>Pectobacterium chrysanthemi</i> (slow	Major	Considerable loss

		wilt)		
42	Fungi	<i>Phacidiopycnis tuberivora</i> (dryrot: potato)	No Information	No Information
43	Fungi	<i>Phialophora parasitica</i> (wilt: date palm)	No Information	No Information
44	Fungi	<i>Phoma andigena</i> (black blight of potatoes)	Major	potato has been reported to result in up to 80% crop loss
45	Fungi	<i>Phoma eupyrena</i>	No Information	No Information
46	Fungi	<i>Phoma exigua</i> var. <i>exigua</i> (leaf blotch)	Minor	A weak pathogen but widespread in soils
47	Fungi	<i>Phoma foveata</i> (potato gangrene)	Major	losses of up to 20% have occurred on tubers
48	Fungi	<i>Phytophthora citrophthora</i> (brown rot of citrus fruit)	Major	Considerable loss
49	Fungi	<i>Phytophthora cryptogea</i> (tomato foot rot)	Major	<i>P. cryptogea</i> is a serious plant pathogen in many countries
50	Fungi	<i>Phytophthora drechsleri</i> (watermelon fruit rot)	Major	losses due to <i>Phytophthora</i> blight to be 98%,
51	Fungi	<i>Phytophthora erythroseptica</i> var. <i>erythroseptica</i> (pink rot)	Major	endemic in many soils throughout the world
52	Fungi	<i>Phytophthora megasperma</i> (apoplexy)	Major	causes debilitation rather than substantial plant death.
53	Fungi	<i>Polyscytalum pustulans</i> (skin spot of potato)	Major	total yield of infected seed stocks was usually significantly lower
54	Fungi	<i>Puccinia pittieriana</i> (common rust of potato)	Major	Greatest losses are reported in northern Ecuador
55	Fungi	<i>Pythium butleri</i>	No Information	No Information
56	Fungi	<i>Pythium ultimum</i>	No Information	No Information
57	Fungi	<i>Pythium vexans</i> (damping off)	Minor	concerning diseases caused by <i>P. vexans</i> is sparse
58	Fungi	<i>Rosellinia bunodes</i> (black root rot)	No Information	No Information
59	Fungi	<i>Rosellinia necatrix</i> (dematophora root rot)	Minor	Minor host
60	Fungi	<i>Septoria lycopersici</i> var. <i>malagutii</i> (annular leaf spot of potato)	Major	considerable yield losses occur in the Andean countries
61	Fungi	<i>Thecaphora solani</i> (potato smut)	Major	present a high risk to commercial potato-growing areas around the world
62	Fungi	<i>Ulocladium atrum</i> (almond mould complex)	Major	Primary host
63	Fungi	<i>Verticillium albo-atrum</i> (verticillium wilt of alfalfa)	Major	Significant losses
64	Fungi	<i>Verticillium dahliae</i> (verticillium wilt)	Major	In potato, losses in the USA as high as 30-50%
65	Fungi	<i>Verticillium nigrescens</i> (seed reduction: soybean)	No Information	No Information
66	Fungi	<i>Verticillium tricorpus</i>	No Information	No Information
67	Virus	<i>Andean potato latent virus</i>	Major	It is also considered of quarantine concern by NAPPO
68	Virus	Andean potato mottle virus (Andean mottle of potato)	Major	virus is considered of quarantine concern by NAPPO and COSAVE and
69	Virus	Arracacha virus B	Major	Considerable loss

70	Virus	Beet curly top virus (curly top)	Major	BCTV used to be an EPPO A2 quarantine pest
71	Virus	Pepino mosaic virus	Major	Significant losses
72	Virus	Potato 14R (?) tobamovirus	No Information	No Information
73	Virus	Potato Andean latent tymovirus	Major	It is also considered of quarantine concern by NAPPO
74	Virus	Potato Andean mottle comovirus	Major	considered of quarantine concern by NAPPO and COSAVE
75	Virus	Potato black ringspot virus (calico disease of potato)	Major	Restricted for movement and major diseases
76	Virus	Potato deforming mosaic virus (deforming mosaic of potato)	Major	Up to 35% yield reduction in the potato cultivar Baronesa.
77	Virus	Potato mop-top virus	Major	Significant losses
78	Virus	Potato spindle tuber viroid	Major	Significant losses
79	Virus	Potato virus T	Major	Major host and significant losses
80	Virus	Potato virus V	Major	Significant losses
81	Virus	Potato yellow dwarf virus (yellow dwarf of potato)	Minor	Not much economic importance
82	Virus	Potato yellow vein virus	Major	Yields reductions of about 50%
83	Virus	Potato yellowing virus	Major	Considerable loss
84	Virus	Solanum apical leaf curling (?) bigeminivirus	No Information	No Information
85	Virus	Solanum yellows luteovirus	Major	Significant losses
86	Virus	Southern potato latent (?) carlavirus	No Information	No Information
87	Virus	Tobacco necrosis virus	Major	Losses of between 20 and 50% have been recorded
88	Virus	Tobacco rattle virus (spraying of potato)	Major	Significant losses
89	Virus	Tobacco ringspot virus (annulus tabaci)	Major	Considerable loss
90	Virus	Tobacco streak virus	Major	Major host
91	Virus	Tomato black ring virus	Major	Considerable loss
92	Virus	Tomato infectious chlorosis virus	Major	Major host

Table 3. Potential quarantine pest (pathogen), its risk assessment, risk management and additional requirement for Potato importation in Nepal

Potential Quarantine Pest (PQP)/pathogen, Fungi, Bacteria and viruses	Category	Risk Assessment Rating	Risk Management Rating	Additional declaration
<i>Aecidium cantense</i> (Aecidium potato rust)	Fungi	Medium	Medium	Not required
<i>Alternaria radicina</i> (black rot of carrots)	Fungi	Medium	Low	Not required
<i>Arthrinium phaeospermum</i>	Fungi	No information	No information	no information
<i>Bacillus polymyxa</i> (bacterial fruit rot)	Bacteria	Medium	Medium	Required
<i>Belicobasidium purpureum</i>	Fungi	No information	No information	no information
<i>Botryotinia fuckeliana</i> (Botrytis rot)	Fungi	Medium	Medium	Not required
<i>Burkholderia cepacia</i> (slippery skin of onion)	Bacteria	Low	Low	Required
<i>Burkholderia gladioli</i> pv. <i>gladioli</i> (corm scab)	Bacteria	Low	Medium	Required
<i>Chalara elegans</i> (black root rot)	Fungi	Medium	Medium	Not required

<i>Choanephora cucurbitarum</i> (Choanephora blossom blight)	Fungi	Low	Medium	Required
<i>Cochliobolus australiensis</i>	Fungi	Medium	Medium	Required
<i>Cochliobolus hawaiiensis</i> (leaf spot: maize)	Fungi	Medium	Medium	Required
<i>Coleosporium tussilaginis</i> f.sp. <i>senecionis-sylvati</i>	Fungi	No information	No information	no information
<i>Colletotrichum coccodes</i> (anthracnose of tomato)	Fungi	No information	No information	no information
<i>Didymella bryoniae</i> (gummy stem blight)	Fungi	Medium	High	Required
<i>Didymella lycopersici</i> (canker of tomato)	Fungi	Low	Medium	Not required
<i>Erwinia carotovora</i> subsp. <i>carotovora</i> (bacterial root rot of sweet potato)	Bacteria	High	High	Required
<i>Erwinia chrysanthemi</i> pv. <i>chrysanthemi</i> (bacterial maize stalk rot)	Bacteria	Medium	Medium	Required
<i>Erysiphe orontii</i> (powdery mildew)	Fungi	High	Medium	Required
<i>Fusarium</i>	Fungi	Low	Low	Not required
<i>Fusarium culmorum</i> (culm rot: cereals)	Fungi	Low	Medium	Required
<i>Fusarium oxysporum</i> f.sp. <i>tuberosi</i>	Fungi	Medium	Medium	Required
<i>Geotrichum candidum</i> (sour rot: Citrus spp.)	Fungi	Medium	Medium	Required
<i>Gibberella avenacea</i> (bud rot)	Fungi	Medium	High	Required
<i>Gibberella baccata</i> (biocontrol: velvetleaf)	Fungi	Low	Low	Not required
<i>Helminthosporium solani</i> (silver scurf)	Fungi	High	High	Required
<i>Hypocrea rufa</i> (fruit rot: Citrus spp.)	Fungi	Low	Low	Not required
<i>Melanotus communis</i> (wireworm, common)	Fungi	Low	Low	Not required
<i>Nectria haematococca</i> (dry rot of potato)	Fungi	Medium	Medium	Not required
<i>Pectobacterium chrysanthemi</i> (slow wilt)	Bacteria	High	High	Required
<i>Phacidiopycnis tuberivora</i> (dryrot: potato)	Fungi	No information	No information	no information
<i>Phialophora parasitica</i> (wilt: date palm)	Fungi	No information	No information	no information
<i>Phoma andigena</i> (black blight of potatoes)	Fungi	Medium	Medium	required
<i>Phoma eupyrena</i>	Fungi	Medium	Medium	Required
<i>Phoma exigua</i> var. <i>exigua</i> (leaf blotch)	Fungi	Low	Low	Not required
<i>Phoma foveata</i> (potato gangrene)	Fungi	Medium	Medium	Required
<i>Phytophthora citrophthora</i> (brown rot of citrus fruit)	Fungi	Low	Low	Not required
<i>Phytophthora cryptogea</i> (tomato foot rot)	Fungi	Medium	Low	Not required
<i>Phytophthora drechsleri</i> (watermelon fruit rot)	Fungi	High	High	Required
<i>Phytophthora erythroseptica</i> var. <i>erythroseptica</i> (pink rot)	Fungi	High	High	Required
<i>Phytophthora megasperma</i> (apoplexy)	Fungi	High	High	Required
<i>Polyscytalum pustulans</i> (skin spot of potato)	Fungi	High	High	Required
Potato purple-top wilt phytoplasma	Phytop[ls ma	High	High	Required
Potato stolbur phytoplasma	Phytop[ls ma	No information	No information	no information

<i>Potato witches' broom phytoplasma</i>	Phytoplasma	High	High	Required
<i>Pseudomonas fluorescens</i> (biocontrol: Damping off (cotton))	Bacteria	Low	Low	Not required
<i>Pseudomonas putida</i> (biocontrol: <i>Erwinia</i> spp.)	Bacteria	Low	Low	Not required
<i>Pseudomonas syringae</i> pv. <i>garcae</i> (bacterial blight of coffee)	Bacteria	Medium	Medium	Required
<i>Pseudomonas syringae</i> pv. <i>tabaci</i> (angular leaf spot)	Bacteria	Medium	Medium	Required
<i>Puccinia pittieriana</i> (common rust of potato)	Fungi	High	High	Required
<i>Pythium butleri</i>	Fungi	High	High	Required
<i>Pythium ultimum</i>	Fungi	High	High	Required
<i>Pythium vexans</i> (damping off)	Fungi	Medium	Medium	Required
<i>Ralstonia solanacearum</i> race 3	Bacteria	High	High	Required
<i>Rhizobium radiobacter</i> (crown gall)	Fungi	High	High	Required
<i>Rhizobium rhizogenes</i> (bacterial gall)	Fungi	High	High	Required
<i>Rosellinia bunodes</i> (black root rot)	Fungi	No information	No information	no information
<i>Rosellinia necatrix</i> (dematophora root rot)	Fungi	Medium	Medium	Not required
<i>Septoria lycopersici</i> var. <i>malagutii</i> (annular leaf spot of potato)	Fungi	High	High	Required
<i>Thecaphora solani</i> (potato smut)	Fungi	High	High	Required
<i>Ulocladium atrum</i> (almond mould complex)	Fungi	Medium	Medium	Required
<i>Verticillium albo-atrum</i> (verticillium wilt of alfalfa)	Fungi	High	High	Required
<i>Verticillium dahliae</i> (verticillium wilt)	Fungi	High	High	Required
<i>Verticillium nigrescens</i> (seed reduction: soybean)	Fungi	No information	No information	no information
<i>Verticillium tricorpus</i>	Fungi	No information	No information	no information
Andean potato latent virus	Virus	High	High	required
Andean potato mottle virus (Andean mottle of potato)	Virus	High	High	required
Arracacha virus B	Virus	Medium	Low	required
Beet curly top virus (curly top)	Virus	Medium	Medium	required
Pepino mosaic virus	Virus	Medium	Medium	required
Potato 14R (?) tobamovirus	Virus	no information	no information	no information
Potato Andean latent tymovirus	Virus	High	High	required
Potato Andean mottle comovirus	Virus	High	High	required
<i>Potato black ringspot virus</i> (calico disease of potato)	Virus	High	High	required
<i>Potato deforming mosaic virus</i> (deforming mosaic of potato)	Virus	High	High	required
<i>Potato mop-top virus</i>	Virus	High	High	required
<i>Potato spindle tuber viroid</i> (spindle tuber of potato)	Virus	High	High	required
<i>Potato virus T</i>	Virus	High	High	required
<i>Potato virus V</i>	Virus	no information	no information	no information

<i>Potato yellow dwarf virus (yellow dwarf of potato)</i>	Virus	High	High	required
<i>Potato yellow vein virus (yellow vein of potato)</i>	Virus	High	High	required
<i>Potato yellowing virus</i>	Virus	High	High	required
<i>Solanum apical leaf curling (?) bigeminivirus</i>	Virus	no information	no information	no information
<i>Solanum yellows luteovirus</i>	Virus	no information	no information	no information
<i>Southern potato latent (?) carlavirus</i>	Virus	no information	no information	no information
<i>Tobacco necrosis virus</i>	Virus	Medium	Medium	required
<i>Tobacco rattle virus (spraying of potato)</i>	Virus	High	High	required
<i>Tobacco ringspot virus (annulus tabaci)</i>	Virus	Medium	Medium	required
<i>Tobacco streak virus</i>	Virus	Medium	Medium	required
<i>Tomato black ring virus</i>	Virus	Medium	Medium	required
<i>Tomato infectious chlorosis virus</i>	Virus	High	High	required
<i>Tomato yellow mosaic virus</i>	Virus	Medium	Medium	required

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Performance of Potato Clones against Late Blight Disease under Terai and Mid Hill Conditions of Nepal

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ABSTRACT

Late blight caused by *Phytophthora infestans* (Mont) de Bary is economically important disease of potato causing substantial yield loss each year in Nepal. In 2006 and 2007 potato clones were screened at Parawanipur (terai 115m a s l), Sharadnagar (inner terai 270 masl) and Khumaltar (mid hill 1360 m a s l) under natural epiphytotic conditions where late blight severity on susceptible variety reaches at the highest level. Potato clones CIP392657.8, CIP 384321.15, CIP 392637.10, CIP393280.57, CIP393077.159 and LBr 40 were found consistently resistant to late blight disease over the years under different agro climatic conditions. Out of promising 29 crosses selected from previous screening PR 25861.10 and PR 225861.5 at mid hill (Khumaltar) and two crosses PR 85861.12 and PR 85861.8 at terai (Chitwan) were found moderately resistant to late blight along with significantly higher tuber yield than the existing potato varieties.

INTRODUCTION

Potato (*Solanum tuberosum*) is one of the important food crops after rice, wheat and maize which occupy total area of 150,864 hectares with the productivity of 13.11 t/ha (ABPSD 2007). Late blight (LB) caused by fungus *Phytophthora infestans* (Mont.) de Bary is the most devastating disease of potato and most important biotic constraints to potato production in Nepal. The disease first reported in Nepal was between 1883 and 1897 (Shrestha 1976) and has been appearing in epidemic proportions since mid 1990s. Subsequent outbreaks have been observed almost annually and cultivars previously known to resistant became susceptible to late blight. In the high hills losses have been encountered more than 75 percent and in terai losses have been reported 50-90 percent in some years (Shrestha 2000). In Nepal, when yield loss due to late blight is estimated to a minimum level of 20 percent, the monetary loss reaches up to NRs.1.8 billion annually (Sharma and KC 2004). Potato late blight occurs in most potato-growing areas around the world, but it can be particularly devastating in areas with warm and humid weather during the growing seasons (Hijmans et al 2000). Most of the potato growing farmers of Kathmandu valley use 10–15 times fungicides spray on Sept-Oct planting potato to control late blight (Sharma et al 2007, Dhital et al 2007).

Regarding the causal organisms of late blight, two mating types of *P. infestans* namely A1 and A2 have been reported for the first time in Nepal particularly A2 isolates were mainly from the high hills (2000-2500 m) where local and Andean types of potatoes are grown (Shrestha et al 1998). Frequency of A2 mating type is increasing and spreading in new areas by displacing A1 at hills (Shrestha 2005).

Despite of small country Nepal has highly-diversified climate. Potato is grown in almost all the season in Nepal, but planting time varies as per the altitudes and local weather conditions of terai, hills and mountain. The level of resistance in existing potato varieties is only intermediate, and access to resistant varieties by farmers is often limited. Kufri Jyoti, Kufri Sindhuri, Desiree, Khumal seto-1, Khumal rato-2, Janakdev, Cardinal and NPI-106 are the major commercially grown potato varieties in Nepal (Khatri et al

2004). Most of these varieties have got susceptible to late blight. Objectives of present studies were to identify late blight resistant accessions/clones maintained at the National Potato Research Programme and field evaluation of recently crossed potato clones against late blight, along with farmer's participation under highly disease conducive environments, and enhance adoption.

MATERIALS AND METHODS

Fifty-eight potato clones received from CIP and other sources were screened against late blight disease at Parawanipur (115 masl), Sharadanagar (270 masl) and Khumaltar (1360 masl) representing terai, inner terai and mid hill agro climatic conditions respectively during 2006 and 2007. Ten tubers of each potato clones were planted with the spacing of 25 x 60 cm in a 2.5 m long row under natural epiphytotic conditions. Tubers apparently healthy and in the same physiological conditions were planted in the fields during 2nd week of September in Khumaltar whereas 4th week of October in Parawanipur and 3rd week of November in Sharadanagar to adjust with farmers cropping systems. Kufri Jyoti and K. Sindhuri were used as late blight susceptible variety. Experiment was planted in an Augmented design (Scott and Milliken 1993) where susceptible check variety only replicated for each block but test clones appeared only once. Respective susceptible check variety was planted after each 9 rows of test clones and a border of susceptible variety was planted for the creation of late blight inoculum pressure to the test materials in all the locations. Prior to planting, fertilizer 150:100:60 kg NPK/ha along with 10 t/ha farm yard manure/compost were applied as basal dose. Intercultural operations and irrigation was applied as per recommendations and farmers decision. No control measures were taken against late blight throughout the crop period. Usually late blight disease becomes epidemic each year when potato planted on the above mentioned time in the respective locations. Artificial inoculation of pathogen was not needed to create the disease pressure.

Late blight disease severity was scored on 1-9 CIP rating scale (Henfling 1987). Where 1 indicates no disease symptoms on foliage and 9 indicates 100 percent damaged by the disease. Disease was scored three times 60, 70 and 80 days after planting (DAP). Disease score of 70 DAP was used for comparing the disease reaction of the potato clones. Every year a single observation at appropriate single date (ie when susceptible control has 90-98% blighted foliage) is good enough to broadly group the genotypes into different classes of resistance (Gopal and Singh 2003). Test clones were categorized into four groups based on 1-9 disease rating scale.

<u>Range of score</u>	<u>Reaction category</u>
<=1	HR (Highly resistant)
>1 to <=2	R (Resistant)
>2 to <=4	MR (Moderately resistant)
>4 to <=6	S (Susceptible)
>6 to <=9	HS (Highly susceptible)

Among the four sets of test potato clones, one set was planted in farmer's field with their own management. Farmers in association with researchers scored the disease during 70 and 80 DAP and farmers kept selected genotypes for further multiplication as per their preference. Their selection was almost similar to the selection of researchers in the on-station trial. Researchers realized that farmer's participatory selection serves as best statistical tools for significant validation of the result.

RESULTS AND DISCUSSION

Mid hills

Out of fifty eight potato clones screened, CIP numbers 384321.15, 391058.35, 391617.54, 392270.32, 392271.58, 392637.10, 392657.8, 393077.159, 393280.57, 396233.38, 800982 and LBr-40 were found resistant to late blight disease under mid hill (Khumaltar) conditions. These clones showed consistent reaction in both the years 2006 and 2007. Autumn season (Sept-Oct planting) was most conducive for LB

development. Thirty potato clones showed moderate resistance reaction with the disease score ranging >2.0 to <5.0 and rest of the clones were reacted susceptible to highly susceptible. In Khumaltar, overall late blight severity in 2007 was higher than the previous year 2006 (Table1).

In another set of NPRP bred potato clone screening, PR 15861.30, PR 15861.7 PR225861.5, PR 25861.11 and PR 25861.1 showed highly resistant reaction to late blight. Out of these highly resistant genotypes, JD x LBr40.5 PR 225861.5 produced highest tuber yield (15.33 t/ha). PR 25861.8, PR 35861.13, PR 35861.18 and PR 25861.10 were found resistant. Potato clones PR 25861.7, Cardinal x 27/40.5, PR 15861.14 were found at par with the susceptible check variety 'Kufri Jyoti' (Table 2).

Table 1. Reaction of potato clones against late blight under field conditions of terai and mid hills

Potato clones	2006		2007		Mean LB score	Over all reaction to LB
	Kumaltar	Parwanipur	Khumaltar	Chitwan		
	LB score	LB score	LB score	LB score		
378711.7	7.0	4.0	9.0	9.0	7.3	HS
383178.22	3.0	2.0	4.0	9.0	4.5	S
384321.15	2.0	3.0	1.0	1.0	1.8	R
384329.21	2.5	2.0	4.0	7.0	3.9	MR
385021.12	2.0	5.0	3.0	8.0	4.5	S
385556.4	3.0	3.0	4.0	9.0	4.8	S
386201.3	2.5	4.0	4.0	8.0	4.6	S
388576.3	2.5	6.0	2.0	6.0	4.1	S
389746.2	2.0	4.0	5.0	6.0	4.3	S
391002.6	2.5	5.0	4.0	9.0	5.1	S
391046.2	2.5	5.0	5.0	9.0	5.4	S
391058.35	2.0	4.0	2.0	2.0	2.5	MR
391396.96	3.0	2.0	5.0	9.0	4.8	S
391617.54	2.0	4.0	2.0	2.0	2.5	MR
392228.66	3.0	5.0	3.0	8.0	4.8	S
392240.29	3.0	2.0	5.0	8.0	4.5	S
392243.17	4.0	4.0	6.0	7.0	5.3	S
392243.52	5.0	3.0	6.0	6.0	5.0	S
392258.11	5.0	2.0	7.0	9.0	5.8	S
392270.32	2.0	4.0	2.0	2.0	2.5	MR
392271.58	2.0	3.0	2.0	3.0	2.5	MR
392637.10	2.5	2.0	1.5	2.0	2.0	R
392657.8	2.0	2.0	2.0	2.0	2.0	R
392661.18	2.5	2.0	2.0	8.0	3.6	MR
393077.159	2.0	2.0	NA	NA	2.0	R
393077.54	2.5	2.0	3.0	5.0	2.3	MR
393280.57	2.0	2.0	2.0	2.0	2.0	R
393280.64	2.5	2.0	2.0	7.0	3.4	MR
393339.242	2.5	4.0	3.0	5.0	3.6	MR
393385.39	2.5	3.0	2.0	4.0	2.9	MR
394005.12	8.0	7.0	8.0	9.0	8.0	HS
394051.4	8.0	7.0	9.0	9.0	8.3	HS
395014.97	5.0	4.0	6.0	7.0	5.5	S
396010.42	2.5	4.0	3.0	3.0	3.1	MR
396233.38	2.0	4.0	2.0	5.0	3.3	MR
800982	2.0	5.0	2.0	2.0	2.8	MR
384331.10 LB	4.0	4.0	6.0	9.0	5.8	S
388572.1 K	3.0	3.0	4.0	6.0	4.0	MR
388574.6D	3.0	2.0	5.0	9.0	4.8	S
388578.2 D	3.0	3.0	6.0	7.0	4.8	S
393574.72 B	5.0	5.0	7.0	9.0	6.5	HS
AKK-69.1	3.0	4.0	4.0	4.0	3.8	MR
CEZ-69.1	2.0	4.0	5.0	7.0	4.5	S

Curza-27	3.0	4.0	3.0	7.0	4.3	S
K.Chipsona-1	5.0	3.0	6.0	9.0	5.8	S
K.Chipsona-2	2.5	4.0	5.0	8.0	4.9	S
Khumal Seto-1	4.0	5.0	6.0	8.0	5.8	S
Kinga	2.5	2.0	4.0	7.0	3.9	MR
RW-8201.19	2.5	3.0	3.0	4.0	3.1	MR
LBr-40	1.0	1.0	1.0	1.0	1.0	HR
390347.50	2.5	4.0	3.0	6.0	3.9	MR
392206.35	7.0	5.0	8.0	6.0	5.8	S
392227.15	2.5	3.0	3.0	4.0	3.1	MR
394038.105	2.5	2.0	4.0	6.0	3.6	MR
388572.4 K	3.0	3.0	4.0	6.0	4.0	MR
T-55X TPS67	5.0	5.0	8.0	9.0	6.8	HS
Veri Karnali	6.0	5.0	8.0	9.0	7.0	HS
388580.6	5.0	3.0	7.0	9.0	6.0	S
Kufri Jyoti	7.8	-	9.0	-	8.4	HS
Kufri Sindhuri	-	7.0	-	9.0	8.0	HS

LB score 1= no disease; 2= < 5%; 3= 5 to <15%; 4=15 to <35%; 5=35 to <65%; 6= 65to<75%; 7=75 to 85; 8=85 to <95%; and 9= 100% damage; Reaction: HR (<=1); R (>1 to <=2); MR (>2 to <=4); S (>4 to <=6); HS (>6 to <=9).

Table2. Performance of NRPP-bred potato clones at mid-hill (Khumaltar) in autumn season 2007

Potato Clones	LB score	Reaction	Tuber yield (t/ha)	Tuber color
PR 15861.30	1	HR	2.83	-
PR 15861.3	4	MR	4.67	-
PR 15861.7	1	HR	6.44	-
PR 25861.7	8	HS	5.04	-
PR 25861.8	2	R	9.33	DR
PR 35861.13	2	R	5.53	R
PR 35861.18	2	R	5.00	-
PR 85861.6	3	MR	12.13	R
PR 225861.5	1	HR	15.33	W
Cardinal x27/40.5	8	HS	4.13	DR
PR 15861.14	8	HS	2.52	LR
PR 25861.10	2	R	18.67	DR
PR 15861.8	5	S	7.78	W
Cardinal x 27/40.7	7	HS	4.4	DR
PR 55861.8	7	HS	2.87	DR
PR 25861.11	1	HR	7.67	R
1 PR 25861.1	1	HR	7.78	R
Resistant check (LBr40)	1	HR	15.85	W
Susceptible check (Kufri Jyoti)	9	HS	2.52	W

Skin colour: W=White; R=Red; LR= Light red; DR= Dark red; LB score 1= no disease; 2= < 5%; 3= 5 to <15%; 4=15 to <35%; 5=35 to <65%; 6= 65to<75%; 7=75 to 85; 8=85 to <95%; and 9= 100% damage; Reaction: HR (<=1); R (>1 to <=2); MR (>2 to <=4); S (>4 to <=6); HS (>6 to <=9)

Terai

Same set of clones as screened at Khumaltar, were tested at Parawanipur (terai) during 2006 crop season. Clone LBr-40 showed highly resistant reaction to late blight. Fourteen clones showed resistance and two clones 394005.12 and 394051.4 showed comparable susceptibility with Kufri Sinduri, a terai check variety. Rest of the clones, were found susceptible (Table1). In Parawanipur, overall disease severity at 70 days after planting was lower than the Khumaltar conditions of the same year. The reason could be the prevalence of sunny and unfavorable weather for LB during that particular crop period.

Inner terai

In 2007, under participatory LB disease screening trial at Sharadanagar Chitwan potato clones 384321.15 and LBr-40 were found highly resistant and clones 391058.35, 391617.54, 392270.32, 392637.10, 392657.8, 393280.57 and 800982 resistant to late blight. Rests of the clones were susceptible to highly susceptible reaction. Observation on late blight disease severity showed that environment of this site was found to be the most conducive for potato germplasms screening. Some of the clones like Chipsona-1, Chipsona-2, Khumal seto-1, Kinga and 384329.21 which had shown resistance in Khumaltar and Parawanipur were found highly susceptible at Sharadanagar (Table 1).

Regarding the NPRP-bred potato clones tested at Sharadanagar PR 15861.8 and PR 15861.16 were found highly resistant with the considerable tuber yield 19.87 t/ha and 13.47 t/ha respectively (Table 3). Eight clones showed resistant to late blight with the significantly higher tuber yield ranging 16.33 to 26.6 t/ha. Obtained yields were almost triple of the yield of susceptible check cultivars Cardinal and Desiree (Table 3). Participating farmers had expressed their satisfaction by getting late blight resistant potato clones with the desirable tuber yield without spraying any fungicides.

Table3. Farmer's participatory selection of National Programme bred potato clones at Sharadanagar in 2007

Clones	LB score	Reaction	tuber yield t/ha	Tuber colour
PR 15860.8	2	R	19.67	W
PR 15861.35	3	MR	20.33	W
PR 35861.24	3	MR	16.33	R
PR 225861.7	3	MR	19.53	W
PR 85861.9	7	HS	4.67	W
PR 85861.12	3	MR	26.60	R
PR 255861.2	3	MR	22.47	W
PR 255861.1	3	MR	20.47	W
PR 85861.8	3	MR	22.33	R
PR 15861.16	2	R	13.47	R
PR 85861.11	3	MR	22.33	W
PR 15861.1	9	HS	3.33	W
Resistant check (LBr44)	1	HR	19.87	W
Susceptible check (Desiree)	9	HS	6.67	R
Susceptible check (Cardinal)	9	HS	7.33	R
Susceptible check (K. Sindhuri)	9	HS	8.20	R

LB score 1= no disease; 2= < 5%; 3= 5 to <15%; 4=15 to <35%; 5=35 to <65%; 6= 65to<75%; 7=75 to 85; 8=85 to <95%; and 9= 100% damage; Reaction: HR (<=1); R (>1 to <=2); MR (>2 to <=4); S (>4 to <=6); HS (>6 to <=9).

Of 58 potato clones screened at three different climatic conditions LBr40, 384321.15, 392637.10, 392657.8, 393077.159 and 393280.57 were found consistently resistant to late blight over the experimental years and the locations (Figure1).

CONCLUSION

Five potato clones LBr40, 384321.15, 392637.10, 392657.8, 393077.159 and 393280.57 were found consistently resistant to late blight over the experimental years and three different climatic conditions. Among the NPRP crosses, PR 25861.10, PR 225861.5, PR 85861.12, PR 85861.8, PR 85861.2, PR 15860.8 and PR 85861.11 were found resistant to LB with significantly higher yield. Farmers require further evaluation opportunities for judging tuber yield, storability, and processing quality of the selected clones. However, skin colour, shape and eye depth were the other selection criteria in addition to tuber yield and disease resistance.

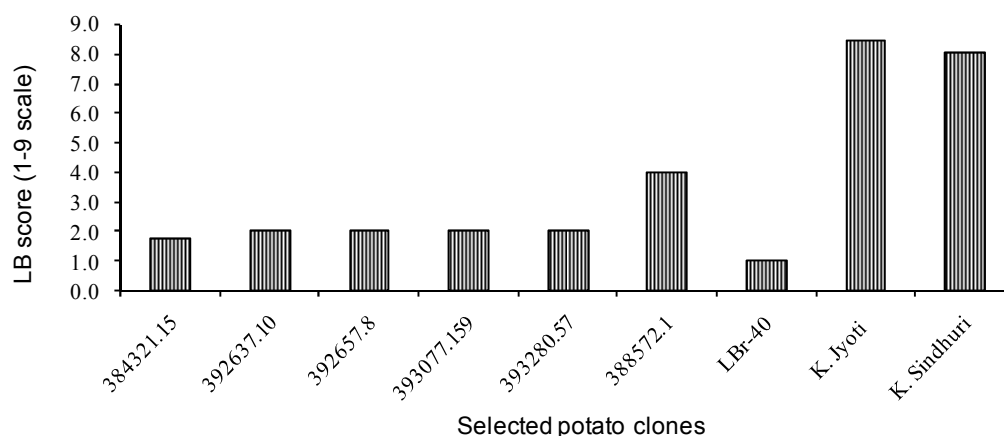


Figure 1. Late blight disease severity of the selected eight potato clones compared with susceptible check varieties during 2006 and 2007 under multi locations in Nepal

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Physico-morphological Evaluation of Banana (*Musa* sp.) Genotypes at Nepalgunj

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ABSTRACT

An experiment was conducted at RARS, Khajura during 2058-2063 to evaluate the physico-morphological characters and yields of different cultivars. The experiment was laid out in RCBD with three replications. Spacing was maintained in 2 x 1.5 meters, in which uniform size of suckers (40-45 cm height) was planted and physico-morphological characters were evaluated. Highest pseudo-stem length was recorded for Khajura Malbhog. Maximum girth was recorded for Robasta and minimum for Harichal. Maximum leaf length was obtained for Chitawan Malbhog. Likewise, maximum width of leaf was shown by Robasta. Similarly, Willium Hybrid was found earliest and Chiniya Champa variety was most late in maturity. Khajura Local had shown heaviest than other cultivars. Although, maximum number of clusters was observed for Jahajee, highest yield ha⁻¹ was observed for Khajura Local, followed by Jahajee. Maximum number of finger bunch⁻¹ was obtained for Jahajee, however, maximum finger weight, length and girth was recorded for Chitawan Malbhog. Significantly minimum peel and maximum pulp percent was recorded for Chitwan Malbhog. Likely, the test panel had preferred most to Willium Hybrid, and second most to Robasta.

Key words: Banana, banana genotypes, banana germplasm, variety evaluation

INTRODUCTION

Banana (*Musa* sp.), a high value commodity, is grown from the terai to mid hills of Nepal. The total area under banana production is 3401 hectares, which produces approximately 48005 metric tones of fruits (MoAC 2000). Most of the farmers of Nepal used to grow banana in kitchen gardens and homestead land in the past. But, in recent years, commercial cultivation has rapidly coming up. Although the area under banana cultivation and its production is increasing rapidly, the productivity is low. The productivity of banana in Nepal is 20-40 percent lower than the neighboring country. The reasons for low productivity are insufficiency of appropriate varieties, poor management practices, including clump management, soil fertility maintenance, proper irrigation and plant protection measures (LARC 1993). As a result of that the demand for fruit has not yet been met by domestic production.

Banana is a triploid sterile plant and propagated vegetative means by using suckers. Therefore crop improvement through sexual hybridization is not possible. In this context collection, maintenance, selection and adoption of superior cultivars might be a most feasible alternate for varietal improvement of banana in Nepal. Moreover, germplasm characterization is the fundamental basis for crop improvement. In this context this experiment was carried out to study the physico-morphological variation, crop duration and yield potentiality of banana germplasm for both qualitative and quantitative characters, aiming to identify the most productive varieties.

MATERIALS AND METHODS

The experiment was carried out at RARS, Khajura, Nepalgunj during 2058-2063. Germplasm survey was conducted in banana growing areas of the country, located diversity and collection had been done. A total of ten genotypes of banana viz Harichal, Willium Hybrid, Robasta, Tarhara Local, Khajura Malbhog, Khajura Local, Jahajee, FIA, Chiniya Champa were collected, maintained and sufficient number of suckers were produced. The experiment was laid out in RCBD with three replications. Spacing was maintained in 2 x 1.5 meter, two plants were kept in a plot but single plant treated as a plot. Pits of 0.5 m³ size were dug and uniform size of suckers 40-45 cm height had been planted. Fertilizer was applied as 15 kg compost, 0.5 kg bone meal in basal and 100g nitrogen, 40 g phosphorus and 100 g potash year⁻¹ plant⁻¹. Observation was taken on pseudo stem length, pseudo stem girth, leaf dimensions, maturity period, yield and other yield attributing characters, quality attributes and sensory evaluation. Sensory evaluation was performed by formation of test panel of five members. The data was analyzed by using MSTAT-C and Microsoft Excel computer software packages.

RESULTS AND DISCUSSION

The data revealed that the significant difference ($p \leq 0.01$) on pseudo stem length and pseudo stem girth (Table 1a). Accordingly, maximum height was recorded for Khajura Malbhog (366.7 cm) which was followed by Khajura Local (311.7 cm), whereas minimum height was observed for Harichal (121.7 cm). Maximum pseudo-stem girth was recorded for Robasta (77.0 cm) and minimum for Harichal (40.3 cm). Similarly, the leaf dimensions were also found significantly different ($p \leq 0.01$) among the cultivars. Longer leaf was recorded for Chitwan Malbhog (202.8 cm) and FIA (196.3 cm) cultivars. Wider leaves were found for Robasta (76.2 cm) and FIA (73.6 cm). Statistically different ($p \leq 0.01$) maturity days were observed for cultivars, that is, earliest for Willium Hybrid (358 days) and Khajura Local (392 days). Bunch weight and yield were also observed significantly different ($p \leq 0.01$) among the cultivars evaluated. Bunch weight and yield were found highest for Khajura Local (31.0 kg bunch⁻¹ and 1033.3 q ha⁻¹, respectively). The cultivar Chiniya Champa had produced lowest bunch weight and yield (8.4 kg bunch⁻¹ and 278.9 q ha⁻¹, respectively). Other cultivars were in between them.

Number of cluster bunch⁻¹ and number of finger bunch⁻¹ were also significantly difference ($p \leq 0.01$) among the cultivars (Table 1b). Significantly higher number of clusters was recorded for Jahajee (14.3) and Khajura Malbhog (12.7), whereas minimum number of clusters was recorded in Chitwan Malbhog (7.3). Similarly, finger weight, finger length and finger girth were also found significantly different ($p \leq 0.01$). Statistically heavier fingers were found for Chitwan Malbhog (224.3 g finger⁻¹) and Khajura local (214.9 g finger⁻¹), whereas finger weight of 84.1 g finger⁻¹ was recorded for Chiniya Champa. The finger length was ranged from 12.8 cm to 18.6 cm for Khajura Malbhog and Chitwan Malbhog, respectively. Likewise, the range of 3.2 cm to 5.1 cm was found for finger girth (Jahajee and Chitwan Malbhog, respectively).

The data on peel percent and pulp percent of ripened fruits revealed that the differences among varieties were significant ($p \leq 0.01$). Significantly lower peel percent was observed for Chitwan Malbhog, Robasta and Chiniya Champa (26.2, 24.1 and 24.4 percent, respectively). Likely, the range of pulp percent was observed for 62.7 to 78.4 percent for Kahjura Local and Chitwan Malbhog, respectively. The data obtained from the test panel score by using the organoleptic tests revealed that the cultivars Willium hybrid, Harichal, Robasta and Jahajee preferred most with higher scores among 10 tested cultivar. Similarly, significantly more sensory evaluation score 9.3 was observed in Willium Hybrid followed by FIA and Robasta, whereas minimum score 5.3 was recorded in Khajura Local. Khajura Local and Khajura Malbhog were lest preferred by the test panel.

Table 1a. Physico-marphological characters of banana genotypes

Genotypes	Pseudo stem length (cm)	Pseudo stem girth (cm)	Leaf length (cm)	Leaf width (cm)	Maturity Days	Bunch weight (kg)	Yield q ha ⁻¹
Harichal	121.7	40.3	131.7	56.6	518.3	14.8	442.2
William Hybrid	176.3	44.3	173.3	57.1	353.0	11.2	372.3
Robasta	190.0	77.0	172.0	76.2	497.3	22.0	733.3
Tarhara Local	305.0	65.7	188.7	60.9	450.0	15.4	512.2
Khajura Malbhog	366.7	72.7	192.7	54.1	501.7	16.5	550.0
Khajura Local	311.7	65.3	167.0	65.9	392.0	31.0	1033.3
Jahajee	141.7	64.7	183.3	56.4	472.3	22.3	744.4
FIA	183.3	53.0	196.3	73.6	441.6	16.2	494.4
Chitwan Malbhog	298.3	69.0	202.0	63.4	418.3	19.5	650.0
Chiniya Champa	246.7	72.7	181.0	61.5	543.0	8.4	278.9
F test	**	**	**	**	**	**	**
LSD	32.47	2.55	25.97	8.93	52.25	5.8	212.7
CV%	8.08	2.38	8.47	8.32	6.64	19.0	21.3

Table 1b. Fruit characters of banana germplasm

Genotypes	No.of cluster/bunch ⁻¹	No.of finger bunch ⁻¹	Finger weight (gm)	Finger length (cm)	Finger girth (cm)	Peel %	Pulp %	Sensory evaluation
Harichal	8.0	105.7	108.6	17.3	3.7	28.4	71.6	8.3
William Hybrid	7.7	111.0	89.5	13.7	3.5	31.1	68.8	9.3
Robasta	10.7	168.3	122.8	14.9	4.0	24.1	75.9	8.7
Tarhara Local	9.7	110.3	122.6	14.8	4.7	32.3	67.7	6.3
Khajura Malbhog	12.7	159.3	90.8	12.8	3.9	27.4	72.6	6.0
Khajura Local	10.0	140.7	214.9	15.5	5.1	36.9	62.7	5.3
Jahajee	14.3	277.3	122.7	14.5	3.2	34.5	65.8	7.3
FIA	9.0	159.3	105.4	15.9	4.0	29.6	70.4	8.7
Chitwan Malbhog	7.3	88.0	224.2	18.6	5.2	21.6	78.4	7.3
Chiniya Champa	8.0	91.7	84.1	14.2	3.7	25.4	74.6	7.3
F test	**	**	**	**	**	**	**	**
LSD	1.74	40.42	28.66	2.17	0.63	6.04	6.06	0.56
CV%	10.43	16.6	13.0	8.35	8.97	12.1	5.1	4.39

CONCLUSION

The experiment revealed that the cultivar Khajura Local is better cultivar among the tested ten cultivars in terms of yield, bunch weight and finger weight. William hybrid has earlier maturity days. In contrast, Jahajee cultivar produce more cluster bunch⁻¹ and finger cluster⁻¹. Both of the cultivars have lower pulp percentages in comparison to other cultivars. William Hybrid, Rubasta, FIA and Harichal are the most preferred cultivars from the test panel.

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Management of Citrus Decline and Rejuvenation Strategies for Declining Orchards of Dailekh

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ABSTRACT

A participatory rural appraisal (PRA) was conducted by Agricultural Research Station (Horticulture), Dailekh during 2006/2007 at major citrus pockets viz Dullu, Mallika, Gamaudi, Kal Bhairav, Lakuri, Goganpani and Kandechar to collect information regarding the incidence of citrus decline along with general cultivation practices followed by the citrus growers. PCR diagnoses of HLB in citrus samples of Dailekh analyzed at RONAAT, Kathmandu during 2002 showed that out of 14 citrus samples, 9 samples were detected for presence of Huanglongbing disease (HLB) by PCR. DAS-ELISA diagnosis for CTV on the citrus samples of Dailekh analyzed at GREAT, Kathmandu during 2001 showed that all the 40 citrus samples were free from CTV. Twenty soil and twenty-three leaf samples analyzed at Soil Science Division, Khumaltar during 2001 revealed that soils of majority of citrus orchards in Dailekh were strongly acidic in nature containing low level of organic matter and nitrogen.

Information gathered from PRA and field observation, results of laboratory analysis of CTV and HLB, soil and leaf sample analysis indicates that infestation of citrus orchards by many diseases and insects (HLB, powdery mildew, canker, Phytophthora root rot, scales, trunk borer, leaf miner, lemon butter fly, aphids, red ant, green stink bug and fruit fly) and parasitic plants (*Loranthus* and lichens); poor soil and plant nutrient status of mandarin orchards, poor orchard management practices and use of poor quality planting material, acute moisture stress during winter and summer seasons may result many type of abnormalities leading to citrus decline. Citrus decline management strategies have been developed for rejuvenation of declining orchards of the mid western development region of Nepal and implemented by this station in recent years.

Key words: Citrus decline, CTV, Citrus greening disease, *Diaphorina citri*, PCR analysis

INTRODUCTION

Citrus is an important high value commodity of Nepal accorded high priority in APP and 10th Plan of government of Nepal covering about 25 percent of the total area under fruit cultivation. The mid hills of Nepal are quite suitable for cultivation of citrus fruits, particularly *Citrus reticulata*, *Citrus sinensis* and *Citrus aurantifolia* and *Citrus limon*. In the last 25 years, area coverage of citrus has increased by nearly 20 folds but productivity has not increased significantly. Currently, yields of citrus are quite low averaging 10 mt/ha. (CDS 2001). The recently constructed road linking Dailekh with Surkhet provide a good market access to citrus product and has comparative advantage for exporting citrus fruits to Bangladesh and Indian market because of high quality fruits. However, the citrus growers have not been able to obtain optimum benefit from this crop due to narrow production period of existing varieties and incidence of citrus decline problem. Citrus decline caused by various factors is considered one of the reasons for low productivity of citrus in Nepal. The whole citrus orchard of ARS, Dailekh collapsed totally within last decade. Citrus decline or die back is not a specific disease but is a symptomatic

expression of many disorders in the plant. Citrus plants after 5-6 years of excellent growth usually start declining with gradual decrease in vigor and yield. The magnitude of decline increases with the age of the plant and after 15-20 years the affected plants become uneconomical to maintain. The symptoms declined trees include retarded growth, appearance of chlorotic leaves, sparse foliage, dieback of twigs and in general sickly appearance of the tree. Declined trees do not usually die but remain unproductive. In most cases the trees continue to linger on in a state of poor health for many years with a considerable reduction in fruit production. It was very difficult to find absolutely healthy orchard on the basis of foliage appearance, general tree growth and quality of fruits. Therefore, this paper intends to identify the major factors causing citrus decline and highlights appropriate citrus decline management strategies with a view to improve the socio-economic status of citrus growers of the command areas of ARS, Dailekh.

MATERIALS AND METHODS

Following research activities were carried out in order to identify key factors responsible for the decline and to develop appropriate management strategies to solve the problem.

- A checklist was prepared for PRA to obtain required information focused on citrus decline. PRA was conducted during the winter season of 2005/2006 in seven major citrus pockets of Dailekh viz Dullu, Malika, Gamaudi, Kal Bhairav, Lakuri, Goganpani and Kandechar to identify intensity of citrus decline along with the management practices adopted by the citrus growers, major diseases and insects and other relevant information.
- 20 soil samples and 23 leaf samples were collected from Dullu and Kal Vairav of Dailekh according to the methods described by Tripathi (1998) and (Regmi et al 2001) respectively. Soil samples and leaf samples were collected, labeled and sent to Soil Science Division, Khumaltar for soil and plant nutrient analysis to identify existing nutrient status of the citrus orchard and establish relation of these nutrients with citrus decline in mandarin.
- Leaf samples from areas which were doubted to have been infected by diseases were collected and sent to RONAST and GREAT for CGD analysis (14 samples) and CTV analysis (40 samples).
- All the diseased citrus trees from ARS, Dailekh and adjoining areas have been uprooted and destroyed.
- An insect proof permanent screen-house has been built and disease-free foundation stocks of mandarin, sweet orange and acid lime obtained from NCRP planted inside screen house (Appendix 4a).
- Demonstration plots of ten different varieties of mandarin, six varieties of sweet orange, five varieties of clementine, five varieties of grapefruit, three varieties of tangor and three varieties of tangelo were established at two blocks of ARS, Dailekh (Appendix 4b).
- Private citrus nursery owners were trained for modern nursery technologies.

RESULTS AND DISCUSSION

The conclusion from PRA Survey and field observation were made only in text forms. It was observed that majority of mandarin orchards were found medium in size (26-100 trees) followed by small holders (<10 trees) and big holders. The source of sapling for orchard establishment was ARS, Dailekh. Regarding the mode of propagation, more than 70 percent farmers used seedlings. The average productivity of a mandarin was 150 kg/tree in Dullu where as 25 kg/tree in Kal Bhairav which may be due to severe intensity of citrus decline in Kal Bhairav (1240 m) where as low intensity in Dullu (1460 m) because of higher citrus psylla population at lower altitude responsible for transmission of HLB. It was observed that citrus psylla population on Kamini flower which is an alternate host of citrus psylla was highest during June-August. Fruit drop due to green stink bug during June-July was a serious problem in Goganpani of Dailekh. Due to small land size, farmers have adopted intercropping practices in mandarin orchard dominated with cereals. Regarding the soil fertility management practices, farmers used FYM in mandarin orchard not for the mandarin trees but for intercrops. Factors which are responsible for inducing declining of mandarin orchards have been identified from this investigation as follows:

Huanglongbing disease (HLB) (Citrus greening disease, CGD)

Results of PCR diagnoses of CGD in citrus samples from ARS, Dailekh showed that out of 14 citrus samples analyzed at RONAAT, Kathmandu during 2002, 9 samples were detected for presence of HLB by PCR (Appendix 1). Therefore, this can be concluded that majority of citrus orchards in Dailekh are already severely infected by CGD which is one of the major factor responsible for citrus decline.

Citrus tristeza virus (CTV)

DAS-ELISA diagnosis for CTV on 40 citrus samples from ARS, Dailekh carried out at GREAT, Kathmandu during 2001 showed that all the samples were free from CTV (Regmi et al 2001). Therefore, this can be concluded that CTV is not responsible for inducing citrus decline under Dailekh conditions (Appendix 2).

Phytophthora root rot

It has been observed that majority of citrus orchards in Dailekh are propagated by seeds, therefore, root rot might be one of the major causes of citrus decline. Domination of fungi over to soil microorganism under acid soil (Brady 1974) and high moisture in rainy season would enhance the problem of root rot that retard the growth of mandarin trees as well as reduced productivity and leads to complete decline of the tree. Therefore, this can be concluded that root rot is one of the major factors responsible for inducing citrus decline problem under Dailekh conditions.

Poor soil and plant nutrient status of mandarin orchards

Soil samples of mandarin orchards and leaf samples of mandarin trees were analyzed for soil pH, organic matter and macro nutrients at Soil Science Division, Khumaltar. Regmi et al (2001) reported that majority of citrus orchards of Dailekh have strongly acidic soil (pH 4.5 - 5.2), low level of soil organic matter (1.0-2.5%), low to medium level of soil nitrogen (0.05-0.2%), low to medium level of soil phosphorus (10-35 kg/ha), medium level of soil potash (110-280 kg/ha), low to satisfactory level of leaf nitrogen (1.9-2.7%), excess level of leaf phosphorus (0.3%) and satisfactory level (1.0-1.7%) of leaf potash (Appendix 3a-3h).

Based on above investigation, it can be concluded that nitrogen was deficient while phosphorus and potassium contents were sufficient and soil organic matter is less than required. Under such situation, trees remain stunted, declined and may exhibit a decrease in flowering and fruiting (Rajput and Haribabu 1995). Therefore, judicious application of nitrogenous fertilizers and organic matter; intercropping with appropriate legumes is strongly recommended. In acid soils (pH<6.0) excess hydrogen ions may replace Ca^{++} , Mg^{++} , K^{+} , Na^{+} where as in highly acidic soils solubility of Mn^{++} and Al^{++} are high, often with toxic effects (Roy and Goldschmidt 1997). In this situation, rain water either washed or leached the soluble micronutrients from the soil during rainy season leading to deficiency of micronutrients. Hence judicious application of lime is recommended to bring the pH at optimum level in order to enhance nutrient uptake efficiency.

Use of poor quality planting materials

Citrus decline may also be caused by the poor quality planting materials used by the citrus growers in Dailekh. The quality of saplings presently produced in government and private nurseries is very poor. If these are seedling, there is no confirmative way to determine that seeds are obtained from elite trees and seedlings are nucellar origin. If planting materials are grafted ones, scions are obtained from any source without the knowledge of their status with respect to graft transmissible diseases such as CGD and CTV. Grafting height is very low: 5-10 cm above the ground level. This results in a bud union, which ultimately is very close to ground, and in many cases it may be buried beneath the soil surface while transplanting in the orchard. This exposes the susceptible scion trunk to infection by *Phytophthora* root rot.

Poor cultural management of orchards

It has been observed that poor cultural management of citrus orchards has also been contributing to accelerate the citrus decline in Dailekh. The growers do not adopt proper management practices such as plant protection, manure and fertilization application, irrigation, mulching and pruning etc. after the establishment of orchard. Majority of citrus trees are planted on edge of terraces to get more spaces for intercropping which limit the root expansion only one side and such trees suffer moisture stress in dry season. Most farmers in Dailekh are using improper intercrops such as maize, millet, wheat or vegetables. Grazing of goats and cattle in citrus orchard and plowing of orchard areas for intercrop lead to wounding and cutting of feeder roots which cause root rot and ultimate decline of trees.

Loranthus parasitic plant (Aijaru)

Seeds of this parasitic plant germinate on the branches of citrus trees and produces haustorium covering all the branches, and then tree start decline ultimately dies. Fig and pear are the alternate host of this parasitic plant. The ripened fruit of this parasite are edible; therefore, birds are responsible for dispersal of the seeds of *Loranthus*. *Loranthus* parasite plant is an important factor responsible for declining of citrus orchard induced mainly due to poor orchard management practices of ARS, Dailekh.

Scale insects

Among the different type of scales arrowhead, soft and red scale were most common scales in Dailekh. The nymph and adults suck sap from the foliage, twig, branches and stem and in severe cases cause decline. Soft scales also secrete honeydew, which causes shooty mould resulting in infection with other fungal diseases. Trees affected with scale insects exhibit yellowing and early shedding of their leaves, bear less fruits and their fruit quality decreases.

Other diseases and insects pests

Many important diseases (powdery mildew and anthracnose), insects (trunk borer, leaf miner, lemon butter fly, red ant, green stink bug, aphids, fruit fly), lichens and micronutrient deficiencies associated in citrus cultivation have been observed during farmer's field visit resulting several types of abnormalities leading to decline of the mandarin orchards.

CONCLUSIONS AND RECOMMENDATIONS

The results of this investigation revealed that key factors responsible for citrus decline has been identified and intensity of citrus decline showed a great threat to citrus cultivation. Thus, following citrus decline management strategies should be followed immediately by concerned research and development institutions in order to rejuvenate declining orchards of citrus in the mid western development region of Nepal.

Initiation of citrus certification program

Citrus certification program should be initiated as soon as possible in order to make available true to type planting materials that are free from graft-transmissible diseases, to guarantee sanitary status and varietal purity of nursery plants produced by private commercial nurseries. Detailed procedures for nursery and bud wood certification should be developed in line with proposed Citrus Nursery Plant Production Scheme (Appendix 6).

Improvement in nursery practices

Both seedling and grafted saplings produced by private nurseries at present are of poor quality (Appendix 5.1-5.4). Pedigree of mother plant is unknown. Growth of rootstock is slow and needs long time to attain the suitable size for grafting. Grafting height is too low. Technology for faster growth of nursery plants including rootstocks should be upgraded with the use of growth accelerating agrochemicals, better media and weed control technique. Quality of planting materials should not be compromised to meet the target of production program.

Rejuvenation and/or eradication of declining trees

Special program for rejuvenation of decline trees should be launched in the citrus pockets of Dailekh where decline is severe. Trees affected with CTV and CGD should be eradicated and replanted with quality planting materials. If necessary, compensation should be provided to the farmers. If decline is related poor orchard management or root rot, then rejuvenation strategy should be changed accordingly. Demonstration plots should be established at farmers' fields for the rejuvenation of unproductive orchard by adopting appropriate package of practices. The problems associated with citrus decline are complex and cannot be solved by single discipline. A complete technological information and service should be provided to the growers to solve the problem. Leaf analysis should be used as an indicator of nutrient uptake and recommendation on fertilizer should be modified according to the result of leaf analysis. Integrated pest management should be an integral part of the rejuvenation program. Phytophthora resistant rootstocks such as trifoliate orange should be used for producing grafted plants. Both predators and parasites of the vectors of CGD should be utilized together with judicious use of insecticide.

Orchard establishment in risk free areas

Detailed survey should be carried out in the citrus growing areas to delineate the CTV and CGD affected and free areas, presence of CTV and CGD vectors and alternative host. Government should establish new commercial orchards using greening and virus free grafted plants only in areas, which are risk free and declared pest free area.

Training

Education is very important in citrus certification program. Citrus growers, technicians working must be informed in every possible way about the latest techniques on citrus nursery and orchard management. Teaching materials such as brochures and visual means suitable for farmers and field level technicians should be developed and made available.

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Appendix 1. Huanglongbing disease survey conducted by ARS, Dailekh during 2002

Name and address	Alt. (m)	Citrus type	Age/ Source	Decline trees (+/-)	Yellow shoot (+/-)	Mottle leaves (+/-)	Leaf curl (+/-)	Fruits with aborted seeds (+/-)	Lop-sided fruits (+/-)	Color inversion of fruits (+/-)	PCR result
ARS, Dailekh	1290	Sour orange	28 yrs Pokhara	+	+	+	-	+	-	-	Positive
ARS, Dailekh	1295	Pummello	25 yrs Dhankuta	-	-	-	-	-	-	-	Negative
ARS, Dailekh	1290	Pummello	25 yrs Dhankuta	-	-	-	-	-	-	-	Negative
ARS, Dailekh	1300	Mandarin	28 yrs	+	+	+	+	+	+	+	Positive
ARS, Dailekh	1320	Mandarin	2 yrs	-	-	-	-	-	-	-	Negative
Dambar Koirala (Panchtalla)	960	Mandarin	20 yrs	-	+	-	-	-	+	-	Positive
Gyan B. Khadka (Kimugaun)	1420	Acid lime	19 yrs	+	+	+	-	-	-	-	Positive
Dambar koirala (Panchtalla)	960	Rough lemon	20 yrs	-	-	+	-	+	-	-	Positive
Dal B. Rawal (Baskot)	1400	Rangpur lime	6 yrs	-	+	+	-	-	-	-	Positive
ARS, Dailekh	1330	Lemon	25 yrs	+	+	+	-	-	-	-	Positive
Ratna P. Regmi (Bhurt)	1450	Sweet orange	22 yrs	-	+	-	-	-	-	-	Negative
ARS, Dailekh	1350	Mandarin	27 yrs	+	+	+	-	+	-	-	Positive
ARS, Dailekh	1330	Acid lime	27 yrs	+	-	+	-	-	-	-	Positive
ARS, Dailekh	1360	Sweet lime	5 yrs	-	-	-	-	-	-	-	Negative

Appendix 2. DAS-ELISA detection of CTV on citrus samples from ARS, Dailekh at GREAT, Katmandu, Nepal, 2001

Sample No	A405 value	DAS-ELISA detection	Sample No	A405 value	DAS-ELISA detection
1	0.211	Negative	22	0.214	Negative
2	0.214	Negative	23	0.239	Negative
3	0.227	Negative	24	0.256	Negative
4	0.215	Negative	25	0.204	Negative
5	0.227	Negative	26	0.212	Negative
6	0.242	Negative	27	0.209	Negative
7	0.219	Negative	28	0.212	Negative
8	0.210	Negative	29	0.229	Negative
9	0.223	Negative	30	0.224	Negative
10	0.233	Negative	31	0.224	Negative
11	0.228	Negative	32	0.218	Negative
12	0.272	Negative	33	0.218	Negative
13	0.204	Negative	34	0.208	Negative
14	0.207	Negative	35	0.206	Negative
15	0.214	Negative	36	0.253	Negative
16	0.209	Negative	37	0.220	Negative
17	0.229	Negative	38	0.216	Negative
18	0.210	Negative	39	0.207	Negative
19	0.210	Negative	40	0.205	Negative
20	0.230	Negative	+ve sample	0.432	Positive
21	0.255	Negative	Blank sample	0.206	Negative

Note: As A405 values for all the samples are well below the average value of positive sample, all the samples tested from ARS, Dailekh were free from CTV.

Appendix 3a: Soil pH of selected mandarin orchards of Dailekh (Regmi et al 2001)

Soil pH					Total samples
Extremely acidic (<4.5)	Strongly acidic (4.5-5.2)	Moderately acidic (5.3-5.9)	Slightly acidic (6.0-6.5)	Nearly Neutral (6.6-7.0)	
5 (25%)	10 (50%)	3 (15%)	-	2 (10%)	20

Appendix 3b: Soil Organic matter content of selected mandarin orchards of Dailekh (Regmi et al 2001)

Soil OM (%)				Total samples
Very Low (<1.0)	Low (1.0-2.5)	Medium (2.5-5)	High (>5.0)	
1 (5%)	17 (85%)	2 (10%)	-	20

Appendix 3c: Soil Nitrogen content of selected mandarin orchards of Dailekh (Regmi et al 2001)

Soil N (%)					Total samples
Very low (<0.05)	Low (0.05-0.1)	Medium (0.1-0.2)	High (0.2-0.5)	Very high (>0.5)	
2 (10%)	8 (40%)	10 (50%)	-	-	20

Appendix 3d: Soil P₂O₅ content of selected mandarin orchards of Dailekh (Regmi et al 2001)

Soil P ₂ O ₅ (kg/ha)			Total samples
Low (10-30)	Medium (30-35)	High (35-110)	
5 (25%)	9 (45%)	6 (30%)	20

Appendix 3e: Soil K₂O content of selected mandarin orchards of Dailekh (Regmi et al 2001)

K ₂ O (kg/ha)			
Low (110-280)	Medium (281-500)	High (>500)	Total samples
10 (50%)	6 (30%)	4 (20%)	20

Appendix 3f: Leaf Nitrogen content of selected mandarin orchards of Dailekh (Regmi et al 2001)

N (%)				
Deficient (<0.6-1.9)	Low (1.9-2.1)	Satisfactory (2.2-2.7)	High (2.8-3.5)	Excess (>3.6)
2 (8.7%)	8 (34.8%)	11 (47.8%)	2 (8.7%)	-
Total samples				
23				

Appendix 3g: Leaf P content of selected mandarin orchards of Dailekh (Regmi et al 2001)

P (%)				
Deficient (<0.07)	Low (0.07-0.11)	Satisfactory (0.12-0.18)	High (0.19-0.29)	Excess (>0.3)
-	-	-	-	23 (100%)
Total samples				
23				

Appendix 3h: Leaf K content of selected mandarin orchards of Dailekh (Regmi et al 2001)

K (%)				
Deficient (0.15-0.3)	Low (0.4-0.9)	Satisfactory (1.0-1.7)	High (1.8-1.9)	Excess (>2.0)
-	1 (4.3%)	13 (56.5%)	3 (13.0%)	6 (26.1%)
Total samples				
23				

Appendix 4a: Citrus varieties introduced from NCRP and maintained at ARS, Dailekh during 2006/2007

Citrus Type	Accession Number	Varieties	No of Saplings	Purpose
Mandarin	NCRP-01	Khoku	50	Orchard establishment
	NCRP-01	Khoku	4	Mother plant and varietal selection
	NCRP-95	Okitsuwase	20	Mother plant and varietal selection
	NCRP-05	Miyagavawase	4	Mother plant and varietal selection
	NCRP-88	Fortune	4	Varietal selection
	NCRP-89	Kara	4	Varietal selection
	NCRP-90	Nova	4	Varietal selection
	NCRP-91	Pixi	4	Varietal selection
	NCRP-92	Dancy	4	Varietal selection
	NCRP-93	Avana	4	Varietal selection
	NCRP-94	Page	4	Varietal selection
	NCRP-22	Washington Navel	10	Mother plant and varietal selection
	NCRP-96	Tamango	4	Mother plant and varietal selection
	NCRP-85	Pineapple	4	Mother plant and varietal selection
Sweet Orange	NCRP-86	Valencia Late	4	Mother plant and varietal selection
	NCRP-84	Lane Late	4	Varietal selection
	NCRP-83	Caracara	4	Varietal selection

Appendix 4b: Citrus varieties introduced from NCRP and maintained at ARS, Dailekh during 2006/2007

Citrus Type	Accession Number	Varieties	No of Saplings	Purpose
Clementine	NCRP-97	Herdandine	4	Varietal selection
	NCRP-98	Oroval	4	Varietal selection
	NCRP-99	Commence	4	Varietal selection
	NCRP-100	Marisol	4	Varietal selection
	NCRP-101	Nules	4	Varietal selection
Grape Fruit	NCRP-76	Henderson	4	Varietal selection
	NCRP-77	Star Ruby	4	Varietal selection
	NCRP-78	Reed	4	Varietal selection
	NCRP-79	Pink Ruby	4	Varietal selection
	NCRP-45	Shamber	4	Varietal selection
Tangor	NCRP-103	Murkott	4	Varietal selection
	NCRP-102	Ellendale	4	Varietal selection
	NCRP-72	Ortanique	4	Varietal selection
Tangelo	NCRP-73	Minneola	4	Varietal selection
	NCRP-74	Orlando	4	Varietal selection
	NCRP-75	Seminol	4	Varietal selection
Total			200	

Appendix 5.1: Proposed Minimum Standards for citrus mother stock

1. Mother stock should be a recommended variety
2. Should be completely free from graft transmissible diseases (CGD and CTV)
3. Should be indexed for CGD and CTV every year prior to scion collection
4. Should be free from scale insects
5. They should be replaced with new lots in every 10 years interval

Appendix 5.2: Proposed Minimum Standards of nursery plants to be qualified for certification Produce

1. Nursery should be registered at DOA and located at above 1000m
2. Scions should be obtained from the certified mother plant maintained inside screen house and free from CGD and CTV
3. Nursery plants should be free from scale insect
4. Grafting height should be 20-25 cm from ground level
5. Nursery plants should be at least one year old after grafting
6. Nursery plants should be at least 2 ft. tall

Appendix 5.3: Recommended scion varieties

Mandarin

1. Khoku local (mid season): Mangsir to mid Magh Harvest
2. Okitsuwase (early season): Aswin to Kartik harvest
3. Murkott (late season): Phagun to Chaitra harvesting

Sweet orange

1. Washington Navel (early season): Kartik - Mangsir harvesting
2. Pineapple and Nepali Junar (mid-season): Poush - Magh harvesting
3. Valencia (late season): Mid Phalgun - Mid Chaitra harvesting

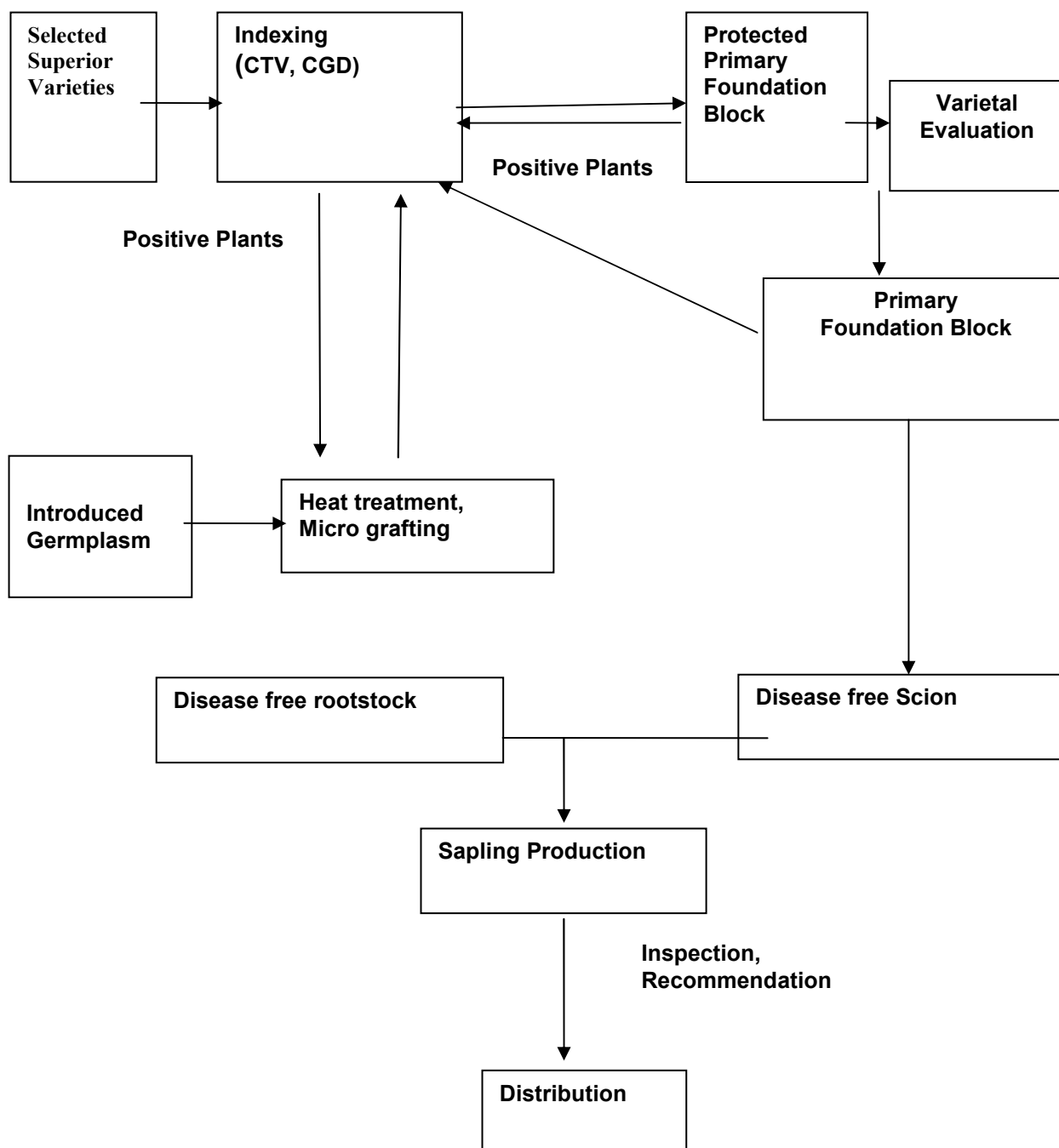
Lime/lemon

1. Terathum local (mid season): Kartik - Poush harvesting
2. Eureka (early season): Shrawan - Aswin harvesting

Appendix 5.4: Recommended rootstock varieties

1. Trifoliate orange, citranges: for areas above 1000 m
2. Rough lemon: for areas below 1000 m, rain fed condition and clay soil

Appendix 6: Proposed Citrus Bud-wood Certification Model in Nepal



Monitoring of Citrus Fruit Flies with Different Lures and Its Management on Sweet Orange Orchard

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ABSTRACT

Experiments were conducted at Kagate (1400 masl) of Dhankuta district on evaluation of different lures and management of citrus fruit flies at sweet orange orchard, and losses of sweet orange caused by citrus fruit flies during 2062 and 2063 fruiting season. Different compositions of protein lure (Treatment I: 22.2 g yeast extract + 27.8 g borax + 1000 ml distilled water, treatment II: 33.3 g yeast extract + 27.8 g borax + 0.5 g peptone + 1000 ml distilled water and Treatment III: 44.4 g yeast extract + 27.8 g borax + 1 g peptone + 1000 ml distilled water) and methyl eugenol with malathion (5 drops of each/trap) as treatment IV were evaluated with seven replications for monitoring of fruit flies at Farmers' field. Empty mineral water bottles for protein lure and yellow colored plastic bottles for methyl eugenol were used as traps. Treatments I, II, III of food lures showed significant number 17.7, 15.3 and 14.7 of female fruit flies trapped as compared to methyl eugenol (0.9) during 2062. Similarly, during 2063 treatments I, II, III of food lures showed significant number 21.0, 18.4 and 16.7 of female fruit flies trapped as compared to methyl eugenol (1.7). Methyl eugenol caught significantly highest number (188.3) male flies as compared to treatment I (8.4), II (6.4), III (9.3) during 2062. Similarly, during 2063 methyl eugenol caught 120.4 male flies whereas, treatments I, II, III trapped 17.3, 23.6, 20.6 male flies respectively. The female fruit flies showed three times population peak during Kartik, Magh and Jestha/Asar. The female fruit flies population increase during Jestha/ Asar coincided with increase of male *Bactrocera dorsalis*, but during Kartik and Magh male *B. dorsalis* population did not show increment. The loss assessment experiment was carried out with thirty heavy bearing trees from the first week of Asoj when premature fruits started dropping. Fruit fly infestation on sweet orange continued up to second week of Mangsir recording more than 97 per cent losses during both years. Maximum fruit loss during 2062 was recorded in first and second week of Kartik with 87.1 and 93.9 fruits per week per tree. During 2063, second and third week of Kartik recorded highest 50.35 and 51.75 fruits loss per week per tree. Another experiment was conducted to assess reduction in losses when orchard was cleaned from all fruit fly infested fruits and sprayed with poison laden protein bait (mixture of 2% hydrolyzed protein, 15% sugar, 0.2% soybean oil, 0.4% tween-20 and 0.4% malathion). The result showed that there was significant reduction in losses recording 88.94 and 83.32 per cent losses during 2062 and 2063, respectively whereas, control recorded 97.03 and 97.10 per cent losses.

INTRODUCTION

Citrus fruit occupies number one position in area and production among fruit crops in Nepal and about 25 percent of total area under the fruit cultivation. The area coverage during 2006/07 was 27979 ha of land production of 171879 t (NCRP 2007). However, farmers have been facing various problems associated with this crop and fruit drop caused by fruit flies (*Bactrocera spp*) is serious one (Shrestha 2000). The true fruit flies (family, Tephritidae) comprising over 4,000 species distributed over most of this planet. Among them oriental fruit fly *Bactrocera dorsalis* (Hendel), is a very destructive pest of fruit in areas where it occurs.

Oriental fruit fly is a highly polyphagous pest whose larvae travel widely in infested fruit. Over 100 host plants for oriental fruit fly have been listed including most types of commercial fruits such as citrus, mango peach plum apple, fig, banana and others. Oriental fruit fly breed continuously in tropical conditions, females are capable of producing 1200-1500 eggs in their lifetime and population growth may be very rapid. Female lays batches of 1-20 eggs in a single fruit. Young males commonly disperse over several miles before they attain sexual maturity. They are very strongly attracted to and actively imbibe methyl eugenol (ME), a sex attractant that occurs naturally in some tropical plants. If ME is laced with an insecticide and widely distributed at bait stations an invading population can be forced to extinction through male annihilation (Anonymous 2006). According to Hawaii Area-Wide Fruit fly Integrated Pest Management program area wide fruit fly control could be achieved through management framework components viz., population monitoring, field sanitation, protein bait, male annihilation and biological control (Anonymous 2007). This study tried to find out seasonal occurrence of fruit flies, losses caused by it and integrated approach to reduce its infestation.

MATERIALS AND METHODS

Different experiments were conducted at Patle of Dhankuata district during 2062/63 and 2063/64 at farmers' field. The detail methodologies of the experiments are given below.

Monitoring and assessment of different lures

Monitoring of fruit flies was accomplished using male sex pheromone (Methyl eugenol) with malathion (5 drops of each/trap) as treatment IV (Standard check). Evaluation of different protein bait traps (Treatment-I: 22.2 g yeast extract + 27.8 g borax + 1000 ml distilled water, treatment II: 33.3 g yeast extract + 27.8 g borax + 0.5 g peptone + 1000 ml distilled water and Treatment III: 44.4 g yeast extract + 27.8 g borax + 1 g peptone + 1000 ml distilled water) was conducted with seven replications at Farmers' fields in Kagate of Dhankuta municipality. Empty mineral water bottles for protein lure and yellow colored plastic bottles for methyl eugenol were used as traps. The baits were changed and observation was recorded fortnightly.

Loss assessment

The loss assessment experiment was carried out at Kagate (farmers' field). Thirty heavy bearing trees were selected. Observation was initiated from the first week of Asoj when premature fruits were seen infested with fruit flies. Branches of sample trees were shaken giving three similar jerks to make the infected fruit dropped. Again, the dropped fruits were dissected across the middle to confirm presence/absence of fruit fly maggots. Number of the infected fruits in sampled trees was recorded in alternate day and final intact healthy fruits were counted at the end of fruiting season. The infested fruits were kept into 300 gauge black polythene bags in order to prevent maggots from entering into the soil for pupation. Per cent loss was calculated using formula: $(\text{infected fruits} / \text{total number of fruits}) \times 100$.

Sanitation and poison laden bait spray

Experiment was conducted to assess reduction in loss when orchard was cleaned from all fallen infested fruits and sprayed with poison laden protein bait. Infested fruits were dropped by shaking trees and packed into 300 gauge black polythene bags. In some places where water tanks were available, infested fruits were drowned into water. Poison laden protein bait (mixture of hydrolyzed protein 2%, sugar 15%, soybean oil 0.2%, tween-20 0.4% and malathion 0.4%) was sprayed to an area about one square meter of northeast quadrant of alternate plant in orchard at 15 days interval during whole fruiting period. Observation was recorded as loss assessment experiment.

RESULTS

The activity of male *Bactrocera dorsalis* started from Chaitra and reached its peak in Asar and continues up to Bhadra during 2062-63 (Fig: 1). Similar trend was shown by female fruit flies during 2063-64 also (Fig: 2).

The female fruit flies showed three times population peak in Kartik, Magh and Jestha/Asar during 2062-63 (Fig: 3). But during 2063-64, female fruit flies showed five times population peak in Bhadra, Kartik, Poush, Chaitra and Jestha/Asar (Fig: 4). The population increase in Jestha/ Asar coincided with increase in male population of *B. dorsalis*, but during Bhadra, Kartik, Poush and Chaitra male population did not show increment as female fruit flies. Female fruit fly population during other periods except Jestha/Asar might be different from *B. dorsalis*.

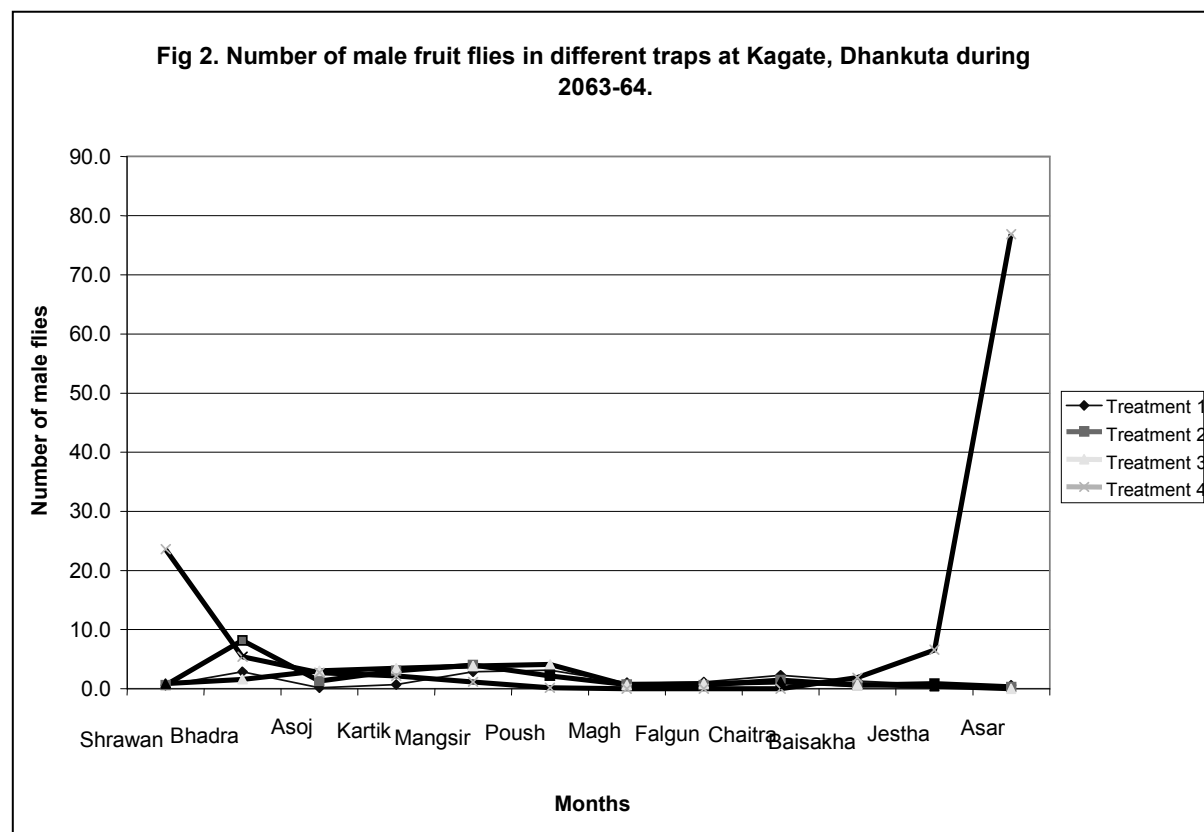


Fig 2. Number of female fruit flies in different traps at Kagate, Dhankuta during 2063-64.

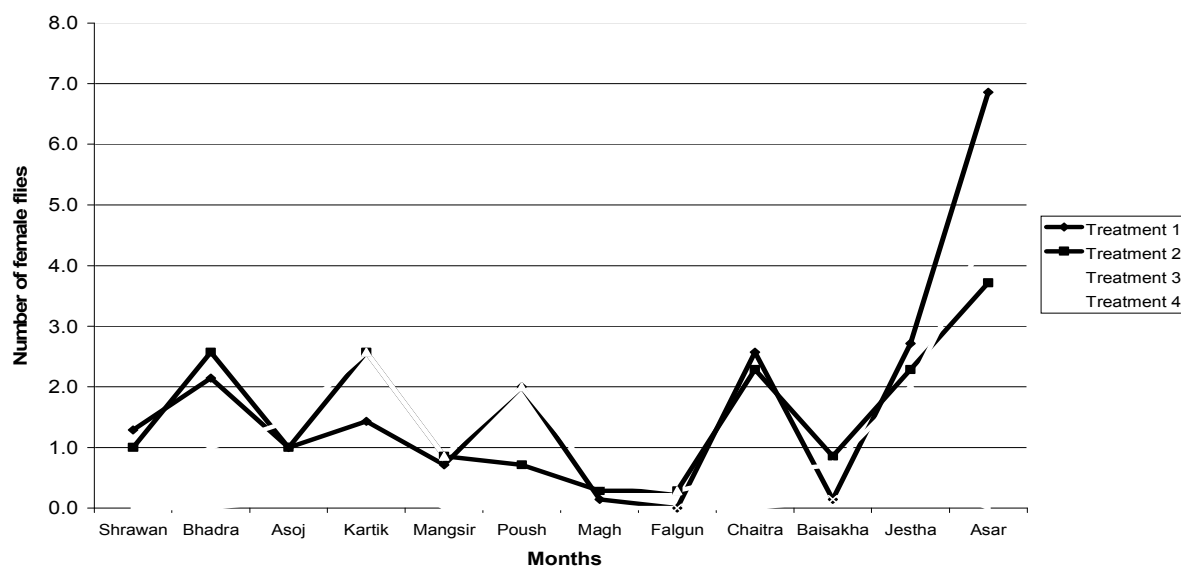
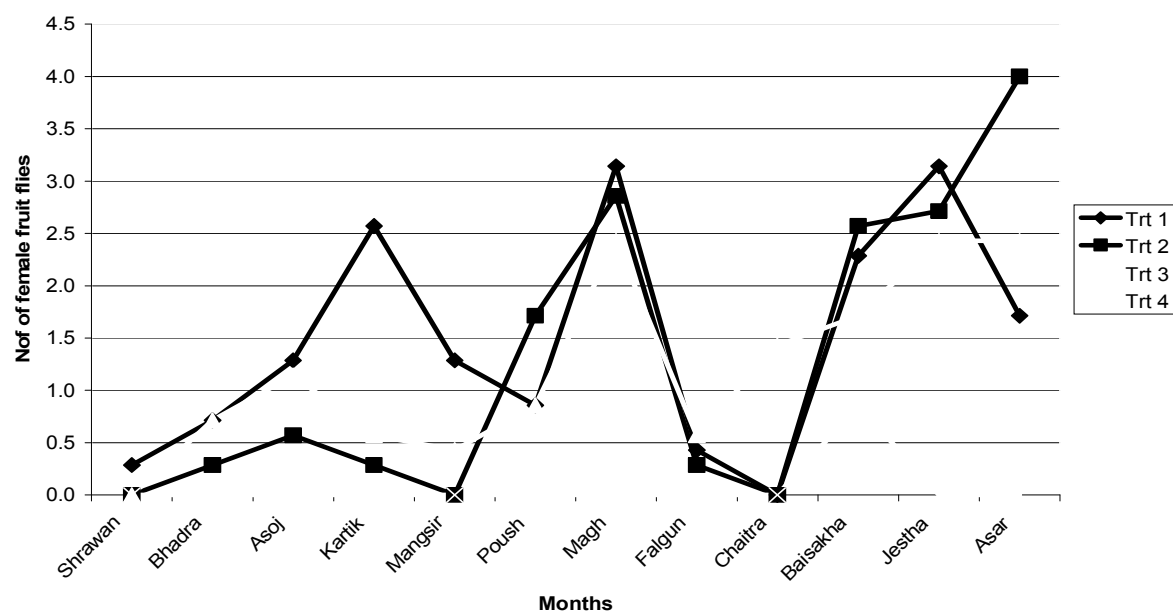


Fig 3. Number of female fruit flies in different traps at Kagate, Dhankuta during 2062-63.



During 2062-63, all the three treatments I, II, III of food lures showed significant number 17.7, 15.3 and 14.7 of female fruit flies trapped as compare to treatment IV (0.9) of methyl eugenol. Methyl eugenol, treatment IV caught significantly highest number (188.3) male flies as compare to treatments I, II, III (8.4, 6.4, 9.3 male flies respectively). Similarly during 2063-64, treatments I, II, III of food lures caught significantly higher 21.0, 18.4 and 16.7 of female fruit flies as compared to treatment IV (1.7) of methyl eugenol. Methyl eugenol caught significantly highest number (120.4) male flies compared to treatments I, II, III (17.3, 23.6, 20.6 male flies, respectively). Among food lures no significant difference were observed in trapping male and female flies during both years (Table 1).

Table 1. Number of female and male flies trapped in different lures at Kagate, Dhankuta during 2062-63 and 2063-64

Treatments	Female flies		Male flies	
	2062-63	2063-64	2062-63	2063-64
Treatment 1	17.7 (4.23)	21.0 (4.57)	8.4 (2.86)	17.3 (4.05)
Treatment 2	15.3 (3.88)	18.4 (4.30)	6.4 (2.56)	23.6 (4.65)
Treatment 3	14.7 (3.69)	16.7 (4.09)	9.3 (2.98)	20.6 (4.56)
Treatment 4	0.9 (0.97)	1.7 (1.41)	188.3 (13.73)	120.4 (10.90)
Treatment	**		**	
Year	ns		Ns	
Treatment * year	ns		Ns	
l. s. d. treatment	0.64		0.79	
cv %	24.8		18.0	

Figure within parentheses are square root transformed values.

Fruit fly infestation on fruits of sweet orange started from first week of Asoj (2.2 fruits/tree) and continued up to second week of Mangsir (9.8 fruits/tree) when fruits were completely harvested during 2063-23 (Fig 5). Maximum damage was recorded during first and second week of Kartik recording damage of 87.1 and 93.9 fruits per tree respectively. The loss showed increasing trend from Asoj second week up to Kartik second week and decreased slowly up to Mangsir second week. The losses in sweet orange orchard recorded 97.10 per cent during this period.

Similar trend was shown during 2063-64 starting from second week of Asoj (5.85 fruits/tree) and continued up to second week of Mangsir (15.75 fruits/tree) when fruits were complete harvested. Maximum damage was recorded during second and third week of Kartik recording damage of 50.35 and 51.75 fruits per tree respectively. The loss showed increasing trend from Asoj second week up to Kartik third week and decreased slowly up to Mangsir second week (Fig. 3). The losses in sweet orange orchard recorded 97.03 per cent.

Losses when orchard was cleaned from all fruit fly infested fruits and sprayed with poison laden protein bait (mixture of 2% hydrolyzed protein, 15% sugar, 0.2% soybean oil, 0.4% tween-20 and 0.4% malathion) showed that there was significant reduction in losses recording 88.94 and 83.32 per cent losses during 2062 and 2063, respectively whereas, control recorded 97.03 and 97.10 per cent losses (Fig 7).

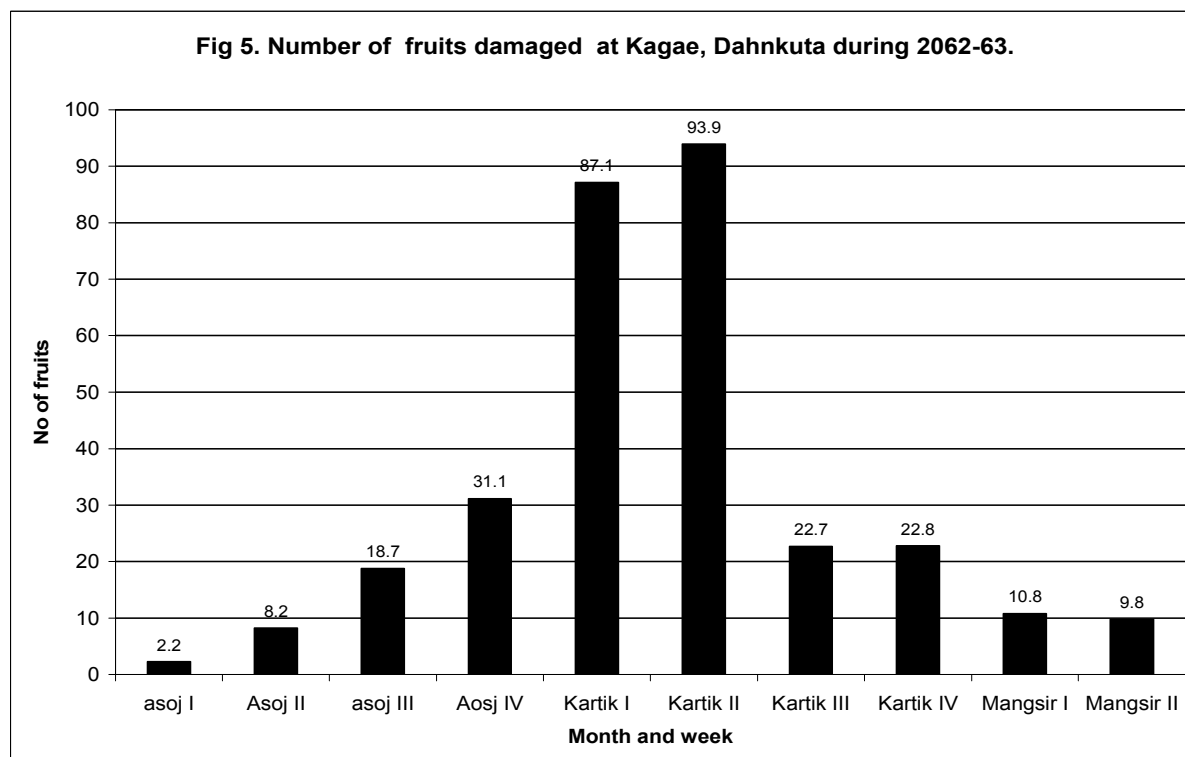


Fig 6. Number of fruits damaged at Kagate, Dhankuta during 2063-64.

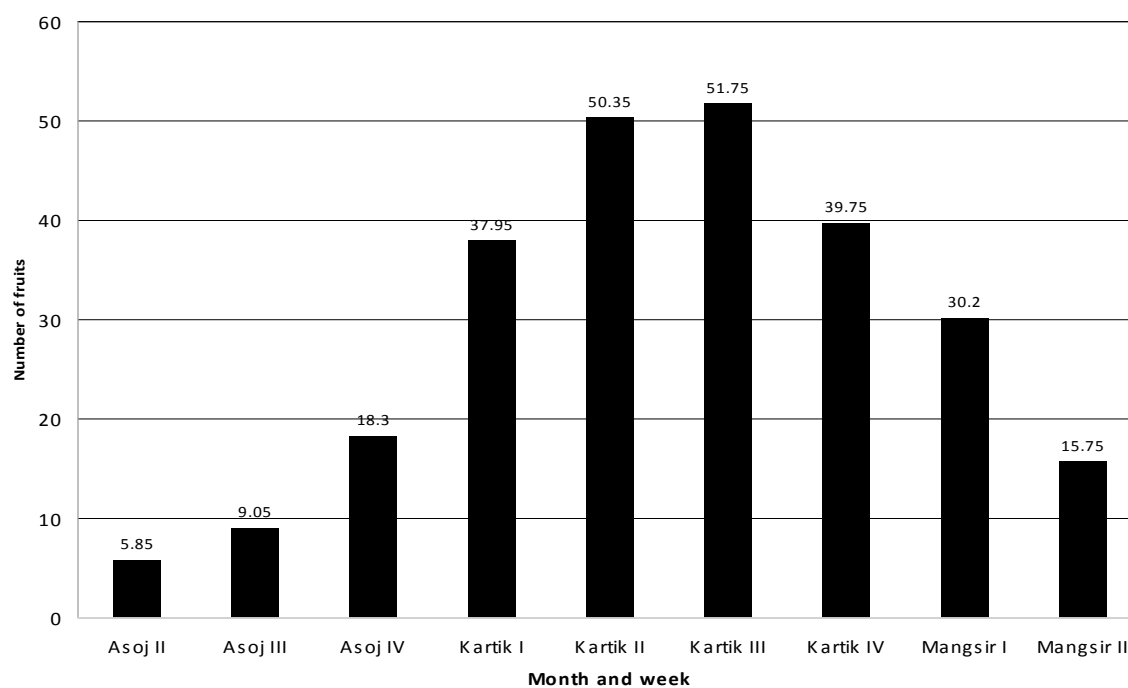
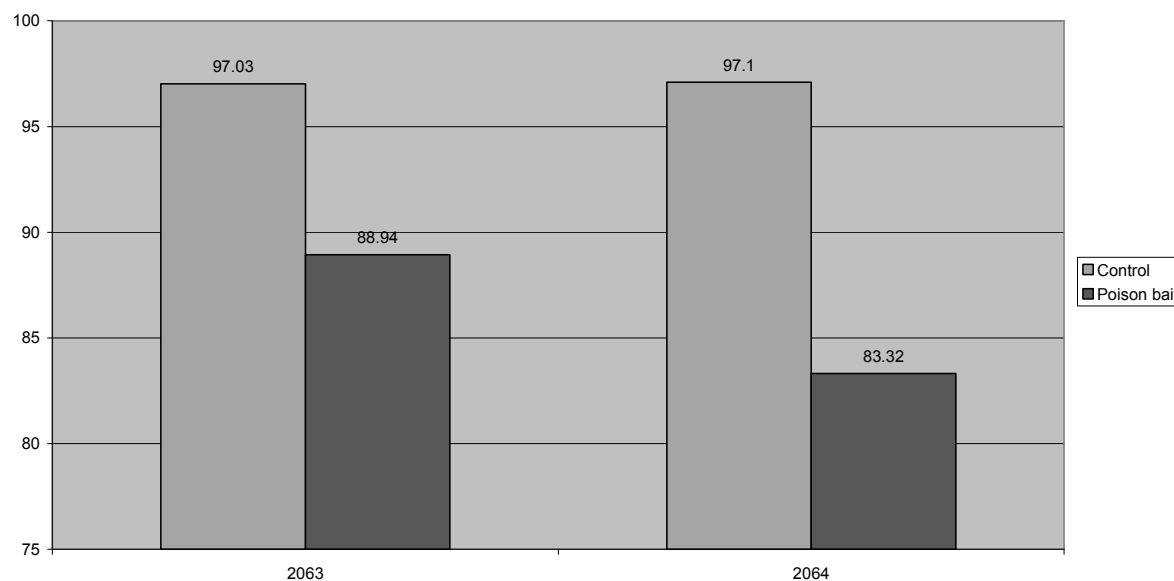


Fig 7. Per cent losses of sweet orange in orchard with poisons laden bait spray and sanitation vs. control orchard.



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Participatory Cabbage Varietal Evaluation for Rainy Season Production in the Western Hills

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ABSTRACT

Participatory varietal evaluation trial on cabbage for rainy season production was conducted at Deurali, Palpa (1130 masl) in two consecutive years 2006 and 2007 to identify cabbage varieties suitable for rainy season production. Six F1 hybrid varieties of cabbage, namely Green Coronet, T-621, Green Stone, Ruby King and Green Crown were evaluated against Copenhagen Market (OP) as the check. These varieties were seeded in the nursery in third week of April and transplanted one month old seedlings in the experimental plots. The results of the experiment showed that Green Stone was the earliest in maturity with an average of 62 days from transplanting and the highest plant survivability was observed in Green Coronet (98.89%). Similarly, more compact heads were produced by Green Coronet (0.816) and the highest marketable fresh head yield was also produced by Green Coronet (37.39 t/ha) followed by T-621 (32.4 t/ha) and the lowest by Copenhagen Market (9.02 t/ha). Farmers preferred Green Coronet variety for its high yield, compactness and green colored heads. The results revealed that Green Coronet was the best variety for its high productivity, yield attributes and farmers' preferences and therefore this variety could be recommended for rainy season production in the western hills of Nepal.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is an important cash generating off-season vegetable crop suitable mainly for hill farmers. In Nepal, cabbage is generally preferred to consume as cooked vegetable but it is also used as salad in urban and peri-urban areas. The production, productivity and cash income of farmers from this commodity particularly from off-season production have been increasing very sharply. During off-season, supply is generally less as compared with the demand. Therefore, farmers generally get higher return during this period. There is always shortage of fresh cabbage during summer and rainy season and the quality and the productivity of available product is very low. Therefore farmers are always eager to get highly productive and good quality cabbage varieties for this season (Pandey and Pokharel 2000).

With the development of heat tolerant hybrid varieties, it can form marketable heads up to the mean temperature of 38°C. Besides appropriate season of production, cabbage production during the hot and wet season is also possible with the introduction of heat tolerant varieties. Many of such hybrids are popular and are widely grown on a wider scale during the off-season as early, late and rainy season production. The main season for cabbage production in the hills is from November to February. Therefore, the time before and after that peak supply period is considered to be the off- season for cabbage in the hills, which has large market in Nepal and India.

There are two main approaches for producing off-season cabbage in the hills. The first option is the utilization of comparative advantage approach in which a particular area is identified for producing the product where during that time climate is favorable for the crop (Pandey and Chaudhary 2004). This approach is favorable and applicable for early season cabbage production where climate plays important role whereas for late season or off-season production irrigation facility, diseases and insect pests control

measures also play important role that are not easily accessible in all potential areas. As the promotion of horticultural crops has been shifted from subsistence level to commercial level, the production and post-harvest problems are also soaring up and it is affecting production, productivity, quality and also discouraging farmers (Pandey and Pun 2004). However the important and easily applicable approach is the exploitation of off-season varieties. These varieties are able to tolerate the stress environment of off-season whereas the normal season variety cannot generally withstand. Cabbage is an important commercial vegetable in Nepal (APP 1995) and it describes that vegetable are an obvious priority because they are much more important than any high value commodity.

Non-heading, loose heading, black rot and soft rot are the major problems of commonly grown present varieties of cabbage during rainy season. Apart from these problems, the cabbage heads are least liked by consumers and marketers of domestic and external markets due to large size, flat shape, light green color of heads and leaves. In view of these problems, this study was designed and carried out to identify the suitable variety for off-season (rainy season) production in the western hills of Nepal. Hybrid varieties have been found suitable for rainy season production as compared to open pollinated varieties. The previously recommended hybrid K.K. Cross is outdated and has been replaced by new hybrids (Green Stone and Green Coronet) due to their small and tight heads which have relatively better storability and are easily marketed (Tiwari et al 1996).

MATERIALS AND METHODS

The experiment was conducted at Deurali, Palpa (1130 masl) during 2006 and 2007 rainy season. The experimental design was randomized complete block (RCBD) with five replications, farmer as replication. Five F1 hybrids namely, Green Coronet, T-621, Green Stone, Ruby King and Green Crown and one open pollinated variety Copenhagen Market as a check were included in the experiment. The individual plot size for the experiment was 7.20 m² (3.0 m X 2.4 m) with one raised bed per plot to drain excess rain water. Spacing was maintained at 50 cm row to row and 40 cm plant to plant maintaining 36 plants per plot. Seeding was done in third week of April and one month old seedlings were transplanted in the experimental plot. The plots were fertilized with FYM 30 t/ha and NPK @ 150:100:100 kg/ha. Whole amount of compost, phosphorus, potash and half amount of nitrogen was applied as basal dose and remaining nitrogen was supplied as top dressing in three equal split doses; at 15, 30 and 45 days after transplanting. Irrigation was given as and when necessary. Head compactness was measured as mean head weight (gm) divided by volume of head. Both qualitative and quantitative characters of varieties were assessed. The major observations on days to first harvest from transplanting, number of harvestings, plant survivability, head compactness, marketable head yield and farmers' preferences were collected and analyzed.

RESULTS AND DISCUSSION

Days to first harvest from transplanting

Days to first harvest from transplanting is an important character for off-season or rainy season cabbage production which determines the earliness of the varieties. Days to first harvest among the varieties ranged from 62.4 to 84.2 days from transplanting (Table 1). The difference among the varieties on days to first harvest was found to be highly significant. Among the evaluated varieties, Green Stone was found to be the earliest in maturity (62.4 days) followed by T-621 (67.6 days). Green Crown was found to be the late variety (84.2 days from transplanting). Pandey and Pokharel (2000) and Budathoki et al (2004) also reported that Green Stone and T-621 are earlier in maturity. Therefore this result coincides with the result presented before.

Number of harvestings

Number of harvestings is an important character for off-season or rainy season cabbage production which determines the quality and market supply of the varieties. Number of harvestings among the varieties ranged from 1.4 to 5.6 times (Table 1). The difference among the varieties on number of harvestings was found to be highly significant. Among the evaluated varieties, Green Coronet was harvested many times (5.6 times) followed by T-621 (5.4 times).

Table 1. Performance of cabbage varieties for rainy season production at Deurali, Palpa (2006 to 2007)

Variety	Days to first harvest	No. of harvestings	Plant stand (%)	Head compactness	Yield (t/ha)	Farmers' preference ranking
Green Coronet	76.4	5.6	98.89	0.816	37.39	1
T-621	67.6	5.4	97.22	0.806	32.40	3
Green Stone	62.4	5.0	96.66	0.750	31.08	2
Ruby King	75.6	4.2	93.97	0.628	22.94	5
Green Crown	84.2	4.8	93.33	0.680	32.10	4
Copenhagen Market (ch)	73.4	1.4	30.55	0.316	9.02	6
Mean	73.27	4.4	85.10	0.666	27.49	
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
LSD %	1.019	0.6813	5.447	0.03106	1.876	
CV %	1.1	11.7	4.9	3.5	5.2	

Plant stand (Survivability %)

Plant stand at harvest of the crop varieties is one of the major characters for off-season or rainy season cabbage production which determines the resistance or tolerance and susceptible of a variety to particular environment. This character is directly correlated with the yield. The survivability of the varieties ranged from 30.55 to 98.89 percent (Table 1). The difference among the varieties plant stand at harvest was found to be highly significant. Among the evaluated varieties, highest plant survivability was observed in Green Coronet (98.89%) followed by T-621 (97.22%). The lowest plant survivability was observed in open pollinated variety Copenhagen Market which is a check (30.55%). In general, the survivability is directly affected by the climatic condition and it is obvious that the genetic characters of a variety shows persistency or survivability.

Head compactness

Head compactness is the character that determines the post-harvest shelf life and marketability of cabbage. More compact the head, longer will be the post-harvest shelf life and marketability. Consumers' and traders' preference also depends on head compactness. The difference among the evaluated varieties on compactness was found to be highly significant (Table 1). Green Coronet produced more compact heads (0.816) followed by T-621 (0.806) and the loose heads were produced by Copenhagen Market (0.316). Pandey and Pokharel (2000) also reported that Green Coronet and T-621 produced more compact heads. Therefore this result coincides with the result presented before.

Marketable head yield

Marketable head yield is the determining character for selecting a variety for off-season or rainy season production. Fresh marketable head among the varieties ranged from 9.02 to 37.39 t/ha (Table 1). The difference among the varieties on marketable head yield was found to be highly significant. Among the evaluated varieties, Green Coronet produced the highest marketable head yield (37.39 t/ha) followed by T-621 (32.40 t/ha). Copenhagen Market produced the lowest marketable head yield (9.02 t/ha). This result coincides with the result presented by Pandey and Pokharel (2000) and Budathoki *et al* (2004). They also reported that Green Coronet, T-621, and Green Stone produced more yield i.e., similar to this report.

Farmers preferred green Coronet for its high productivity, compact heads, high survivability, marketability and green color heads. Farmers ranked first to Green Coronet, second to Green stone, third to T-621, fourth to Green Crown, fifth to Ruby King and the least to Copenhagen Market.

CONCLUSION

- Green Stone was the earliest variety. It matures 62 days after transplanting and Green Crown was late which matured 84 days after transplanting.
- Green Coronet could be harvested many times (6 times) and Copenhagen Market at a time only.
- Plant survivability was highest in Green Coronet (98.89%) and lowest was observed in Copenhagen Market (30.55%).
- More compact heads were produced by Green Coronet and therefore the shelf life, storability and marketability was more in the variety.
- The highest marketable head yield was produced by Green Coronet (37.39 t/ha) and the lowest by Copenhagen Market (9.02 t/ha).
- Farmers preferred Green Coronet variety for its high productivity, compact heads, high survivability, storability and marketability and green color heads. This variety could be recommended for rainy season production in the western hills of Nepal.

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Effect of Organic Nutrients on Cauliflower Production in Dailekh

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ABSTRACT

The experiment was conducted at Agriculture Research Station, Dailekh during 2002 to 2004. The objective of the study was to find out the most effective organic source as an alternative source of nutrient supply to cauliflower. Two levels of organic sources: Asuro (*Justicia adhakota* L.), Titepati (*Artemisia indica*) and Baanmara (*Eupatoriumadenophorum*) and recommended dose of chemical fertilizer and FYM were evaluated. The effect of following sources of nutrients on curd diameter, curd weight and curd yield, number of leaves per plant, leaf area, and total biomass yield of cauliflower var. Kathmandu Local were studied. The highest curd diameter (12.9 cm), curd weight (0.46 kg) and curd yield 25.55 t/ha were recorded in Asuro chops @90 tons/ha followed by Asuro chops @45 tons/ha. The poor performance was given by Baanmara chops @ 45 tons/ha in terms of curd yield (10.13 t/ha) followed by Titepati chops @ 90 tons/ha (14.52 t/ha). The performance of chemical fertilizer and FYM were found intermediate in terms of curd yield and physical characteristics. The overall results revealed that the nutrient supply through Asuro @ 90 tons/ha and 45 tons/ha were found promising in terms of curd yield.

Key words: *Justicia adhakota*, *Artemisia indica*, *Eupatoriumadenophorum*, organic nutrient

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most important crops in terms of income generation of the farmers in Nepal. Further, this crop is cultivated in a larger area compared to other vegetable crops (19,267 ha) in Nepal (Shrestha and Ghimire 1996). A mid-season popular variety, Kathmandu Local, is mostly cultivated during winter. Cauliflower is a heavy feeder crop as it requires large amount of nutrients. In consequence fertility status is declining especially in cauliflower growing areas over time. In addition, Nepal has to spend billions of dollars for import of chemical fertilizer (Joshi and Singh 2004).

Generally farmers apply heavy dose of chemical fertilizer to this crop without the inclusion of organic manure. It shows to emphasize research on fertilizer management in the hills of Nepal. There is growing concern on the adverse affects of chemical fertilizer on soil productivity and environmental pollution (Sharma 2002). An apart, excess use of inorganic fertilizers leads to soil nutrient imbalance causing ill effects on soil health and microflora. Hence, there is need to explore alternative nutrient source of chemical fertilizers (Joshi and Singh 2004). Organic nutrient sources such as Asuro/Melabur nut (*Justicia adhakota* L.), Titepati/ Mug wort (*Artemisia indica*), Baanmara/Corften weed (*Eupatorium adenophorum*), which are locally available, have good potential to be exploited for the improvement of soil fertility as well as soil physical properties. Considering these facts, this study was conducted to find out the response of organic nutrients on the cauliflower production in Dailekh conditions.

MATERIALS AND METHODS

Experiment was conducted in Agriculture Research Station (ARS), Dailekh (altitude 1350 masl) for three consecutive years of 2002 to 2004 during early winter season. The soil in the experimental plot was sandy loam with pH 6.20, having 1.74 percent organic matter, 0.102 percent total N, 72 and 160 kg/ha available P and K respectively. The experiment was designed in randomized complete block design with eight treatments and replicated thrice. The experimental plot size was 3.6 m² accommodating 20 plants.

The eight treatments were: (1) Green chops of Asuro /Melabur nut (*Justicia adhakota* L.) @ 45 tons/ha, (2) Green chops of Asuro /Melabur nut (*Justicia adhakota* L.) @ 90 tons/ha (3) Green chops of Titepati/ Mug wort (*Artemisia indica*) @ 45 tons/ha, (4) Green chops of Titepati/ Mug wort (*Artemisia indica*) @ 90 tons/ha (5) Green chops of Banmara /Croften weed (*Eupatorium adenosporum*) @ 45 tons/ha, (6) Green chops of Banmara /Croften weed (*Eupatorium adenosporum*) @ 90 tons/ha (7) Farm yard manure @ 60 tons/ha (8) fertilizer @ 120 kg N:60 kg P₂O₅: 60 kg K₂O/ha). Half dose of the green chops of Asuro, Titepati, Banmara, Farm yard manure and Nitrogen fertilizer plus full dose of Phosphorus and Potassium were incorporated into soil in 5 days prior to transplanting. Remaining half of the Asuro, Titepati, Asuro, FYM and Nitrogen fertilizer were side-dressed one month after transplanting.

RESULTS AND DISCUSSION

The effect of organic nutrients on curd diameter (cm), curd weight (kg) and curd yield (t/ha) of cauliflower var. Kathmandu Local is presented in Table 1. The curd diameter ($P<0.01$), curd weight ($P<0.01$) and total curd yield ($P<0.01$) were statistically significant in response to different organic nutrients sources and fertilizer. However physical traits namely number of leaves per plant, leaf area, and total biomass yield were noted to be non-significant (Table 2).

Curd diameter, curd weight and curd yield

The results revealed that Asuro chops @ 90 tons/ha was resulted the highest curd diameter (12.90 cm) pursued by Fertilizer @ 120:60:60 NPK Kg/ha (12.16 cm) and Asuro @ 45 tons (11.94 cm). However, the curd diameters obtained in these treatments were statistically at par. On the contrary, FYM @ 60 tons was resulted the smallest curd diameter (8.25 cm), whereas the curd diameters of Titepati chops @ 45 tons/ha, Titepati chops @ 90 tons/ha, Banmara chops @ 45 tons/ha and Banmara chops @ 90 tons/ha were statistically at par (Table 1).

Similarly, Asuro chops @ 90 tons/ha gave the highest average curd weight (0.46 kg) followed by Asuro chops @ 45 tons/ha (0.37 kg) and Fertilizer @ 120:60:60 NPK kg/ha (0.32 kg). Nevertheless, average curd weights of these treatments were statistically at par. The average curd weights of Titepati @ 45 tons/ha, Titepati @ 90 tons/ha, Banmara @ 90 tons/ha and FYM were found intermediate and statistically at par. The lowest curd weight was recorded at Banmara @ 45 tons/ha (0.12 Kg) (Table 1).

Asuro @ 90 tons/ha significantly imparted the highest curd yield (25.55 t/ha) followed by Asuro @ 45 tons/ha (19.20 t/ha) and fertilizer @ 120:60:60 NPK kg/ha (17.64 t/ha). Even so, curd yield of Asuro @ 45 tons/ha was statistically different among the tested treatments. The lowest curd yield was recorded at the Banmara chops @ 45 tons/ha (10.13 t/ha).

On the contrary, Adhikari et al (1998) reported the curd yield of 50.54 t/ha and 80.45 t/ha from FYM and nitrogen @ 120 kg/ha, respectively at Pokhara. Similarly, curd yield of the same variety was recorded much higher in the vicinity areas. However, the curd yields (16.93 t/ha) of same cultivar at Dailekh condition is lower than that of Snowball K-1 (27.43 t/ha) in control treatment (120:60:60 NPK kg/ha) at Pantanagar (Joshi and Singh 2004).

Number of leaves per plant, Leaf area, and Biomass yield

Number of leaves per plant were recorded in the range of 14.8 to 17.1, where the highest leaf number was found at Asuro chops @ 45 tons/ha (17.1/plant) and the lowest at FYM @ 60 tons/ha (14.8/plant). However, effect of the organic nutrients on the number of leaves per plant was not significantly different. Similarly, average leaf area ranged from the min. leaf area of 453.95 cm² at Banmara @ 90 tons/ha to max. leaf area 692 cm² at Asuro chops @ 90tons/ha. The biomass yield varied from 43.9 t/ha at Banmara @ 45 tons/ha to the highest 77.7 t/ha at Asuro chops @ 90 tons/ha (Table 2). The results showed that the following physical characteristics had positively correlated with the curd yield that Asuro chops @ 90 tons/ha had the highest curd yield since it had the higher leaf number and leaf area compared to other treatments.

Table 1. Effect of various source nutrients on diameter, weight and yield of cauliflower curd var. Kathmandu Local

Treatment	Curd Diameter (cm)	Curd Weight (kg)	Curd Yield (t/ha)
Asuro chops @ 45 tons/ha	11.94 a	0.37 a	19.20 b
Asuro chops @ 90 tons/ha	12.90 a	0.46 a	25.55 a
Titepati chops @ 45 tons/ha	9.77 b	0.25 b	14.75 b
Titepati chops @ 90 tons/ha	10.32 b	0.27 b	14.52 b
Banmara chops @ 45 tons/ha	9.48 b	0.12 c	10.13 c
Banmara chops @ 90 tons/ha	9.10 b	0.23 b	17.27 b
Farm yard Manure @ 60 tons/ha	8.25 b	0.29 b	16.34 b
Fertilizer @120:60:60 NPK kg/ha	12.20 a	0.32 a	17.64 b
Mean	10.48	0.30	16.93
P-value	**	**	*
LSD	2.236	0.150	6.02
CV%	17.535	33.53	31.54

** and * significant at P <.01 and <0.05 respectively. Means within column followed by the same letter are not significantly different at 5 % level by DMRT.

Table 2. Effect of different sources nutrients on physical characteristics of cauliflower var. Kathmandu Local

Treatment	No. of leaves	Leaf area (cm ²)	Biomass yield(kg/ha)
Asuro chops @ 45tons/ha	17.1	608.44	68.63
Asuro chops @ 90tons/ha	16.2	692.0	77.7
Titepati @ 45 tons/ha	16.4	581.0	62.2
Titepati @ 90tons/ha	16.6	605.8	59.7
Banmara @ 45tons/ha	16.6	489.1	43.9
Banmara @ 90tons/ha	16.6	454.0	53.2
FYM @ 60 tons/ha	14.8	514.7	48.0
Fertilizer @ 120:60:60 kg/ha	16.4	571.8	48.0
Mean	16.6	564.6	58.6
P-Value	NS	NS	NS
CV%	15.08	19.98	25.20

CONCLUSION

The highest curd yield obtained from Asuro/Melabur nut (*Justicia adhakata* L.) as the organic source of nutrient could definitely be suggested that it is better and safer than fertilizer use for the cauliflower production. Besides, Asuro plus nutrient supplied from other organic sources was not in position to impart superior results as compared to Asuro alone. Furthermore, economic study needs to be investigated in future.

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Response of Okra (var. Parbani Kranti) to Sulphur and Boron for Yield and Quality of Seed in Farm Conditions of ARS Malepatan, Pokhara

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ABSTRACT

Seed yield and quality of crop varieties depends on various soil factors including available nutrients. Limited research works have been accomplished in Nepal on response of okra variety to specific nutrients. A field experiment was carried out at Agricultural Research Station (Horticulture) Malepatan Pokhara during spring summer seasons of 2004 and 2005 to determine the response of okra variety Parbhani Kranti to sulphur and boron for better yield and quality seed production. The experiment was conducted in a randomized complete block design with 16 treatment combinations replicated thrice. Treatments were composed of four levels of borax (8, 16, 24 kg/ha, as soil application and 3 g borax per liter of water as foliar spray before flowering) and four levels of sulphur (6, 12, 18 kg sulphur dust/ha as soil application and 1 g sulphur as foliar spray before flowering). The results indicated that most of the parameters were significantly different in soil application of sulphur and boron spray treatments. The tallest plants (77.6 cm), the highest number of pods per plant (7.3), the longest pods (17.3 cm), the highest number of seeds per pods (54.8) and the heaviest test weight (70.3 g) were observed when the crop was supplied with 12 kg sulphur dust as soil application and 3 g of borax/liter as foliar spray before flowering. Pod diameter (6.2 cm), seed yield (1526.48 kg/ha) were the highest in the crop supplied with 18 kg sulphur dust as soil application and 3 g of borax/liter as foliar spray. From over all results, 12 kg sulphur dust as soil application and 3 g of borax/liter as foliar spray before flowering could be recommended for optimum yield and quality of okra seed production.

Key words: Boron, okra, seed production, sulphur

INTRODUCTION

Okra (*Abelmoschus esculentus*) is one of the most important and popular vegetables by virtue of its high nutritive and culinary values. Okra is best known as a fruit vegetable crop of the tropical and subtropical regions of the world. In Nepal, okra can be cultivated successfully from terai to mid hills. It prefers hot and humid climate for proper growth and development. The seeds do not germinate below 17°C and optimum temperature for seed germination is 29°C (Bose et al 1993). This crop is suitable for cultivation as a kitchen garden crop as well as on large commercial farms.

Quality seed is a primary input without which nobody can expect an increase in the better production of crop. A quality seed plays a major role for successful production of high yield of any crop. Raising the present level of production and supply of quality seeds through appropriate improved technologies is one of the major challenges at present. The research activities on these aspects are meager (Shrestha and Shakya 2004). These days, the demand of quality seed from commercial farmers is everywhere for quality production of fresh vegetable.

Balance and judicious application of nutrients (major and minor) play a vital role in quality production of fresh vegetables as well as vegetable seed. Seeds, which are available in the market, are inferior due to imbalance and improper use of fertilizers. In order to increase crop productively nutrient management may be achieved by the involvement of organic sources, biofertilizers and micronutrients (Singh and

Kaloo 2000). Soils lacking in nutrients produce inferior quality of fresh vegetable as well as vegetable seeds. The balanced nutrients have been paid little attention in agriculture areas of developing world. The deficiencies of micronutrients have emerged in the farmer's field and are recognized as symptoms on foliage and reduction in the quality and yield of the crop. The benefit of micronutrients is not limited solely to the replenishment of the micronutrient itself but in addition micronutrient acts as catalyst in the uptake and use of certain macronutrients (Phillips 2004).

Boron (Bo) has a vital role in both the flower and seed formation and pollen viability. A foliar boron spray can get significant increases in crop yield. Foliar boron should be applied as soon as a flower bud is visible. Sulphur is another essential plant food for production of protein, promotes activity and development of enzymes and vitamins, helps in chlorophyll formation and improves root growth, seed production and helps with vigorous plant growth and resistance to cold. Bajapai and Chauhan (2001) reported that zinc, boron and manganese significantly improved the performance of okra in terms of number of fruits per plant, fresh and dry fruit weight, seed per fruit and seed weight. In the nutrition of seed crops, nitrogen, phosphorus, potassium and several other elements, e.g. boron, molybdenum, zinc, sulphur etc. play an important role for the proper development of plant and seed. It is therefore, advisable to know and identify the nutritional requirements of seed crops and apply adequate fertilizers. Optimum fertilization results in maximum yields, seed quality and better expression of plant type. With this point of view, the project was formulated and conducted in Agriculture Research Station (Horticulture), Malepatan, Pokhara.

MATERIALS AND METHODS

This study was conducted for two consecutive years (2004 to 2005) at Agriculture Research Station (Horticulture), Malepatan, Pokhara. The experiment was laid out in RCBD with three replications of sixteen-treatment combinations. Four levels of sulfur (6, 12, 18 kg/ha) as soil application and 1g/litre of water as foliar spray before flowering and four levels of boron (8, 16, 24 kg borax/ha) as soil application and 3 g/litre of water as foliar spray before flowering. The plot size provided for each treatment was 9 m² (3 m x 3 m) and the spacing was provided as 60 cm row to row and 25 cm plant to plant. Seeding was done at April 18, 2004 in first year and May 4, 2005 in second year. Fertilizers were applied @ 80:60:60 kg NPK in the form of Urea, DAP, MOP and 20 tons of compost per hectare. Half dose of nitrogen, full dose of phosphorus, potash and full dose of compost were applied at land preparation. Remaining half dose of nitrogen was further spited in two parts and top dressed at 30 and 60 days of seeding. Borax and Sulphur dust were applied as basal application in the soil. One gram of sulphur dust and 3 grams of borax/ liter of water was sprayed before flowering.

Data were recorded on days to 1st flowering, plant height, pods/plant, length, pod diameter, seeds/pod, seed yield/plot and converted to per hectare, seed germination percentage and seed test weight (1000 seed weight). Plant protection measures, intercultural operations and irrigations were done as needed. Statistical analysis was carried out applying MSTATC tool.

RESULTS AND DISCUSSION

Days to first flowering

The response of boron and sulphur was not found significant for days to first flowering in both the years. Earliest flowering was recorded 47.3 days after seeding in 6 kg sulphur dust plus 3 g borax/lit and 12 kg sulphur dust plus 3 g borax/lit.. Foliar spray of borax recorded the earlier flowering than soil application. It might be due to quick adsorption of boron by the plant to promote early flowering. This result is in the agreement with the previous report (Anonymous 2001), that the application of foliar fertilizers is the quickest way to deliver nutrients to the tissues and organs of the crop to correct certain nutrient deficiencies. Boron is integral part to a plant's reproductive cycle; controlling flowering, pollen production, germination, seed and fruit development (Anonymous 1998).

Plant height

The maximum plant height (77.6 cm) was recorded in 12 kg sulphur dust applied in soil plus 3 g borax/lit of water as foliar spray followed by (48.7 cm) in the treatment 1 g sulphur dust as foliar spray 8 kg of borax as soil application. The minimum plant height (66.2 cm) was observed in 12 kg sulphur dust plus 8 kg borax /ha as soil application (Table 1).

Pods per plant

The highest numbers of pods per plant (7.3) was recorded in 12 kg sulphur dust/ha as soil application plus 3 g borax per liter as foliar spray followed by 7.1 when the crop was supplied with 18 kg sulphur dust as soil application plus 3 g of borax/lit as foliar spray (Table 1). The minimum pod per plant (5.9) was in 1 g sulphur /lit of water as foliar spray plus 24 kg borax/ha as soil application. The result was not significant. It showed that 12 kg sulphur dust and 8 kg borax as soil application or 3 g borax as foliar spray is sufficient for pods per plant. It indicates that okra is less requiring crop to boron.

Pod length

The maximum pod length (17.3 cm) was recorded in 12 kg sulphur dust as soil application plus 3 g borax per liter as foliar spray followed by 17 cm when the crop was provided by 18 kg sulphur dust as soil application and 3 g borax/lit as foliar spray. The lowest pod length (16.0 cm) was in 6 kg sulphur dust plus 16 kg borax/ha as soil application. The result was significantly difference between treatments.

Seeds per pod

The number of seeds per pod (54.8) was significantly highest when the crop was supplied with 12 kg sulphur dust as soil application plus 3 g of borax as foliar application followed by 54.3 in 6 kg sulphur dust as soil application plus 3 g borax/lit. The minimum numbers of seeds per pod (51.4) were recorded in the treatment 6 kg sulphur dust plus 16 kg borax as soil application.

Seed yield

Significantly highest seed yield (1526.48 kg/ha) was recorded in the treatment 18 kg sulphur dust/ha as soil application and 3 g borax/lit of water as foliar spray before flowering which was at par with the seed yield of 1510.45 kg/ha in the treatment 12 kg sulphur dust as soil application plus 3 g borax/lit of water as foliar spray. The lowest seed yield (1073.29 kg/ha) was recorded in the treatment 6 kg sulphur plus 24 kg borax/ha as basal dose. From the above results, sulphur, as soil application, and boron, as foliar application, were sufficient for okra seed production. It indicated that boron is needed in little amount to the okra crop. This result is similar to the findings of Chattopadhyay et al (2003). According to them, boron at 0.56 kg/ha produced the highest yield (222.71 q/ha) in Pusa Sawani in field experiment.

Seed germination percentage

The germination percentage (98.4) was significantly highest in the treatment of 6 kg sulphur/ha as soil application plus 3 g borax/lit of water as foliar spray followed by 97.7 when the crop was supplied with 12 kg sulphur dust as basal application plus 3 g borax/lit and the lowest germination percentage (92.0) was found in 18 kg sulphur dust plus 8 kg borax as soil application.

Test weight

The highest test weight (70.7 g) was found when the crop was supplied with 12 kg sulphur as basal application and 3 g borax as foliar spray before flowering followed by 70.5 g in the treatment 6 kg sulphur dust as basal application plus 3 g borax /lit where as the lowest test weight (65.5 g) was recorded in 6 kg sulphur dust and 8 kg borax/ha as basal application in the soil.

The above results indicated that there is a little need of borax for okra crop. Less effect of borax application in the soil might be due to low requirement of boron for this crop or there could be reaction between sulphur and boron in the soil and okra could not absorbed boron from the soil so that borax spray was effective.

Table 1. Response of Okra (var. Parbhani Kranti) to Sulphur and Boron on yield attributing parameters (2004 and 2005)

Treatment	Days to 1 st flowering	Plant height (cm)	Pods /plant	Pod diam. (cm)	Pod length (cm)
6 kg sulphur + 8 kg borax	48.5	68.2	6.5	6.1	16.4
6 kg sulphur + 16 kg borax	47.5	66.7	6.0	5.9	16.0
6 kg sulphur + 24 kg borax	48.3	68.2	6.6	5.9	16.5
6 kg sulphur + 3 g borax	47.3	73.2	6.6	5.9	16.6
12 kg sulphur + 8 kg borax	48.8	66.2	7.0	5.9	16.7
12 kg sulphur + 16 kg borax	48.0	68.2	6.5	5.9	16.5
12 kg sulphur + 24 kg borax	48.0	69.0	6.5	6.1	16.5
12 kg sulphur + 3g borax	47.5	77.6	7.3	6.1	17.3
18 kg sulphur + 8 kg borax	47.9	70.2	6.2	6.0	16.2
18 kg sulphur + 16 kg borax	47.9	71.6	7.0	6.1	16.2
18 kg sulphur + 24 kg borax	48.5	69.5	6.9	5.4	16.3
18 kg sulphur + 3g borax	48.3	74.6	7.1	6.2	17.0
1 g sulphur + 8 kg borax	48.7	69.0	6.3	5.8	16.5
1 g sulphur + 16 kg borax	47.7	68.7	6.8	6.1	16.4
1 g sulphur + 24 kg borax	47.7	68.8	5.9	6.1	16.4
1 g sulphur + 3 g borax	48.5	74.3	6.8	6.1	16.5
CV%	4.7	9.05	11.5	3.0	3.5
F test	NS	*	NS	NS	*
LSD (0.050)		7.41			0.68

Table 2. Response of Okra (Var. Parbhani Kranti) to Sulphur and Boron on seeds per pod, yield and quality of seed (2004 and 2005)

Treatment	Seeds/ Pod	Seed yield kg/ha	Germ. %	1000 grain weight (g)
6 kg sulphur + 8 kg borax	52.1	1086.1	96.0	65.5
6 kg sulphur + 16 kg borax	51.4	1235.8	96.0	67.5
6 kg sulphur + 24 kg borax	52.8	1073.3	91.4	66.9
6 kg sulphur + 3 g borax	54.3	1371.1	98.4	70.5
12 kg sulphur + 8 kg borax	52.0	1081.6	94.0	68.7
12 kg sulphur + 16 kg borax	52.4	1156.7	96.7	69.2
12 kg sulphur + 24 kg borax	53.7	1124.6	92.3	67.0
12 kg sulphur + 3g borax	54.8	1510.4	97.7	70.7
18 kg sulphur + 8 kg borax	52.6	1087.9	92.0	69.2
18 kg sulphur + 16 kg borax	52.4	1185.7	94.3	70.1
18 kg sulphur + 24 kg borax	52.8	1181.5	94.0	69.3
18 kg sulphur + 3 g borax	52.3	1526.5	94.3	69.0
1 g sulphur + 8 kg borax	53.3	1190.9	95.7	69.0
1 g sulphur + 16 kg borax	52.5	1275.3	97.3	69.0
1 g sulphur + 24 kg borax	53.7	1098.1	95.3	68.3
1 g sulphur + 3 g borax	52.3	1310.3	95.7	69.5
CV%	7.52	14.8	2.9	2.9
F test	**	**	**	**
LSD (0.050)	2.403	207.7	4.5	3.2

CONCLUSION

The results showed that 12 kg/ha of sulphur dust as soil application and borax spray @ 3 g /lit of water before flowering was needed for seed production of okra in Pokhara valley. From the three year's observation it is noticed that seeding of okra crop before Jestha was seriously attacked by jassid. It might be due to drought condition. Therefore it is advisable for sowing of okra seeds for seed crop in the month of Jestha in Pokhara valley so that Jassid attack would be less and yield loss would be minimum.

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Response of Bottle Gourd and Lady's Finger Vegetables to Irrigation and Fertilizer Applications for Yield Improvement and Crop Diversification

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ABSTRACT

An on-farm trial at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal was conducted to evaluate the effects of irrigation and fertilizers on bottle gourd and lady's finger vegetable crops. The experiment was laid out on split-split-plot design with fertilizer as main-plot factor, frequencies of irrigation as sub-plot factor, and amount of irrigation as sub-sub-plot factor. Data analysis revealed that frequency and amount of irrigation had a significant interaction effect on the number of nodes of bottle gourd and a significant effect of mulch on the number of primary branches ($p=0.05$). None of the other treatments had statistically significant differences in yield and yield-attributing characteristics of this crop. Although non-significant, the results also indicated that frequent application of a greater amount of water could result in reduced water productivity and yield loss in this crop. On the contrary, the yield response of lady's finger to nitrogen application was significant ($p=0.01$). Interaction effect of all factors was also significant ($p=0.05$) on fruit yield of lady's finger. It appears that farm income from the lady's finger vegetable crop could be improved significantly from a judicious combination of low levels of nitrogen and irrigation compared with that of bottle gourd.

INTRODUCTION

Dry season vegetables such as bottle gourd and lady's finger are valued as cash crops in Nepal, but decreased water availability during this season has also been considered identified as a constraint on vegetable production. Therefore, water should be used in an efficient and rationalized manner. Two issues that need to pay attention are 1) finding a means of lowering the current level of water demand by some efficient water use techniques, and 2) promoting economic return to the farmers in an effort to enhance economic incentives. These can be achieved through increased water productivity and crop diversification with high value crops in the area of rice dominated cropping systems of Nepal. It is thus important to maximize water productivity by evaluating the functional relationship between crop yields, water use, and timed input of irrigation water for broader soil and climatic conditions. This would help in developing more practical irrigation schedules in response to available water supply. Higher water productivity is secured when applied to vegetables than to cereal crops because of the market value and increased probability of crop diversity. This is particularly important in a Nepalese context where most of the farmers are small holders and are faced with the situations of vulnerable food insecurity.

Vegetables including bottle gourd and lady's finger are very costly in Nepalese local market during dry and off-season. If grown without reliable irrigation supply during dry season they usually succumb to great yield losses. However, water demand of the crops may be greatly lowered by mulching to conserve soil moisture. This can be an important practical aid in water saving and would minimize the cost of water fees. Increased soil-water storage due to mulching could also help in the uptake of nutrients by plant roots.

The growing vegetable market during the dry season and the improved nutritional awareness of the people have attracted farmers to bring greater areas under vegetable farming in summer and spring seasons in foot-hill and plain areas of Nepal. Dry weather in this season creates a condition of water scarcity for many crops requiring frequent irrigation. Several studies reported mulch to conserve soil moisture and improve crop yield (Singh and Gangwar 1972, Singh et al 1976). Likewise the role of irrigation at proper level and stages of plant growth has great significance in improving the yield (Singh et al 1990). Padem and Alan (1992), Gupta (1990), Bandel et al (1980), and Thomas et al (1970) reported that judicious application of fertilizers in conjunction with proper irrigation is the principal factor affecting the crop yield.

Objectives of this study were to evaluate the effect of frequency and amount of irrigation, as well as to assess the crop response to mulch and fertilizer applications for yield improvement and crop diversification, applicable to hot and humid agro-ecological conditions under coarse acid soils of Chitwan valley, Nepal.

MATERIALS AND METHODS

Nursery preparation

A nursery of bottle gourd was raised during March, using 2-3 seeds/polythene pot 15x12cm in size, and well-decomposed and pulverized manure was applied. Seeds were placed at 2 to 5 cm depth in the pots. Regular care and watering was carried out until the seedlings were ready for transplanting but as the lady's finger does not require a nursery, overnight soaked seeds were sown directly to the experimental plots on March 28-29. Compost was applied @ 20t/ha before sowing. Regular watering, gap filling and plant protection measures were carried out as and when needed. *Pusha Summer Prolific Long* –a variety of bottle gourd, and *Parbhani Kranti* –a variety of lady's finger were used as the test crops.

Land preparation, transplanting and cultural practices

Bottle gourd: The land was ploughed and cross-harrowed three times during the second week of March. After layout, pits of size 1'x1'x1' were dug at 2x2 m spacing, maintained four plants/plot and a gap of 2 m was kept in each side of the plot. The area of sub-sub plot was 16m². Surrounding the main-plots, border plants were grown to avoid border effect. The manure was mixed with topsoil and basal N, P and K were applied @ 50:60:60 kg/ha, respectively. Seedlings of 25 days old were transplanted during April 5-6. Due attention was given to gap filling and regular watering until the plants were well established. Nitrogen was top dressed @ 40 kg/ha 45 days after transplanting.

After the establishment of seedlings the plants were mulched with straw on April 28 in such a way that the area around the plants and the interspaces were covered with 5 cm thick straw mulch. Irrigation treatments were imposed beginning the same day. Daily observations of pan evaporation and rainfall events were made at 8:00 a.m. The amount of rainfall was deducted from a pan evaporation reading to determine the rate of effective evaporation. Since the experiment was conducted during the dry season, all the rainfall was considered effective contributing to plant water requirement. The irrigation application was terminated on May 15. Fruit picking started from May 17 and continued from the middle of May to the middle of July. Yield and yield-attributing characteristics selected for crop performance have been listed in table 1.

Lady's finger: The field was prepared by 2-3 cross-harrowing and well rotten compost was applied @ 20 t/ha one week before sowing the seed. Basal dose of P and K @ 40 kg/ha each were applied at the time of sowing. As N was the main plot treatment, the basal dose was applied before the seeds were sown on March 28-29. The remaining half of N was top dressed 45 days after sowing on May 16. Each sub-sub plot consisted of 35 plants with 5 rows spaced at 40 cm between two rows and 7 plants/row planted at 20 cm between two plants within a row. The net plot consisted of 15 plants, while the plants in the periphery

of a sub-sub plot worked as border plants. Observations were taken from those 15 plants only. Irrigation treatments were started on May 3 when the plant stand was fairly well established and was stopped on May 15. The plants were top dressed with N-fertilizers on May 16. Rogor was sprayed on June 7 to control jassids, because they appeared to be a problem. Fruits were harvested at an interval of 3-4 days and picked 26 times starting from May 16 to July 24.

Table 1. Yield and yield-attributing characteristics selected for measurement

Bottle gourd	Lady's finger
Yield (kg/sub-sub plot)	Yield (gm/sub-sub plot)
Number of fruits	Number of fruits
Average length of fruits	Length of fruits
Average diameter of fruits	Girth of fruits
Number of leaves	Plant heights
Number of primary branches	Days to 50% flowering

Experimental design and irrigation scheduling

The experiment was laid out on split-split plot design with 1) three levels of amount of irrigation (AIW) as sub-sub-plot factor, 2) three levels of frequency of irrigation (daily, two days and four days interval) as sub-plot factor, and 3) two levels of mulching (straw mulch of about 5cm thickness and no mulch) in the bottle gourd experiment, and nitrogen fertilization @ 30:60:90 kg NPK/ha) in the case of the lady's finger's experiment were used as the main plot factors. There were four replications of 18 (2x3x3) treatment combinations in bottle gourd, and four replications of 27 (3x3x3) treatment combinations in lady's finger.

The Irrigation schedule was established by 1) frequency of irrigation (daily, 2 days and 4 days interval between successive irrigations) and 2) amount of irrigation. The amount was determined by IW/Epan as the ratio between a fixed amount of irrigation water (IW) and cumulative open pan evaporation (Epan) minus rainfall. The three levels of irrigation were kept at 1.00, 0.75 and 0.50 thus accounting for the amount of water applied to be equal to Epan, 75% of Epan and 50% of Epan, respectively. This approach was found to be more practical as compared to other methods that are based either on assessment of soil moisture depletion or moisture tension. Contrary to these sophisticated techniques, the approach based on IW/Epan has merit due to its simplicity, practicality and potential for adoption in farmers' field. The calculated amount of water applied is shown in table 2.

Table 2. Amount and frequency of irrigation water for bottle gourd and lady's finger

Irrigation frequency	Water level	Amount of bottle gourd (litre/plant)	Irrigation water lady's finger (litre/plot)
Daily	IW/Epan =1	73.75	139.94
	IW/Epan =0.75	54.06	102.28
	IW/Epan =0.50	34.53	65.23
Two days interval	IW/Epan =1	71.98	139.38
	IW/Epan =0.75	49.35	102.28
	IW/Epan =0.50	31.32	65.22
Four days interval	IW/Epan =1	73.75	139.94
	IW/Epan =0.75	52.12	96.96
	IW/Epan =0.50	30.35	54.59

The measurement of evaporation (Epan) was carried out daily in "Class – A Evaporation Pan," 120 cm diameter and made of 22 gage GI sheet, installed in the experimental area. The depletion of water level was corrected by multiplying it with a pan coefficient of 0.70 to account for thermal mismatch error. Pan coefficient of 0.70 was used based on the earlier findings of Michael (1978) and Prihar and Sandhu (1987) who found the class – A Pan reading to be approximately 30% higher than the evaporation from a

moist soil surface. The measurement of rainfall was carried out using a 8"-diameter non-recording rain gauge installed in the experimental area.

Statistical analysis

Analysis of variance (ANOVA) was carried out using statistical package MSTATC to determine whether yield and yield-attributing characteristics were significantly affected by the treatments. The test of significance has been presented at 0.05 and 0.01 probability levels. The least significant difference (LSD) was computed to compare statistical differences in treatment means. Comparisons of treatment means of interaction effect were made as needed.

RESULTS AND DISCUSSION

Initial soil fertility and growing weather conditions

The soil was classified as Coarse Loamy, Hyperthermic, Micaceous, Typic Haplustoll (Soil Survey Staff 1999). Chemical analysis revealed that the soil was medium in organic matter (2.53%), very low in organic carbon (1.43%) and low in nitrogen content (0.015%) (Landon 1984).

Meteorological data was obtained daily from a nearby meteorological station to establish the weather conditions during the growing season. The data included maximum and minimum temperature, relative humidity, and amount of rainfall (Fig.1). The data obtained were utilized to explain crop water requirement, relate the rate of evaporation to weather condition and to understand the trend of weather change during the growing season. The month of May, being the hottest month, maximum temperatures ranged between 30°C to slightly above 40°C over the entire growing period. Although April and May showed some fluctuations, June and July were observed to have consistent patterns in terms of both temperature and relative humidity (RH). The RH which was slightly lower (around 50%) in April and May increased up to 90% toward June and July. Minimum temperatures which increased steadily, from as low as 10°C in April to as high as 30°C in the middle of June, remained fairly constant thereafter. Weekly average rainfall which was low (<10mm) in April and May increased abruptly to as high as 40mm and started declining from the second week of July onward.

When temperature and relative humidity were on the rise in April and May, rainfall was still low and water supply to the crops was necessary. After that although temperature and humidity approached a steady-state, irrigation was halted because of the onset of monsoon rain which satisfied the crop water demands in these experiments.

Performance of bottle gourd

Analysis of variance (ANOVA) indicated that main-plot treatment of mulch had a significant effect on the number of primary branches (Table 3), the mean square value of which was 0.89. The result was not in keeping with the generally held notion [no-mulch plots gave statistically higher number of primary branches (3.47) relative to mulched plots (3.25) (Table 4). The purpose of mulch is primarily to improve soil moisture storage and to eliminate moisture stress for the crop plant during the dry season. This experiment however showed different result. This might be because the plots had received a calculated amount of water through irrigation treatments at specified time intervals. The addition of rain water resulted in equal water content in all plots irrespective of irrigation treatments during the ripening stage of the bottle gourd. This appears to be one of the possible explanations as to why the mulched plots could not demonstrate a superior effect on crop performance compared with non-mulched plots.

Table 3. Analysis of variance showing mean squares for yield and yield-attributing characteristics of bottle gourd

Source of variance	DF	No. of primary branches	No. of nodes	Yield
Replication	3	0.39	7.22	290.03
Mulching (A)	1	0.89*	0.89 ns	188.63 ns
Error (a)	3	0.037	6.26	100.55
Irr interval (B)	2	2.76 ns	2.68 ns	107.42 ns
A×B	2	1.35	0.09	203.56
Error (b)	12	1.24	7.29	72.13
Amt water (C)	2	0.43 ns	4.35 ns	58.24 ns
A×B	2	0.35	4.35	184.24
B×C	4	2.12	12.86*	54.85
A×B×C	4	1.49	0.87	20.96
Error (C)	36	1.81	3.53	60.95

*, Significant at 0.05 probability level, ns = non significant

Table 4. Effect of mulching and frequency and amount of irrigation on yield and yield- attributing characteristics of bottle gourd

Treatments	No. of fruits	No. of primary branches	Yield (kg/sub-sub plot)
Mulching			
Mulching	17.14	3.25b	25.12
No Mulching	14.58	3.47a	21.88
SEM	1.12	0.03	1.67
LSD at 5%	NS	0.204	NS
Frequency of irrigation			
Daily	16.75	3.75	25.79
2 days	14.45	3.20	21.62
4 days	16.37	3.12	23.09
SEM	1.29	0.32	1.37
LSD at 5%	NS	NS	NS
Amount of irrigation			
IW/Epan=1	15.29	3.20	24.85
IW/Epan=0.75	15.50	3.42	21.80
IW/Epan=0.5	16.79	3.46	23.85
SEM	1.16	0.27	1.59
LSD at 5%	NS	NS	NS

NS = Non-significant, S = Significant, HS = Highly significant

Although non-significant, mulching had a favorable effect on most of the attributes such as fruit yield, number of fruits, number of leaves, days to first female flowering, and main shoot length. On the other hand, the performance of fruit length, fruit diameter, and number of nodes including number of primary branches was inferior under mulched plots compared to non-mulched plots (because of non-significant effect, data not shown). Ghorai (1995) also had similar results which showed that straw mulch and irrigation application did not have a significant effect on the yield and yield-attributing characteristics of the pointed gourd in similar acid soil.

The greater the number of nodes the higher the possibility of branching to bear more fruits. The node is therefore, considered one of the important yield-attributing characteristics. Amount and frequency of irrigation had a significant effect on the number of nodes. A comparison of treatment means indicated that a moderate amount (IW/Epan = 0.75) of daily irrigation produced the highest number of nodes/plant, which was statistically higher than others treatments (Table 5). The graphical representation shown in Fig. 2 indicated that application of a moderate amount of water on daily basis might produce greater yield.

Table 5. Comparison of treatment means of interaction effect of frequency and amount of irrigation on number of nodes of bottle gourd

Irrigation interval	IW/Epan (Amount of water, liter)		
	1	0.75	0.5
	Number of nodes/plant		
Daily	5.37c	9.0a	6.8bc
2 days	8.1ab	6.8bc	7.1abc
4 days	6.7bc	6.7bc	6.6bc
LSD at 5% = 1.905			

Although daily irrigation of a moderate amount of water produced the highest number of nodes/plant, other biological characteristics of the plant remained statistically similar. This might also imply that a higher number of nodes per se do not guarantee a significant increase in yield and hence suggest that daily irrigation might rather lead to a decrease in water productivity. The frequency and amount of irrigation also had a statistically non-significant effect on all of the response variables other than nodes/plant. Obviously, the question then becomes, why was not irrigation effective in giving rise to a statistically significant yield increase in bottle gourd?

A reason for the non-significant effect of irrigation might be that seedlings were transplanted in sufficiently deep and wide pits of 1'x1'x1' size. As the plants grew, roots proliferated deeper into the loosened subsoil where they could acquire a greater volume of water easily. This might have reduced the effect of applied water on the surface during the early part of the growing season when it was still dry. Another reason could be that the fruits were harvested continuously for two months after irrigation was stopped on May 15. Weather data of the growing season presented in Figure 1 indicated that when the irrigation was stopped, a period that marked an abrupt increase in rainfall followed and the intermittent rainfall thereafter kept the soil moist for the next two months until the end of July. It means the treatment effect of irrigation in all experimental plots was most probably masked by rainwater. In other words, the onset of monsoon weather conditions might have interfered with the treatment effect of irrigation. However, such reasoning might not be applicable in all cases and situations. To explore other possible factors for such outcomes, a similar experiment has to be repeated where the crop is allowed to mature and harvest before the onset of the monsoon season.

Performance of lady's finger

Analysis of variance (ANOVA) indicated that nitrogen had a highly significant effect on the yield of lady's finger (Table 6). The mean yields (1365 and 1238 g/sub-sub-plot) obtained by applying nitrogen @ 30 and 60kg/ha, respectively were statistically similar to each other but were significantly greater than the yield (1044 g/sub-sub plot) obtained by applying nitrogen @ 90 kg/ha (Table 7). Higher yields from lower levels of nitrogen may partly be attributed to the relationships of nitrogen with other soil nutrients, especially phosphorus in terms of its availability to plants uptake. Phosphorus availability for the plant, for instance, is decreased with an increase in nitrogen level in the soil (Tisdale et al 1993). Therefore, given the water is not a limiting factor in the soil, higher yield from lower level of nitrogen might be thought of due to efficient utilization of soil phosphorus by the crop plant. The fact that the experiment that did not consider the nitrogen treatment relative to the availability of other elements in the soil might be considered a design defect in this research.

Furthermore, though nitrogen increased yield significantly, all yield-attributing characteristics such as plant height, days to 50% flowering, number of fruits and fruit girth could not respond significantly to the application of nitrogen (non-significant data not shown). It could be that the cumulative effect of nitrogen on these attributes was significant in increasing the crop yield.

Table 6. Analysis of variance showing mean squares for yield and yield-attributing characteristics of lady's finger

Source of variance	DF	Yield	Plant height (cm)	Days to 50% flowering
Replication	3	1800056.16	321.50	168.52
Nitrogen (A)	2	940486.0 **	334.23 ns	17.58 ns
Error (a)	6	74227.20	157.13	47.17
Irrigation interval (B)	2	321407.95 ns	533.63 ns	22.53 ns
A×B	4	270129.55	244.64	62.11
Error (b)	18	149344.45	182.34	53.30
Amount of water (C)	2	71402.51 ns	78.17 ns	16.33 ns
A×B	4	50644.94	47.34	21.67
B×C	4	54708.55	60.55	42.44
A×B×C	8	237489.56 *	88.69	25.92
Error (C)	54	93914.00	61.68	16.95

*, ** Significant at 0.05 and 0.01 probability level, respectively, ns = non significant

Table 7. Effect of nitrogen rates, and frequency and amount of irrigation on the yield and yield-attributing characteristics of lady's finger

Treatments	Yield (gm/ sub-subplot)	Plant height (cm)	Days to 50% flowering
Nitrogen (kg/ha)			
N30	1364.55a	47.75	71.64
N60	1237.97a	52.84	72.80
N90	1043.67b	47.40	72.89
SEM	45.40	2.089	1.14
LSD at 5%	157.1	NS	NS
Frequency of irrigation			
Daily	1315.0	46.10	71.75
2 days	1204.17	53.59	72.28
4 days	1127.03	48.29	73.30
SEM	64.40	2.25	2.10
LSD at 5%	NS	NS	NS
Amount of irrigation			
IW/Epan=1	1266.47	47.71	71.67
IW/Epan=0.75	1184.67	49.67	72.83
IW/Epan=0.5	1195.05	50.60	72.83
SEM	51.07	1.30	0.68
LSD at 5%	NS	NS	NS

NS = Non-significant, S = Significant, HS = Highly significant

In regard to the issue of irrigation, although single effects of frequency and amount of irrigation were observed to be non-significant on any of the response variables, an interaction of these, when combined with nitrogen was found to be significant in increasing the yield of lady's finger (Table 6). A comparison of treatment mean values revealed two possible options; one, the likelihood of obtaining high yield (1609 g/2.8m²) by applying shallow irrigation (IW/Epan = 0.5) on a day-to-day basis which still keeps the level and cost of nitrogen low, ie 30 kg/ha (Fig. 3, Table 8); two, if the grower wants to irrigate a field at wider time intervals without losing yield and keeping the nitrogen cost low, water application at 4 days interval could be an appropriate alternative. The results showed that in both of these situations, the yield of lady's finger obtained was statistically similar.

From the foregoing discussions, it seems that lady's finger and bottle gourd vegetable crops responded to the treatments in quite different ways. This variation has been explained in this paper partly by the examination of the treatments themselves but also need an evaluation of differences due to physiological characteristics of the plant, and field management techniques during the growing season of these crops. For instance, seeds of lady's finger soaked overnight were sown directly to the top-soil without making a pit, but because of the existence of plough pan on the experimental site, these plants grown on the

loosened shallow surface soils might have been influenced more by added water. This is because sub-surface stored water could not be readily available for the plants unless plough pan is broken through some means of sub-soiling.

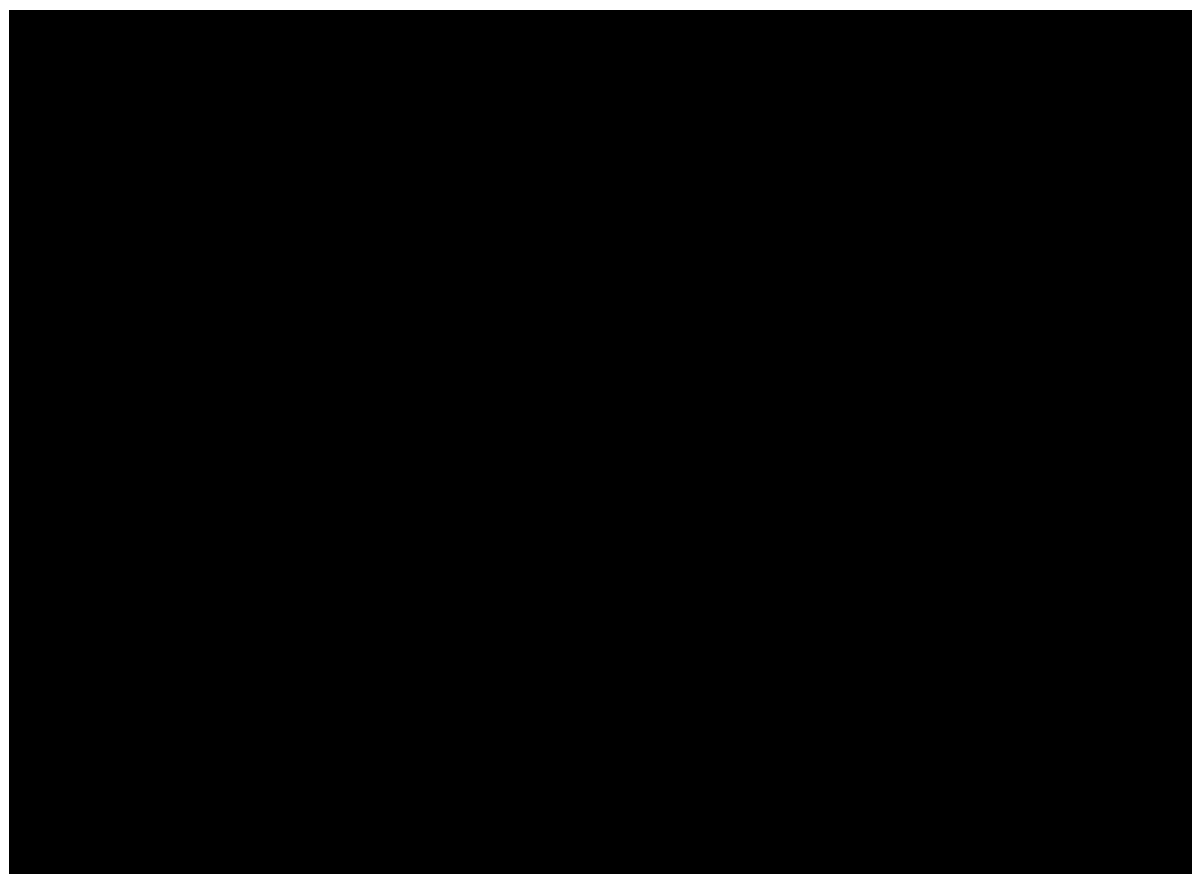
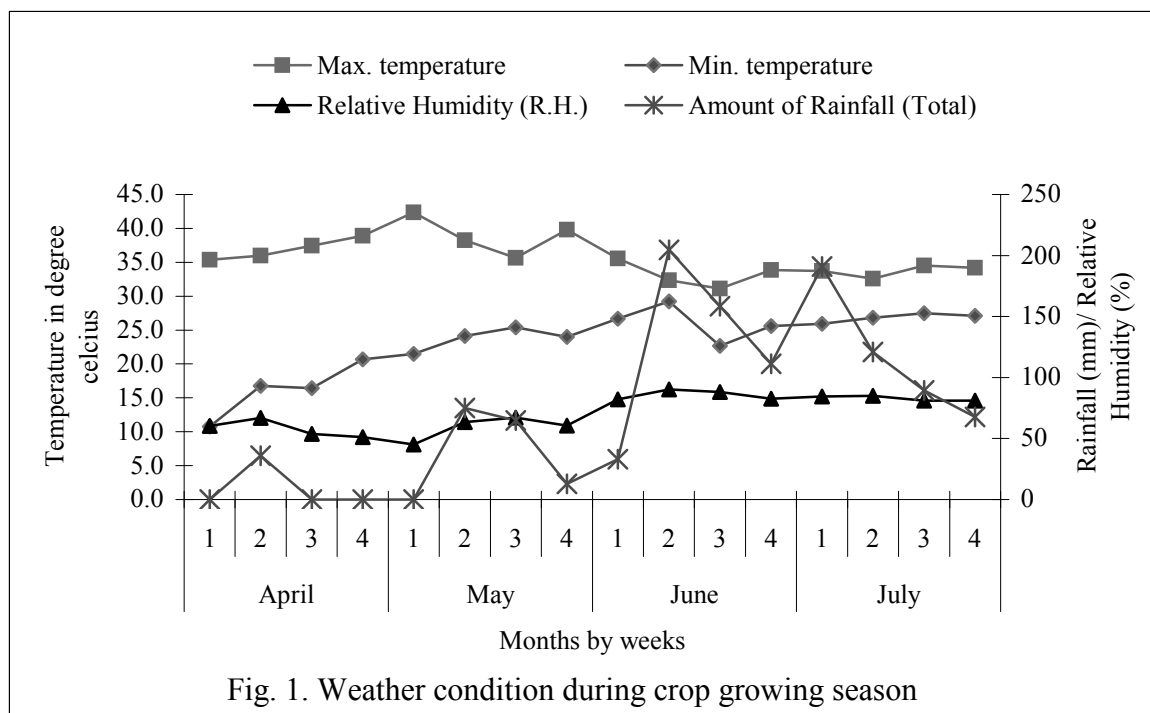
On the other hand, bottle gourd seedlings prepared in polyethylene bags were transplanted to sufficiently deep and wide pits filled with well rotted manure and fertile soil. Interesting to note was that bottle gourd plants developed extensively thick and bushy vegetative growth which might have adversely affected fruit bearing ability. Furthermore, while picking the fruits intermingling vines posed difficulty in identifying which fruits belonged to which experimental plots.

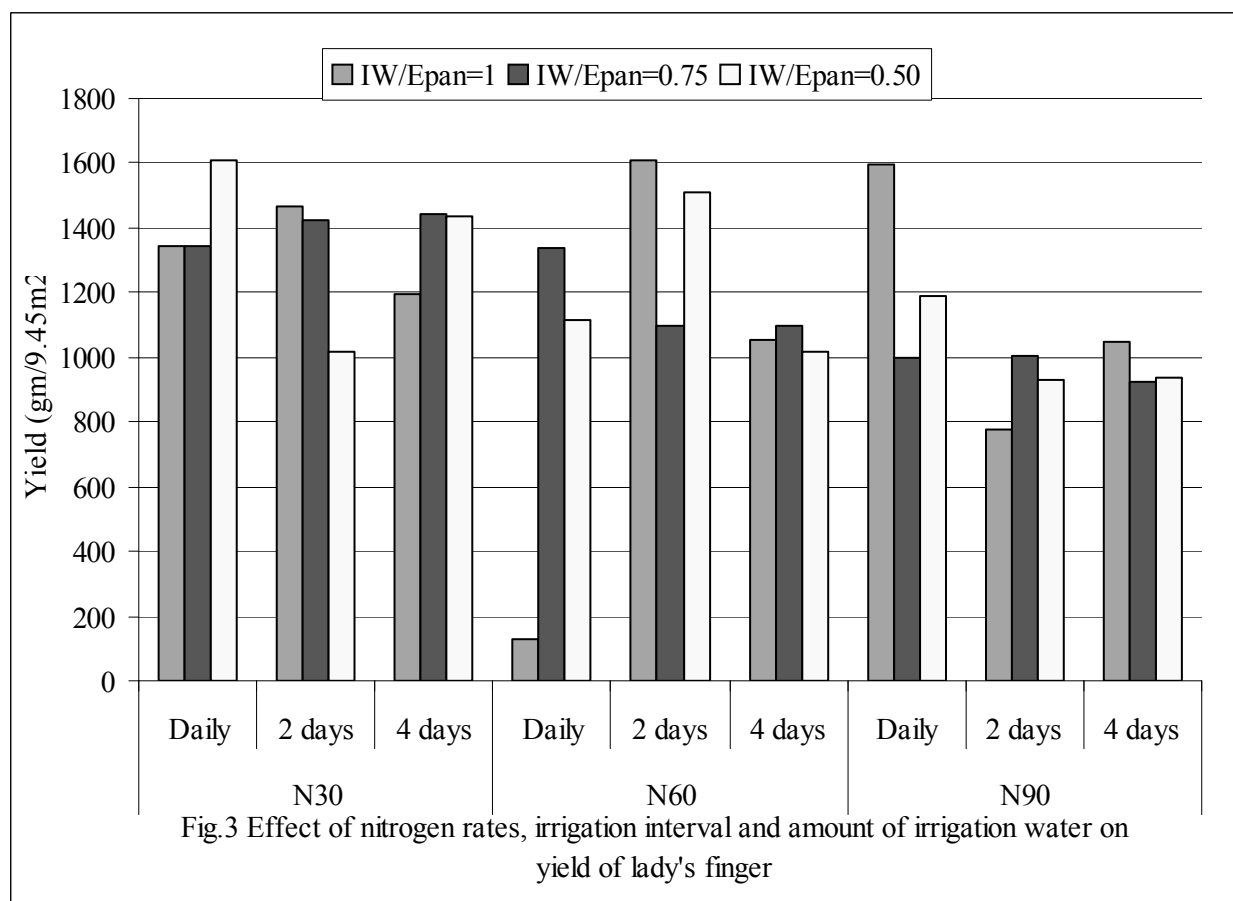
Table 8. Comparison of treatment means of interaction effect of nitrogen rate, and frequency and amount of irrigation on the yield of lady's finger

Nitrogen (kg/ha)	Irrigation interval	IW/Epan (Amount of water, liter)		
		1	0.75	0.5
		-----yield (gram/2.8m ²)-----		
N30	Daily	1345abcdefg	1341abcdefg	1609a
N30	2 days	1467abc	1425abcdef	1018defgh
N30	4 days	1196abcdefgh	1442abcd	1434abcde
N60	Daily	1305abcdefg	1335abcdefg	1112bcdefgh
N60	2 days	1610a	1098bcdefgh	1512ab
N60	4 days	1053cdefgh	1098bcdefgh	1015befgh
N90	Daily	1599a	995fgh	1189abcdefgh
N90	2 days	775h	1003efgh	928gh
N90	4 days	1045cdefgh	921gh	935gh
LSD at 5% = 434.4				

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Effect of Plant Growth Regulators on Growth, Sex Expression and Fruit Yield in Bottle Gourd (*Lagenaria siceraria*)

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ABSTRACT

Bottle gourd (*Lagenaria siceraria*) is one of the major summer vegetables in terai. Generally, it is noticed that when the day length increases, number of fruits decreases resulting to reduced yield. Therefore, this trial was conducted for two years (2004 and 2005) on Pusa Summer Prolific Long (PSPL) variety to identify proper growth substance for improving the yield of bottle gourd. Among the growth substances, Vegimax at the rate of 0.25 milliliter per liter water gave significantly highest fruit yield (32.4 tons/ha) followed by Humicil @ 1 ml per liter water (27.2 tons) application as compare to control (17.6 ton). Likewise, average weight of fruit was also highest (2.4 kg) in Vegimax @ 0.25 ml per liter applied plot. Economical analysis also showed that Vegimax @ 0.25 ml per liter had given the highest benefit cost ratio (37.9). Hence, Vegimax @ 0.25 ml per liter had increased 86 percent fruit yield and highest benefit cost ratio (37.9) is recommended to spray in Parwanipur condition.

Key words: Benefit cost ratio, growth substance, summer vegetable

INTRODUCTION

Bottle gourd is one of the major summer vegetables of terai region. The area of this crop is increasing every year but the productivity is not satisfactory in farmer's field. It may be due to the improper use of plant nutrients, soil fertility problems and imbalance of plant hormones within the plant itself. In cucurbits, male flowers are dominant over female flowers in the initial stage, so that there is low yield in cucurbits. For high yield, female to male ratio should be high at the time of flowering. Plant growth hormones have been reported to influence the growth, flowering and sex expression and fruit yield.

There is interaction of the genetic and hormonal regulation of growth, flowering and sex expression in plants (Chailakhyan 1979). The initiation of flowering in plants is controlled by environmental and endogenous signals 1, 2. Endogenous signals regulate the autonomous and gibberellins pathways (Austin et al 1990). Application of certain plant hormones promote flowering. For example, the hormones ethylene promotes flowering in pineapple and other bromeliads. Treating a biennial rosette, i.e. carrot, with the plant hormone gibberellic acid stimulates it to flower (Hershey 2002). Singh and Chaudhary (1979) observed that ethrel at 50 and 100 ppm induced the first pistillate flower earlier at lower nodes.

The main objective of this experiment is to improve female flower production and fruit setting at early stage of bottle gourd for getting better yield. In Nepal, research in growth regulators on vegetable crops is rarely done. In other countries researches on plant growth regulators in different vegetable crops have been done and results had shown an increase in fruit setting and yield of different vegetable crops. Kooner et al (2000) reported that the application of maleic hydrazide (MH), ethrel and cycocel increased the number of female flowers and ultimately the total fruit yield in bottle gourd. Generally, it is noticed that when the day length increased, the number of fruit setting decreased the effect of which resulted less yield. Therefore, this trial was conducted on Pusa Summer Prolific Long variety to identify the proper growth hormone for improving the yield of bottle gourd.

MATERIALS AND METHODS

This study was conducted for two consecutive years (2004 to 2005) at Regional Agriculture Research Station Parwanipur, Bara. This trial was laid out in randomized complete block design (RCBD) with three replications of seven treatments. The treatments were: Control (water spray), Ethephon @ 0.24 ml, Miraculan (triacantanol a.i. 0.05%) @ 0.5ml, Vegimax (trace elements plus vitamins) @ 0.125 ml, Vegimax @ 0.25ml, Humicil (6% humic acid) @ 1 ml, Multiplex (micro nutrients) @ 3 ml/lit of water. Plot size was 4 m x 3 m (12 m²) where seedlings were transplanted by maintaining the spacing three meter line to line and 80 centimeter plant to plant. Fertilizer was applied at the rate of 100:40:40 kg NPK and 20 ton farm yard manure per hectare. Chemicals (growth substances) were applied two times at true two-leaf stage and before flowering. Seedlings were transplanted on second week of Falgun and first harvest was done on first week of Baisakh each year. Insecticide (Metacid) and fungicide (Blitox) were sprayed once to control Red pumpkin beetle in early stage and blight disease in later stage. Plants were allowed to spread over the ground. Intercultural operations were done as needed. Observations were recorded on plant survival per treatment, number of vines/ plant, percentage of female flowers, female to male flower ratio, vine length, fruits number and yield per plot and converted to fruit yield per hectare.

RESULTS AND DISCUSSION

Plant survival

During the early fruiting stage, numbers of plants survived were counted. Among them, plants sprayed with water (control) had the least percent of survivality (83%) whereas the Ethephon @ 0.48 ml, Humicil @ 1 ml and Multiplex @ 3 ml had the highest percentage of survivality (97%).

Vine length

Highest vine length was measured (635 cm) in Miraculan @ 0.5 ml application followed by Humicil @ 1ml (552) whereas the lowest vine length (419 cm) was measured in Ethephon @ 0.24 ml application. Number of vines per plant was ranged from 2.6 (control) to 3.7 in Humicil applied plot. However, all the chemicals had promoted the number of vines (Table 1).

Vine number/plant

The highest vines per plant (3.7) were recorded in Vegimax @ 0.25ml followed by 3.4 in the treatment Ethephon @ 0.48 ml. The lowest vines/plant (2.6) was observed in control treatment.

Number of female flowers

Number of female flowers and total number of flowers on the day of observation were recorded after each three days. Cumulative record showed that highest percentage of female flower (22) was given by Ethephon @.48ml application followed by Humicil (18%) application.

Female to male flower ratio

The highest ratio of female to male flower (1: 5.6) was obtained in the control and the least in Ethephon @.48ml (1: 3.6). All the test growth substances had promoted the number of female flowers as compared to the control (Table 1).

Fruit yield

Vegimax @ 0.25 ml gave the highest fruit yield (32.74 ton/ha) followed by Humicil @ 1ml (27.19 ton/ha) application whereas control plot had only 17.56 tons per hectare. Likewise, average fruit weight (2.41 kg) was also highest in Vegimax @ 0.25 ml application followed by Multiplex @ 3 ml (2.34 kg) whereas control had the least weight (1.56 kg) of fruit. It showed that plants sprayed with growth substances gave higher fruit yield as compared to control (Table 2).

Economic benefit

The highest yield increment was (86.7%) in Vegimax @ 0.25 ml application followed by Humicil @ 1ml (54.8%). Likewise, when it was calculated on monetary value, highest benefit cost ratio was (37.9) was obtained from Vegimax @ 0.25ml application followed by Vegimax @ 0.125 ml (27.5) application.

Therefore, on the basis of over all characters, Vegimax @ 0.25 ml is recommended to spray for increasing benefit under Parwanipur conditions (Table 2).

Table 1. Effect of growth substance on vegetative growth and sex expression parameter in bottle gourd (two years mean)

Treatments	Survival (%)	Vine length (cm)	Vines/plant (no)	Female flower (%)	Female:Male flower ratio
Control: water	83	522	2.6	16	1: 5.6
Ethephon @ 0.24 ml	87	419	3.1	15	1: 5.4
Ethephon @ 0.48 ml	97	511	3.4	22	1: 3.6
Miraculan @ 0.5ml	90	635	3.2	16	1: 5.2
Vegimax @ 0.125 ml	90	506	3.3	17	1: 4.2
Vegimax @ 0.25ml	87	540	3.7	16	1: 5.3
Humicil @ 1ml	97	552	3.2	18	1: 4.4
Multiplex @ 3 ml	97	461	3.1	16	1: 5.2
CV %	18.4	21.4	15.4		
F-test (.05)	NS	NS	NS		
Year x treatment	NS	NS	NS		

Table 2. Effect of growth substance on fruit yield and economical benefit in bottle gourd

Treatments	Yield (ton/ha)	Yield increment (%)	Avg fruit.wt (kg)	Benefit amount (Rs)	Cost of growth subs. (Rs)	Net benefit (Rs)	Benefit cost ratio
Control: water	17.56	0	1.56	0	0	0	0
Ethephon @ 0.24 ml	22.83	30	1.78	21350	1852	19508	11.0
Ethephon @ 0.48 ml	25.92	48	2.24	38650	2704	35946	13.3
Miraculan @ 0.5ml	23.36	33	1.93	29000	5125	23875	4.6
Vegimax @ 0.125 ml	26.28	50	2.16	43500	1528	41972	27.5
Vegimax @ 0.25ml	32.74	86	2.41	79900	2056	77844	37.9
Humicil @ 1ml	27.19	55	2.31	48150	4900	43250	8.8
Multiplex @ 3 ml	25.47	45	2.34	39550	3075	36475	11.9
CV %	22.0						
F-test (0.05)	*						
Year x Treatment	NS						

CONCLUSION

It is concluded that Vegimax @ 0.25 ml is found beneficial for increasing fruit yield and economic benefit in bottle gourd. Thus, Vegimax @ 0.25 ml is could be recommended to apply for better fruit yield of bottle gourd under Parwanipur conditions.

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A New Approach on Time and Method of Nitrogen Application for Seed Production of Radish var. Mino Early in Mid Western Hills of Nepal

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ABSTRACT

An experiment was conducted to assess effect of different methods and time of nitrogen fertilizer application for seed production of Mino Early radish. Eight method and time packages of nitrogen (urea) application were evaluated in RCB design with three replications for two years 2004/05 and 2005/06. The plot size was 6.48 m² (2.4-m x 2.7-m) and the seed was sown in 1st week of October. Seed was sown at a spacing of 60 x 45-cm² and there were 24 plants after thinning on each plot. Days to 50% flowering, days to maturity and test weight were found not influenced by nitrogen fertilizer application package. However, average fruiting branches/plant and productivity was significantly influenced by these treatments. The highest fruiting branches/plant (18.74) was recorded from band placement of ½ N₂ as basal plus ½ N₂ as side dressing at 30-35 DAS. However, productivity was recorded significantly highest (2170 kg/ha) from treatment containing band placement of incubated urea (½ N₂ as basal + ¼ N₂ at 30 DAS + ¼ N₂ at bolting stage). Twenty-four hour incubation of urea: moist soil (1:10) and application as above-mentioned schedule is promising in moisture stress areas of mid-hills where there is the possibility of radish seed production.

INTRODUCTION

Radish is a very popular root crop in Nepal. Owing to the fact that this crop requires little space and is ready for harvest after six to seven weeks, it is a preferred crop in kitchen garden (Poon et al 2004). Mino early is most popular cultivar of radish so far released in Nepal because of its high root yielding ability, earliness and sweet taste. Additionally this crop can be grown year round in one or another physiographic region of Nepal (LARC 1985). Seed is regarded as an important source to maintain stability in good root production. But seed production is a highly specialized job and requires proper technical know-how. Mino Early variety of radish is the major vegetable seed exported from Nepal. In 2004/05, approximately NRs 2.84 million of seed was exported, out of which 93 percent was exported to Bangladesh (AEC 2007).

The agro-climatic condition of mid-hills of mid and far-western region, in particular, is quite suitable and there is enormous scope of commercial seed production of radish (Poon et al 2004), but there is meager information on crop husbandry of radish seed production in Nepal, especially on nutrition management. Nitrogen plays vital role on seed production of vegetable crops. But, its application in chemical form needs proper timing at proper zone for better uptake and utilization. Mid western and far-western mid-hills of Nepal is moisture stressed area where low humidity and high temperature favors higher volatilization of nitrogen and water application after fertilization is always not possible. In such instance, a study was carried out to find proper timing and application method of nitrogenous fertilizer for seed production of Mino Early radish.

MATERIALS AND METHODS

To evaluate effect of time and method of nitrogen fertilizer application on seed production of radish, an experiment was carried out at ARS (Horticulture), Dailekh. Eight treatments (Table 1) were evaluated in a randomized complete block design (RCBD) with three replications. The plot size was 6.48 m² (2.4-m x 2.7-m) and the seed was sown in 2nd October 2004. Seed was sown at a spacing of 60 x 45 cm² and there were 24 plants after thinning on each plot. The crop was fertilized @ 10.69 Kg urea, 6.95 kg di-ammonium phosphate and 3.33 kg muriate of potash/ropani where as FYM was applied @ one ton/ropani. All amount of P₂O₅ and K₂O were applied as basal done and N₂ according to the treatment combination. During incubation of nitrogenous fertilizer 200 g of moist soil was used for 20 g urea. Incubation period was 24 hours. Yield and yield attributing characteristics were recorded during study and statistically analyzed.

RESULTS AND DISCUSSION

Days to 50% flowering

Treatments effect on days to 50% flowering was found non-significant both the years separately and average of both years (Table 1). However, the least days was taken by treatment containing band placement of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS+ $\frac{1}{4}$ N₂ at 60-70 DAS, where as the highest number of days was taken with broadcasting of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS+ $\frac{1}{4}$ N₂ at bolting stage.

Table 1. Effect of nitrogenous fertilizer application method and time on days to 50% flowering of Mino Early radish at ARS, Dailekh in year 2005 and 2006

Treatment	1st year	2nd year	Combined
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	121	119.3	120.2
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	121	118.7	119.8
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	124.3	123.3	123.8
Broadcasting of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at bolting stage)	122.7	120	121.3
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	121	120	120.5
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	122.67	120	121.3
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	121	119.3	120.2
Broadcasting of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	122.7	121.3	122
GM	122.04	120.25	121.2
CV	1.8	2.2	2
P value	0.471	0.515	0.126
LSD	3.761	4.617	2.835

Days to maturity

Treatments effect was found non-significant on days to maturity in the first year; however, that was significant in the second year and average of two years (Table 2). The least days (203 DAS) were taken with band placement of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS+ $\frac{1}{4}$ N₂ at 60-70 DAS. In an average, the least day was also taken by same treatment but the highest number of days were taken with broadcasting of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage and band placement of incubated $\frac{1}{2}$ N₂ as basal + $\frac{1}{2}$ N₂ at 30 DAS.

Average fruiting branch/plant

Highly significant effect of treatment was observed on both years and average of both years (Table 3). In the first year, band placement of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS+ $\frac{1}{4}$ N₂ at 60-70 DAS gave the highest number of fruiting branches (21.11/plant) but that was the highest (17.93/plant) from band placement of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{2}$ N₂ at 30-35 DAS in second year. The least branches/plant (14.78/plant) was produced with broadcasting of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage in first year, where as it was from broadcasting of band placemen of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage in second year. In average, treatment no. 1, 2 & 3 gave the highest no. of fruiting branches and treatment containing broadcasting of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage gave the least fruiting branches.

Table 2. Effect of nitrogenous fertilizer application method and time on days to maturity of Mino Early radish at ARS, Dailekh in year 2005 and 2006

Treatment	1st year	2nd year	Combined
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	204.3	204	204.2a*
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	204.7	203.7	204.2a
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	203.3	204.7	204a
Broadcasting of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at bolting stage)	203.7	205	204.3a
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	204.7	205	204.8a
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	204.7	202.7	203.7b
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	204	204.7	204.3a
Broadcasting of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	204.3	204	204.2a
GM	204.21	204.21	204.21
CV	0.6	0.5	0.5
P value	0.8	0.099	0.743
LSD	2.097	1.627	1.221

*Values with same letters in a column don't differ significantly at 5% LSD

Table 3. Effect of nitrogenous fertilizer application method and time on average fruiting branches/plant of Mino Early radish at ARS, Dailekh in year 2005 and 2006

Treatment	1st year	2nd year	Combined
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	19.55	17.93	18.74a*
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	21.11	15.93	18.52a
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	18.89	17.8	18.34a
Broadcasting of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at bolting stage)	14.78	15.33	15.06b
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	15.11	15.8	15.46bc
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	16.67	16.07	16.37b
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	17	15.4	16.2bc
Broadcasting of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	15.67	15.13	15.4c
GM	17.35	16.17	16.76
CV	6.1	2.8	4.7
P value	<.001	<.001	<.001
LSD	1.839	0.8057	0.931

*Values with same letters in a column don't differ significantly at 5% LSD

Test weight

Treatments were non-significant in both the years for test weight. Similar result was observed in average of two years (Table 4). In average, band placement of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{2}$ N₂ at 30-35 DAS recorded the highest test wt (20.33g) and the least from broadcasting of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage and band placement of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{2}$ N₂ at 30-35 DAS.

Table 4. Effect of nitrogenous fertilizer application method and time on test weight of Mino Early radish at ARS Dailekh in year 2005 and 2006

Treatment	1st year	2nd year	Combined
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	20.67	20	20.33
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	19	20.67	19.83
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting)	21.67	18	19.83
Broadcasting of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at bolting stage)	20	19.33	19.67
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	20	18	19
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	20.33	18.67	19.5
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	19.33	19.33	19.33
Broadcasting of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	20	18	19
GM	20.12	19	19.56
CV	4.3	8.6	6.8
P value	0.055	0.397	0.677
LSD	1.511	2.872	1.574

Productivity

Productivity was highly significant in both years and average of two years (Table 5). In the first year, the highest productivity (2811 kg/ha) was from broadcasting of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage where as that was the highest (1739 kg/ha) from band placement of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS+ $\frac{1}{4}$ N₂ at 60-70 DAS in second year. Band placement of $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS+ $\frac{1}{4}$ N₂ at bolting stage recorded the least productivity on both years as well as average of two years (1650 kg/ha). In average, band placement of incubated $\frac{1}{2}$ N₂ as basal+ $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage recorded the highest productivity (2171 kg/ha) which was significantly different from all treatments.

Table 5. Effect of nitrogenous fertilizer application method and time on productivity of Mino Early radish at ARS, Dailekh in year 2005 and 2006

Treatment	1st year	2nd year	Combined
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	2698.4	1388.9	2043.6bc*
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	2248	1471.2	1859.6e
Band placement of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting)	2018.2	1275.7	1646.9f
Broadcasting of ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at bolting stage)	2363.1	1502.1	1932.6d
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{2}$ N ₂ at 30-35 DAS)	2373.5	1512.3	1942.9d
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ at 60-70 DAS)	2213.4	1738.7	1976cd
Band placement of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N ₂ at bolting stage)	2797.7	1543.2	2170.5a
Broadcasting of incubated ($\frac{1}{2}$ N ₂ as basal + $\frac{1}{4}$ N ₂ at 30 DAS + $\frac{1}{4}$ N at bolting stage)	2810.7	1306.6	2058.6b
GM	2440.4	1467.3	1953.8
CV	2.4	3.3	2.6
P value	<.001	<.001	<.001
LSD	100.8	83.67	60.47

*Values with same letters in a column don't differ significantly at 5% LSD

CONCLUSION

Twenty-four hour incubation of urea; moist soil (1:10) and application as band placement of incubated urea ($\frac{1}{2}$ N₂ as basal + $\frac{1}{4}$ N₂ at 30 DAS + $\frac{1}{4}$ N₂ at bolting stage) is promising in moisture stress areas where there is the possibility of radish seed production.

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Evaluation of Cucumber Genotypes for Open Field and Plastic House in the Western Hills of Nepal

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ABSTRACT

Field experiments were conducted to find out the response of different cucumber genotypes for cultivation under plastic house and open field in outreach site of Regional Agricultural Research Station (RARS), Lumle at Hemja, Kaski during February and April planting seasons of 2004/05. Ten exotic and indigenous cucumber genotypes were tested in two planting dates; first on February and second on April in open field and under plastic house. The genotypes Mahyco Green Long (2807 kg/ropani) and Bhaktapur Local (2748.5 kg/ropani) were recommended for both plastic house and open field conditions due to their higher yield for February planting. Similarly, these genotypes were also found suitable for April planting with yield of 2765 kg/ropani and 2730 kg/ropani on Mahyco Green Long and Bhaktapur Local, respectively. The genotypes, Dhankuta Local, Ninja-179, Raniya, Kanane and Malini produced the statistically same yield under plastic house and open field conditions for April planting. In all tested genotypes, powdery mildew incidence was found minimum in open field than in plastic house, whereas downy mildew incidence was found minimum under plastic house. The genotypes Mahyco Green Long, KCU-F1, Super Market and Dhankuta Local were found more tolerant to powdery mildew whereas, the genotypes Super Market, Raniya and Dhankuta local were more tolerant to downy mildew under plastic house conditions. In open field conditions, the genotypes Super Market, Raniya, Malini and Mahyco Green long showed more tolerant to downy mildew whereas, Kusule, Ninja-179 and KCU-F1 showed more susceptible to downy mildew.

Key words: Cucumber genotypes, plastic house, powdery mildew, downy mildew

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most important members of family Cucurbitaceae grown in Nepal. It is grown commercially and becoming important cash generating crop in peri urban and road accessible areas in the western hills of Nepal. Traditionally, cucumber was grown for home consumption and its production was concentrated from September to November. The introduction of off-season production technologies and introduction of Bhaktapur Local in hills and Poinsette and Sarlahi Long cultivars in terai have made possible for off-season cucumber production (Bhattarai and Subedi 1995). At present, cucumber is commercially produced from March-May and other months of the year are under supplied. However, there is year round demand of cucumber in Nepal due to increase in consumption habit of consumers.

The off-season cultivation of cucumber is labour intensive hence it has significant contribution to employment generation in the rural and peri-urban areas. The involvement of women farmers is very high in cucumber production, harvesting and marketing. Women focus and employment generations are two major priority areas of Agriculture Perspective Plan (APP).

The use of plastic house technology for cucumber production has helped to increase the yield and extend the cucumber production season to some extent but farmers have lack of knowledge about suitable genotypes of cucumber production under plastic house conditions. Most of farmers use only Bhaktapur Local cucumber genotypes for normal season production in open field and off-season production under plastic house. However, this popular genotype has several drawbacks. These drawbacks are high number of curved fruits, short productive life, high male female ratio, presence of cavity in the center and susceptible to diseases such as powdery mildew and downy mildew (Gautam et al 2006). Furthermore, this variety was infected by Cucumber Mosaic Virus (CMV) and was found seed-borne and readily transmitted by sap, aphids, and human beings to new areas (PPD 2005).

Cucumber grown under plastic house helps the farmers to catch early market and increase the total yield due to increases temperature, retain moisture, promote seed germination and emergence. Rongsen (1994) reported by Upadhyay et al (2004) that the plastic film technology enables various crops to mature 5-20 days earlier than normal, increases the yield by 30-50 percent and increases the out put value by 40-50 percent and prolongs the harvesting period of vegetables by 30-60 days. However, there are none any identified genotype for off-season production under plastic house and the normal season genotypes have been utilized for off-season production without considering the temperature, season and other yield attributing characters. Therefore, this experiment was conducted to find out the response of different cucumber genotypes for open field and plastic house condition. The experiment was carried out in outreach site of RARS Lumle at Hemja (1000 masl) during February and April planting seasons of 2004/05.

MATERIALS AND METHODS

The experiment was conducted in low hill at Hemja (1000 masl) in Kaski district to find out the response of different genotypes of cucumber for open field and plastic house conditions during February and April planting seasons of 200/05. Ten genotypes of cucumber namely Bhaktapur Local, Dhankuta Local, Mahyco Green Long, Kusule, Raniya, KCU -F1, Super Market, Ninja-179, Malini and Kanen -F1 were collected from different parts of the country and aboard and evaluated both in open field and under plastic house. The experiment was conducted in RCB design with 4 replications considering one farmer as one replication both in open field and plastic house. The plot size was maintained 9 m². Planting was done at 1.5 m x 1.5 m distance. Manure and fertilizers were applied before planting at the rate of 2.0 kg compost, 15.0 g DAP, 9.0 g urea and 9.0 g potash per pit. Fifteen gram urea was top-dressed at 45 days after transplanting. Cucumber was directly seeded in the month of February and transplanting of seedling raised in poly pot was done in April.

Seedlings were transplanted in field at 4 true leaf stages. Bamboo and other tree branches were used as staking materials. Irrigation and other cultural practices were done as and when required. Pheromone traps (Cueliar) were used for control of fruit fly. Observation was recorded on first flowering male and female nodes, days to fruit picking after female flower emergence, days to first picking after transplanting, days to last picking, male to female flower ratio, length and diameter of the fruits and yield of normal fruits. Similarly, observation was also recorded on flesh thickness, hollowness (fruit cavity), growth habit, yield of misshapen fruits, sugar content of the fruit and area under disease progress curve (AUDPC) for incidence of downy mildew and powdery mildew.

RESULTS AND DISCUSSION

February planting

The analysis of data showed that there was highly significant difference on first male and female flowering node, days to fruit picking after female flower appearance, days to first and last picking, male to female ratio, diameter and length of fruit and yield of cucumber due to genotypic effect under plastic house condition (Table 1). In open field condition, besides first male and female flowering nodes and fruit length all others above mention parameters showed a significant difference due to genotypic effect

The interaction effect of open field and plastic house showed a significant difference on male to female ratio, fruit length and yield of cucumber. The highest mean yield (2807.0 kg/ropani) was recorded on genotype Mahyco Green Long under plastic house and it was found at par with Bhaktpur Local 2748.5 (kg/ropani). The lowest mean yield (480.5 kg/ropani) was recorded on genotype Raniya and it was found at par with KCU-F1 (568.0 kg/ropani), Kanane (725.0 kg/ropani) and Ninja-179 (740 kg/ropani) under plastic house. The detail analysis of quantitative and qualitative data is presented in Table 2 and Table 3, respectively.

Most of the farmers preferred the genotype Mahyco Green Long and Bhaktpur Local due to their higher yield both in open field and plastic house condition. However, the farmers who have the problem of staking they preferred genotype Mahyco Green Long due to its capacity to produce same quantity of yield over thatching materials ie without staking. During this season, most of the farmers preferred growing of cucumber under plastic house due to higher yield, early marketing and more profitable than open field for all genotypes.

Table 1. Response of cucumber genotypes on yield attributing parameters during February planting in open field and plastic house in low hill, Hemja , Kaski, 2004/05

Genotypes	First male flowering node		First female flowering node		Days to first picking after female flower initiation		Days to first picking after sowing of seeds		Days to last picking	
	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)
BKT Local	7	6	10	11	15	15	66	77	106	107
Dhankuta Local	9	8	14	11	19	20	83	83	116	121
Super Market	4	5	5	6	14	15	60	68	95	90
Ninja -179	7	6	7	8	12	14	58	61	92	84
Raniya	4	7	6	7	14	16	59	65	87	74
Mahyco G. Long	6	6	11	8	14	15	67	75	104	93
KCU-F1	5	6	7	6	16	16	57	57	88	72
Kanane	6	6	5	5	16	17	57	61	89	74
Malini	5	6	6	6	15	17	63	63	100	96
Kusule	5	5	6	7	16	16	59	62	97	83
Mean	5.65	5.97	7.6	7.5	15.05	16.02	62.75	66.05	97.2	89.3
F-Test	**	NS	**	NS	**	**	**	**	**	**
LSD	1.689	-		-	0.920	0.411	4.963	2.220	8.662	3.874
CV (%)	29.0		23.4		5.9		7.6		9.3	
Interaction of (AxB)	NS		NS		NS		NS		NS	
LSD	=		-		-		-		-	

Table 2. Response of cucumber genotypes on yield and yield attributing parameters during February planting in open field and plastic house in low hill, Hemja , Kaski, 2004/05

Genotypes	Male/Female ratio		Fruit diameter (cm)		Fruit length		Yield (kg/ropani)		Mean kg/ ropani)
	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	
BKT Local	4.18	4.21	5.6	5.0	46.5	20.0	2748. 5	1902. 5	2325. 5
Dhankuta Local	5.33	5.03	6.4	6.0	30.4	26.0	1648. 5	1394. 5	1521. 5
Super Market	2.64	3.49	4.5	4.0	17.1	19.0	1241. 5	466. 5	854. 0
Ninja -179	1.84	2.41	5.0	5.0	10.3	15.0	740. 0	284. 5	512. 5
Raniya	3.19	3.37	4.9	4.5	8.2	21.2	480. 5	340. 0	410. 5
Mahyco G. Long	6.95	5.21	5.6	6.3	44.8	23.7	2807. 0	1671.0	2239. 0
KCU-F1	7.74	8.65	5.5	4.7	8.2	14.2	568.0	251. 5	409. 5
Kanane	1.78	3.07	5.2	5.5	10.8	14.1	725. 5	329. 0	541. 0
Malini	2.48	5.84	4.9	4.5	28.2	13.8	2150. 0	672. 0	1411. 0
Kusule	4.45	2.67	5.3	5.0	33.6	14.1	2237. 5	1119. 5	1678. 5
Mean	3.75	4.73	5.30	5.14	23.81	18.12	1537. 5	843. 0	1190. 5
F-Test	**	**	**	NS	**	NS	**	**	**
LSD	1.15	0.51	0.543	-	11.10	-	394. 7	175. 5	555. 0
CV (%)	21.9		10.4		11.5		32.9		32.9
Interaction of AxB	**		NS		**		**		-
LSD	3.11		-		2.988		11.101		-

Table 3. Response of cucumber genotypes on yield attributing parameters during February planting under open field and plastic house in low hill, Hemja , Kaski, 2004/2005

Genotypes	Flash thinness (mm)		Hollowness (1-5) scale		Growth habit (1-5) scale		Weight of mis- shapen fruit (t/ha)		Sugar content (° Brix)	
	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)
BKT Local	15.6	15.6	1.0	1.25	3.0	3.0	1.14	0.0	3.8	3.8
Dhankuta Local	14.0	14.0	1.00	1.00	2.5	1.0	0.0	0.0	3.0	3.0
Super Market	9.2	9.2	1.00	1.00	1.5	3.0	2.19	0.53	3.0	3.0
Ninja -179	12.2	12.2	1.75	1.75	3.0	3.0	1.30	0.0	2.6	2.7
Raniya	16.28	15.18	2.00	2.00	2.0	2.0	1.0	0.0	3.0	3.0
Mahyco G. Long	11.90	12.18	1.25	1.25	2.0	2.0	1.89	0.0	3.8	3.8
KCU-F1	13.23	13.25	1.00	1.00	3.0	1.0	0.33	0.47	3.0	3.0
Kanane	13.49	13.63	1.25	1.00	1.0	1.0	1.30	0.53	3.1	3.0
Malini	14.0	14.25	2.25	2.25	3.0	3.0	0.0	0.0	3.0	3.0
Kusule	12.5	15.0	1.75	2.00	3.0	3.0	2.11	2.83	4.0	4.0
Mean	13.2	13.45	1.422	1.45	2.4	2.2	1.13	0.44	3.227	3.230
F-Test	**	**	**	NS	**	**	*	*	**	NS
LSD	1.243	1.244	0.38	-	0.324	0.145	1.302	0.582	0.051	-
CV	9.3		26.8		21.9		166.3		1.0	
Interaction of AxB	NS		NS		**		NS		NS	
LSD			-		0.159		-		-	

April planting

There was highly significant difference on first male and female flowering nodes, days to fruit picking after female flower appearance, days to first and last picking, male to female flower ratio, diameter and length of fruit and yield of cucumber due to genotypic effect in open field. Under plastic house condition, first male flowering node, days to first and last picking and diameter of fruit showed a non-significant difference and other parameters showed significant and highly significant differences.

The interaction effect of open field and plastic house showed a significant difference on male to female flower ratio, fruit length and yield of cucumber. The highest fruit yield (2765 kg/ropani) was recorded on genotype Mahyco Green Long followed by Bhaktapur Local (2730 kg/rop) whereas the lowest mean yield (1315 kg/ropani) was recorded on genotype KCU-F1 under plastic house. The genotype Super Market was not liked by farmers due to its lower yield and dark black colour. The detail analysis data of open field, plastic house and their interaction is presented from Table 4 to 6.

Based on the yield performance, there is no need of plastic house for genotypes Dhankuta Local, Ninja-179, Raniya, Kanane and Malini because they have capacity to produce statistically same yield under open field during April Planting. It was reported that the genotype Malini produce bitter taste under plastic house condition during this season, this could be due to high temperature.

Table 4. Response of cucumber genotypes on yield attributing parameters during April planting under open field and plastic house in low hill, Hemja , Kaski, 2004/05

Treatments	First male flowering node		First female flowering node		Days to fruit picking after female flower initiation		Days to First picking		Days to last picking	
	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)
BKT local	4	4	9.0	11.0	14	17	66.0	63.0	119.0	120.0
Dhankuta Local	11	9	15.0	17.0	17	20	79.0	82.0	130.0	147.0
Super Market	3	3	5.0	6.0	14	16	57.0	54.0	84.0	82.0
Ninja -179	3	4	5.0	7.0	12	16	53.0	55.0	85.0	86.0
Raniya	3	3	4.0	6.0	13	18	55.0	54.0	86.0	87.0
Mahyco G. Long	5	4	10.0	8.0	13	15	60.0	60.0	117.0	124.0
KCU-F1	2	3	4.0	4.0	15	19	57.0	55.0	85.0	84.0
Kanane	3	3	4.0	4.0	15	18	53.0	55.0	82.0	81.0
Malini	3	5	5.0	7.0	14	18	64.0	54.0	103.0	99.0
Kusule	3	3	5.0	5.0	15	15	60.0	59.0	101.0	101.0
Mean	4	4.1	6.6	7.5	14.2	17.2	60.4	59.1	99.2	101.1
F-Test	NS	**	**	**	**	**	NS	**	NS	**
LSD	-	1.136	0.59	1.32	0.316	0.706	-	4.168	-	6.748
CV	-	23.8	-	16.0	-	3.9	-	1.2	-	1.2
Interaction of AxB	NS		NS		***		NS		NS	
LSD	-		-		0.998		-		-	

Table 5. Response of cucumber genotypes on yield and yield attributing parameters during April planting under open field and plastic house in low hill, Hemja, Kaski, 2004/05

Treatments	Male/Female ratio		Fruit diameter (cm)		Fruit length (cm)		Yield (Kg /Rop)		Mean Fruit yield Kg/ Rop.)
	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	
BKT local	4.85	5.06	4.59	6.20	20.0	18.0	2730.0	2385.0	2555.0
Dhankuta Local	4.84	4.35	5.60	6.20	23.0	26.0	1660.0	1630.0	1645.0
Super Market	2.10	2.05	4.52	4.59	20.0	19.0	1370.0	930.0	1145.0
Ninja -179	3.42	3.57	4.32	4.86	20.0	19.0	1435.0	1425.0	1430.0
Raniya	3.24	3.06	5.02	4.29	19.0	21.0	1515.0	1630.0	1575.0
Mahyco G. Long	3.55	3.84	6.07	6.08	19.0	23.0	2765.0	2555.0	2660.0
KCU-F1	3.33	3.34	4.41	4.16	20.0	17.0	1315.0	1075.0	1195.0
Kanane	1.76	2.03	5.00	5.22	17.0	17.0	1440.0	1380.0	1410.0
Malini	2.36	2.60	4.57	4.68	20.0	18.0	2075.0	2110.0	2095.0
Kusule	4.64	4.21	5.70	5.15	20.0	17.0	2055.0	1645.0	1350.0
Mean	3.41	3.44	4.98	5.14	19.95	19.3	1837.5	1177.0	1757.0
F-Test	*	**	NS	**	**	**	**	**	NS
LSD	0.24	0.52	-	0.645	0.433	0.969	107.0	248.0	-
CV	8.1		10.9		4.2		1.2		11.5
Interaction of A x B	**		NS		**		NS		
LSD	2.16		-		1.370		-		

Table 6. Response of cucumber genotypes on yield attributing parameters during April planting under open field and plastic house in low hill, Hemja, Kaski, 2004/05

Treatments	Flash thinness (mm)		Hollowness (1-5)		Growth habit (1-5)		Wt. of mis-shapen fruit (t/ha)		Sugar content (° Brix)	
	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)	Plastic(A)	Open(B)
BKT local	15.6	15.6	1.0	1.0	3.0	3.0	6.4	3.8	3.8	3.8
Dhankuta Local	14.0	14.1	1.0	1.0	3.0	3.0	5.2	6.9	3.0	3.0
Super Market	9.2	9.3	1.0	1.0	1.0	1.0	4.4	5.9	2.6	2.6
Ninja -179	12.2	12.3	2.0	2.0	3.0	3.0	0.8	0.5	3.0	3.1
Raniya	16.3	16.4	2.0	2.0	2.0	2.0	0.0	1.6	3.8	3.8
Mahyco G .Long	11.9	11.8	1.0	1.0	2.0	2.0	0.0	0.0	3.0	3.0
KCU-F1	13.2	13.1	1.0	1.0	3.0	3.0	3.1	1.9	3.0	3.0
Kanane	13.5	13.4	1.0	1.0	1.0	1.0	1.9	0.1	3.0	3.0
Malini	14.0	13.9	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0
Kusule	14.9	14.8	2.0	2.0	3.0	3.0	4.2	5.6	4.0	4.0
Mean	13.48	13.45	1.5	1.5	2.4	2.4	2.49	2.54	3.22	3.23
F-Test	**	**	-	-	-	-	*	**	NS	NS
LSD	0.049	0.109	-	-	-	-	1.18	2.74	-	-
CV (%)	0.70		-	-	-	-	89		NS	-
Interaction of AxB	NS		-	-	-	-	NS		0.0	
LSD	-		-	-	-	-	-		-	

Incidence of Powdery mildew and Downy mildew under plastic house

The AUDPC of powdery mildew on February and April planting under plastic house at low hill, Hemja, Kaski showed a significant difference due to genotypes. The lowest AUDPC (78) of powdery mildew on February planting was observed on genotype Mahyco Green Long and it was found at par with genotypes

Ninja-179 (143), KCU F1 (149), Super Market (157), Malini (169) and Dhankuta Local (192) whereas highest AUDPC of powdery mildew (630) was observed on genotype Kusule.

In April planting, there was also significant difference on AUDPC of powdery mildew due to genotypic effect. The lowest AUDPC (118) of powdery mildew was recorded on genotype Mahyco Green long followed by Malini (158.6) and Super Market (163) whereas the highest AUDPC (280.5) was recorded on genotype Bhaktapur Local followed by Ninja-179 (193.1) and Kusule (187.6).

The AUDPC of downy mildew also showed significant differences both on February and April planting under plastic house due to genotypic effect. The lowest AUDPC of downy mildew (211) was recorded on genotype Super Market followed by Raniya (229) whereas the highest (721) was recorded on genotype Ninja-179 followed by KCU-F1 (719) on February planting. In April planting, the lowest AUDPC (275) was recorded on genotype Super Market and the highest AUDPC (552) was recorded on genotype Ninja-179. The detail is presented in Figure 1.

Based on above results the genotypes Super market and Raniya could be used as source materials for tolerance of powdery mildew and downy mildew. However, the genotype Mahyco Green Long was found more tolerance to powdery mildew than other genotypes along with high yield potential.

Incidence of Powdery mildew and Downy mildew under open field condition

There was non-significant difference on powder mildew due to effect of genotypes under open field condition. However, significant difference was recorded on downy mildew due to effect of genotypes. The lowest AUDPC (258) was recorded on genotype Super Market and it was found at par with genotypes Raniya (331), Malini (406) and Mahyco Green Long (420) and the highest AUDPC (1153) on genotype Kusule (figure 2). Even low incidence of downy mildew in genotype Raniya, it was not liked by farmers due to low yield and dark green colour. Based on observation of powdery and downy mildew in different conditions, it is concluded that powdery mildew incidence was found the minimum in open field condition whereas downy mildew incidence was found the minimum under plastic house. It is concluded that the genotypes Mahyco Green Long, KCU-F1, Super Market and Dhankuta Local were found more tolerance to powdery mildew and the genotypes Super Market, Raniya and Dhankuta local were found more tolerant to downy mildew under plastic house. In open field condition, the genotypes Super Market, Raniya, Malini and Mahyco Green long were more tolerant to downy mildew whereas Kusule, Ninja-179 and KCU-F1 were more susceptible to downy mildew. The detail is presented in Figure 2.

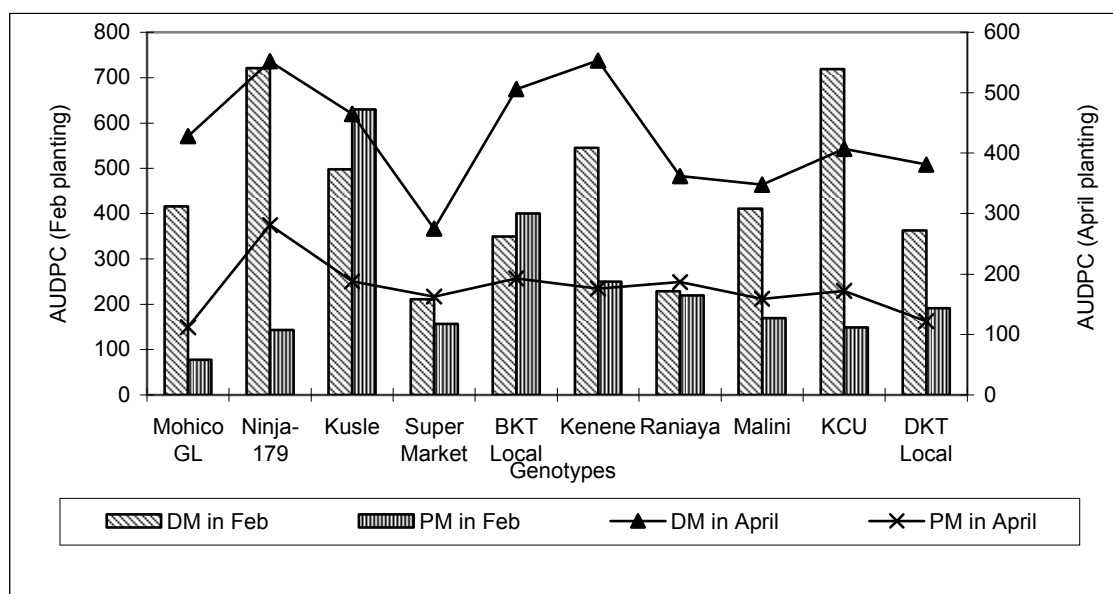


Figure 1. Mean AUDPC of powdery mildew and downy mildew in different genotypes of cucumber grown under plastic house in February and April planting, low hill at Hemja, 2004/05

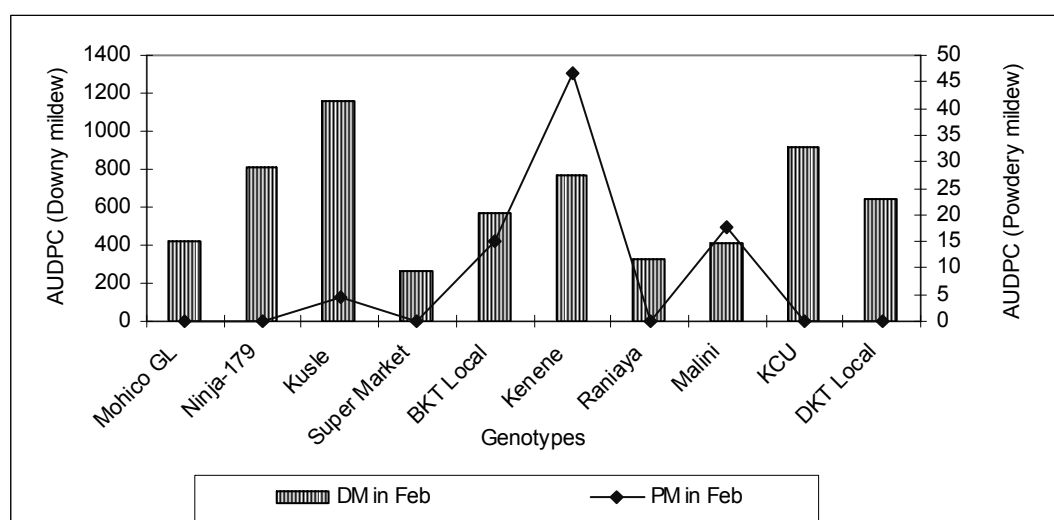


Figure 2. Mean AUDPC of powdery mildew and downy mildew in different genotypes of cucumber grown in open field on February planting, low hill at Hemja, 2004/05.

CONCLUSION AND RECOMMENDATIONS

Based on the results of two planting dates of different cucumber genotypes under plastic house and open field and feed backs from farmers the following conclusion and recommendation have been made for further verification and dissemination of technologies.

- The genotypes Mahyco Green Long (2807 kg/ropani) and Bhaktapur Local (2748.5 kg/ropani) are recommended for February planting on both plastic house and open field due to their higher yield. Commercial farmers preferred growing of cucumber under plastic house due to higher yield and early marketing.
- All the tested genotypes produced statistically higher yield under plastic house than open field for February planting. The farmers, who have the problem of staking, preferred genotype Mahyco

Green Long due to its capacity to produce statistically same quantity of yield over thatching materials ie without staking.

- The genotypes Mahyco Green Long (2765 kg/ropani) and Bhaktpur Local (2730 kg/ropani) are recommended for April planting both for plastic house and open field condition due to their higher yield.
- There is no need of plastic house for genotypes Dhankuta Local, Ninja-179, Raniya, Kanane and Malini for April planting because they have capacity to produce statistically same yield under open field. The genotype Malini produce bitter taste under plastic house condition during this season, this could be due to high temperature.
- Under plastic house conditions, the genotypes Mahyco Green Long, KCU-F1, Super Market and Dhankuta Local were found more tolerance to powdery mildew and the genotypes Super Market, Raniya and Dhankuta local were more tolerant to downy mildew.
- Under open field conditions, the genotypes Super Market, Raniya, Malini and Mahyco Green long were more tolerance to downy mildew whereas Kusule, Ninja-179 and KCU-F1 were more susceptible to downy mildew.
- Powdery mildew incidence was found minimum in open field condition whereas downy mildew incidence was found minimum under plastic house condition

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Evaluation of Plastic-Covered Environment in Cucumber Cultivation for Mid Hill Conditions of Nepal

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ABSTRACT

Plastic-covered environment was evaluated for three factors: a. plastic house (200 gauge normal, 90 and 120 gsm UV- stabilized Silpaulins); b. mulching (with and without black plastic) and c. irrigation (ordinary and magnetized water) on Bhaktapur Local variety of cucumber at Khumaltar during two planting seasons and years to find an economically viable technology for off-season cucumber cultivation in mid-hills. Overall effect of plastic house and mulching was found to increase the marketable cucumber yield by 5.8 and 3.7 kg, per plot (4 sq.m.) respectively. Slight effect of magnetized irrigation on fruit yield was found (0.1 kg/plot) only in March-July planting season. Highest marketable yields of 21.6 kg and 13.8 kg per plot were obtained during Aug-December and March-July seasons in 120 and 90 gsm Silpaulins respectively, by using black plastic mulching and ordinary water. Analysis showed that marketable yield increments due to plot mulching were highly significant in both planting seasons. Interaction of mulching and irrigation on cucumber yield was found to be statistically significant. One of the reasons for lower yield during March planting season was found to be reduction in dry bulb temperature from planting to maturity period. Average increase in dry bulb temperature inside partially covered plastic houses compared to open field conditions was observed to be about 2.2°C. Positive effect of plot mulching was also observed on fruit number/plot, unit fruit weight, fruit length, plant height, number of leaves/plant and soil temperature. Economic analysis for 5 m x 30 m area showed that cucumber cultivation using 120 gsm UV-stabilized Silpaulin with plot mulching was found to give maximum net annual income.

Key words: Black plastic mulching, cucumber, magnetized water, plastic house, UV-stabilized silpaulin

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the cash-generating crops. Its consumption pattern is changing/increasing due to better public awareness on nutritive values, people's realization on importance of vegetables in their diet and also by increased per capita incomes in Nepal. Net return from vegetable farming is mostly higher than other agro-enterprises. However, demand for vegetables in Nepal has not yet been met by domestic production. About 155 MT of cucumber was imported from India and other sources from wholesale market at Kalimati, Kathmandu (KFFVM 2003). Experiences have shown that commercialization of the existing farming practices with the wider adoption of off-season vegetables production technologies can improve the livelihood of the farmers. Development of off-season cucumber production technique could mean enhancement of quality and productivity, favourable market price to farmers and an additional source of income and employment opportunities for growers. The supply is generally reduced and cost is increased during off-season (Oct/Nov -Apr/May). It is advised to cover by some means to save the crop from heavy rain, dews, hailstones and cold injury for modifying natural environment and to create a favorable micro-climate for crop production in adverse situations.

Air temperature is one of the most critical factors, which influences on all physiological activities of plants (Shrestha et al 2001). Cucumber is extremely susceptible to temperature changes. The optimum temperature for the cucumber is about 21°C especially during maturity period. Controlled (plastic covered) environment, a barrier between plant microclimate and ambient conditions helps to increase atmospheric temperature for plant growth and retains soil moisture. It has also the effect of enhancing reflex light, prolonging the effect of light, enhancing photosynthesis and strengthening the crop functioning. It is reported that plastic film technology enables various crops to mature 5-20 days earlier than normal, increases the yield by 30-50 percent (Upadhyay et al 2004). Therefore, this experiment was carried out to find an economically viable technology on plastic covered environment for off-season cucumber cultivation in the mid-hills.

MATERIALS AND METHODS

The study on plastic covered environment was conducted in cucumber crop in two planting seasons (August-December and Mar-July) at Khumaltar during the fiscal years 2003/04 and 2004/05. The experiment was designed in RCBD in factorial arrangements with three replications. The treatment factors were:

Plastic house: 3 levels - normal transparent plastic (200 gauge), UV-stabilized (90 gsm and 120 gsm) Silpaulin and without plastic house (open field condition) as control

Black plastic mulching: 2 levels - with and without mulching

Irrigation: 2 levels - ordinary and magnetized water

Bhaktapur Local variety of cucumber seedlings were used to conduct the study. Row to row and plant-to-plant distances were 1 m each. After planting, irrigation was applied daily for about a week; at 2 days interval for next 30 days and at 3-4 days interval for the rest of the period. Basal dose of fertilizer was applied on pits for each plant as well as in between two rows; at the rate of 328:368:240 kg of N:P:K and at 20 ton of FYM (cow dung and poultry manure mixed), each per ha in channels in between two rows. Basal dose per pit or plant was 36:92:60 kg of N:P:K and 1.25 ton of FYM, each per hectare. Top dressing was done only by N @ 46 kg per hectare. Fertilizer and FYM were uniformly mixed with the soil in pits as well as in channels. Diameter and depth of pit dug was 30 cms and 20 cms respectively. Similarly, channel width and depth, each varied from 20-25 cms.

Statistical analysis of cucumber yield was done for plastic house conditions with year also as one of the factors. Open field conditions were not used for the analysis due to too much lower fruit yield values. Four missing cucumber yield values during March - July planting time in the first year were calculated by the method suggested by Gomez & Gomez (1984) and Snedecor & Cochran (1989). During the study, Lux meter was used to take the observation on solar flux/ illumination in the experimental plots. Those data were later converted in to solar radiation (Watt/sq. m.) by calibration with solar radiation sensor.

Construction Method: The plastic-covered environment consisted of a bamboo frame consisting of bamboo poles, rafters and purlins which were tied by plastic ropes. Bamboo frames were covered with plastic sheets of different types as per treatments. These plastic and Silpaulins were fixed by tying with thick/stiff plastic ropes at about 1 metre distance with the help of vertical poles. Each plastic house consisted of four plots, each 2 m x 2 m size. Of the four plots in each shelter and open field, two plots were provided with mulching and other two were without mulching. Field mulching was done by a black polyethylene sheet. Among the set of two plots, one was irrigated with ordinary water and the other was provided with magnetized water. Magnetized water was produced by fixing/connecting a magnetizer around the polythene pipe close to its discharge end. But, during planting time, ordinary water was provided to all pits made for the purpose. In each plastic house, a passage between plots was kept to provide area for easy movement to supervise and for recording data. During August-December crop period, they were closed from all sides most of the times, except entrance and exit. For March-July period, they were covered from the top only; hence, for this period, manual pollination was not required.

RESULTS AND DISCUSSION

Monthly Dry bulb temperature (DBT) and relative humidity (RH) of air

Constant temperature of 21°C is required for cucumber (Jones 1981), which was not fulfilled in Mar-July season, during maturity period, the crucial time for any crop. Aug-Dec season records about 2.1°C higher temperature inside plastic house compared to Mar-July season, considering that of only up to maturity period when cucumber plant is extremely susceptible to temperature changes (Table 1). Variation of DBT increases inside plastic houses ranged from 1.6°C to 3.6°C for Aug-Dec and from 1.9°C to 2.4°C for Mar-July season. Lower difference of DBT was observed inside plastic houses compared to open field condition, as they were covered only partially; otherwise, it could raise 10-12°C (Arya 2000).

Table 1. Monthly DBT and RH in two crop periods

Month	Dry bulb temperature, °C				Relative humidity, %				Month	Dry bulb temperature, °C				Relative humidity, %			
	OF	200	90	120	OF	200	90	120		OF	200	90	120	OF	200	90	120
g	gsm	gsm	g	gsm	gsm	g	gsm	Gsm	g	gsm	gsm						
Aug	22.8	25.0	24.4	24.4	84.5	79.0	79.1	79.3	Mar	18.6	20.9	21.0	20.9	72.2	68.5	68.8	68.6
Sept	23.8	25.6	25.5	25.5	86.6	81.4	81.7	81.6	Apr	18.5	20.6	20.8	20.6	73.6	69.5	70.1	69.7
Oct	20.0	21.8	21.8	21.8	76.6	73.0	73.2	73.2	May	21.5	23.5	23.4	23.5	76.4	72.1	72.3	71.7
Nov	16.4	18.9	18.7	19.0	70.7	69.7	69.7	69.8	June	23.7	25.6	25.7	25.8	84.8	78.7	79.1	78.7
Dec	11.3	14.6	14.9	14.9	67.5	66.3	65.9	66.1	July	23.8	25.7	25.8	25.7	87.1	80.7	80.7	80.5
Av	18.9	21.2	21.1	21.1	77.2	73.9	73.9	74.0	Av	21.2	23.3	23.3	23.3	78.8	73.9	74.2	73.9

DBT's were average of morning, day and evening conditions; OF Open field; g gauge; gsm gm/sq. m.

RH was found to be reduced with the increase in DBT (Table 1). Reductions of RH inside plastic houses were found to vary from 0.9 to 5.5 percent in Aug- Dec and about 3.4 to 6.6 percent in Mar-July season. During maturity period, RH was found to be lower in Mar-July compared to Aug-Dec season. Low humidity accelerates formation of staminate flowers. High RH helps to increase process of formation of female flowers (Arya 1999).

Daily minimum and maximum temperature

Daily minimum DBT in Mar-July season, especially during maturity period, did not rise above 12°C (Table 2). Jones (1981) mentioned that night temperature should not fall below 16°C for cucumber crop, which was fulfilled during Aug-Dec season. Daily maximum temperature inside plastic houses were observed to be 36.4°C (Aug-Dec season) and 37.2°C (Mar-July season), which were slightly more than recommended by Graham (2005). He stated cucumbers grow well in temperatures up to 35°C.

Table 2. Daily minimum and maximum DBT in two crop periods

Month	Daily minimum DBT, °C				Daily maximum DBT, °C				Month	Daily minimum DBT, °C				Daily maximum DBT, °C			
	OF	200	90	120	OF	200	90	120		OF	200	90	120	OF	200	90	120
	g	gsm	gsm		g	gsm	gsm			g	gsm	gsm		g	gsm	gsm	
Aug	18.2	18.4	19.4	19.9	34.9	35.4	36.2	36.4	Mar	9.6	9.8	10.3	11.2	33.2	34.7	35.7	37.2
Sept	16.2	17.2	17.6	18.5	32.8	34.2	34.4	35.3	Apr	8.3	8.9	9.1	9.9	30.2	31.6	32.4	33.5
Oct	12.5	12.7	12.6	12.6	31.0	31.1	31.5	31.1	May	11.7	12.1	12.3	13.3	31.5	33.8	35.2	35.2
Nov	5.5	6.1	6.6	6.1	29.5	34.4	32.5	35.6	June	14.8	16.1	16.1	17.1	32.0	32.3	32.6	32.3
Dec	0.9	1.7	1.7	2.8	27.0	32.2	31.9	32.3	July	17.9	18.4	18.7	19.0	30.7	30.7	32.4	31.9
Av	10.7	11.2	11.6	12.0	31.0	33.5	33.3	34.1	Av	12.5	13.1	13.3	14.1	31.5	32.6	33.7	34.0

Temperatures were averages of daily records in the day time; OF Open field; g gauge; gsm gm/sq. m.

Days to maturity, plant life and number of harvests

Average days for cucumber fruits to mature in plastic houses in August planting was found to be 47 days with variation from 40 to 54 days (Table 3) which were found to be about 15 days earlier compared to March planting times. Jett et al (2005) mentioned about 45 to 60 days range for maturing cucumber of different cultivars planted in August.

Plant life inside plastic houses was enhanced by 3 days in March compared to August planting. Number of harvests varied from five to seven in August and from three to nine in March planting times.

Table 3. Average days to maturity, plant life and number of harvests in two planting times

Planting time	Year	Days to maturity, days		Plant life, days		No of harvests	
		PH	OF	PH	OF	PH	OF
August	2003/04	40	40	82	61	7	5
	2004/05 *	54	54	107	107	7	6
	Av	47.0	47.0	94.5	84	7	5.5
March	2003/04	58	58	75	75	3	3
	2004/05	67	79	120	107	9	7
	Av	62.5	68.5	97.5	91	6	5

§ Days after transplant; PH Plastic house; OF Open field; * Seeds sowing date

Effect of plastic house on marketable cucumber yield (kg/plot)

August Planting – Highest marketable yield of 21.6 kg ($\approx$ 54 t/ha) was obtained per plot (2 x 2 sq.m.) by 120 gsm Silpaulin in mulching and ordinary water condition (Table 4). Compared to open field conditions, marketable yield increments due to plastic houses were observed to be 85.0, 130.8 and 128.7 percent with equivalent weights of 5.2 kg, 8.0 kg and 7.9 kg, per plot from 200 gauge normal plastic, 90 gsm and 120 gsm Silpaulin sheets respectively (Table 7).

March Planting – During March planting, marketable yield of 13.8 kg/plot from 90 gsm Silpaulin was the highest yielder in mulching and ordinary water condition (Table 4). Increments in marketable yield due to 200 gauge normal plastic, 90 gsm and 120 gsm Silpaulin sheets compared to open field conditions were observed to be about 73.7, 87.2 and 58.8 percent, respectively with equivalent weights of 4.5 kg, 5.3 kg and 3.6 kg, per plot (Table 7). Plot yields were found to be statistically non-significant among the plastic houses.

Table 4. Marketable yields (kg/plot*) of cucumber in plastic houses and open field conditions in two planting times

Planting time	mulching	Irrigation	Plastic house/open field condition					Difference
			200 g	90 gsm	120 gsm	Av	Open field	
August	Mulching	Magnetized	12.0	12.9	12.8	12.6	6.8	5.8
		Ordinary	12.1	18.7	21.6	17.5	7.7	9.8
	Non-mulching	Magnetized	11.2	14.3	10.5	12.0	4.4	7.6
		Ordinary	10.4	11.1	11.6	11.0	5.8	5.2
March	Mulching	Magnetized	13.1	13.3	11.6	12.7	8.6	4.1
		Ordinary	11.2	13.8	12.8	12.6	7.7	4.9
	Non-mulching	Magnetized	7.4	9.4	8.2	8.3	4.2	4.1
		Ordinary	10.5	9.0	6.0	8.5	3.8	4.7

Plot size = 4.0 Sq. m.; g = gauge; gsm = Gram/sq. m.; MW = Magnetized water; OW = Ordinary water

Effect of mulching on marketable cucumber yield

Black plastic mulch helped to increase the marketable cucumber yields; about 32.0 percent (3.2 kg per plot) in August planting and about 57.2 percent (4.2 kg/plot) in March planting (Table 7). Averaging over irrigation and planting times, yield was increased 1.7 times by mulch in open field condition. Jimenez et al. (2004) found 2.1 times increment in cucumber yield by mulch compared to bare soil (open field). Pradhan et al (2005) reported an increment in turmeric yield due to LDPE mulch by about 23 percent compared to un-mulched plot in open field conditions. Analysis showed that plot mulching helped to increase the marketable cucumber yield significantly at 1% level in both planting seasons.

Effect of magnetized water on marketable cucumber yield

Magnetized water was found to increase the marketable cucumber yield slightly (0.13 kg per plot), only in March planting season (Table 7). Analysis showed insignificant role of magnetized irrigation to

increase marketable yield. Interaction of mulching and irrigation on marketable cucumber yield was found to be statistically significant at 5% level.

Effect of planting time on marketable cucumber yield

Marketable cucumber yield for plastic house conditions in August planting was found to be increased by about 25 percent compared to March planting time. For open field conditions also, it was slightly increased ($\approx 2\%$) in August compared to March planting time. Statistical analysis showed that planting time helped to increase the marketable cucumber yield at 1% level of significance.

Effect of solar radiation on fruit yield

Percentage increases in marketable cucumber yields with corresponding reductions of solar radiations were observed in 90 gsm and 120 gsm Silpaulins compared to 200 gauge normal plastic houses in both planting season, except for 120 gsm Silpaulin in Mar-July season when percentage of non-marketable cucumber yield was also reduced for the same Silpaulin (Table 5). Arya 1999 mentioned about the tendency of more light towards increasing the staminate flowers in case of cucumber.

Table 5. Percentage reductions of solar radiations (W/m^2) in Silpaulins and changes in cucumber yields compared to normal transparent plastic houses

Planting season	Parameters	90 gsm	120 gsm
Aug-Dec	Reduction in solar radiation, %	22.2	33.3
	Increase in marketable cucumber yield, %	25.4	23.7
	Reduction in non-marketable cucumber yield, %	1.2	-3.0
Mar-July	Reduction in solar radiation, %	23.6	30.9
	Increase in marketable cucumber yield, %	7.5	-8.5
	Reduction in non-marketable cucumber yield, %	42.0	34.0

Effect of sunshine hour

Total sunshine hour observed during Aug-Dec was found to be more than during Mar-July planting season (Table 6). But, within planting to maturity period, the most critical vegetative stage, total sunshine hour was found to be lower in Aug-Dec than in Mar-July season. However, average cucumber yield of Aug-Dec was more than in Mar-July planting season. It showed that length of day light hours have no effect on cucumber yield. It verifies the description by Arya (1999) that cucumber is among the cucurbits and they are day neutral crops.

Table 6. Total sunshine hour during two crop periods and from planting to maturity period compared to average marketable cucumber yield

Planting time	Sunshine hour		Marketable cucumber yield, kg/plot
	Total	Planting to maturity period	
Aug-Dec	961.4	279.9	11.5
Mar-July	938.5	449.4	9.4

Effect on fruit number per plot

A highest number (37) cucumber was obtained per plot (2×2 sq.m.) by 120 gsm Silpaulin in mulching and ordinary water condition in August planting time. Fruit numbers were observed to be increased due to various plastic houses and mulching in both planting times (Table 7). Magnetized water slightly helped to increase the fruit number in March planting only.

Effect on unit fruit weight

Jett (2005) found maximum unit fruit weight of cucumber among few cultivars in high tunnel to be 12.4 oz (about 352 gm). Maximum unit fruit weight of 841 gm was recorded in Bhaktapur Local variety by non-mulching and magnetized water condition during March planting by 90 gsm Silpaulin. Unit fruit weight was observed to be increased due to plastic houses and mulching in both planting seasons (Table 7). Magnetized water helped to increase it only during March planting time.

Table 7. Effects of plastic houses, mulching and magnetized water on marketable fruit and plant characters and on soil temperature in two crop periods

Fruit and plant Characters	Aug – Dec crop period					Mar – July crop period				
	200 g	90 gsm	120 gsm	M	MW	200 g	90 gsm	120 gsm	M	MW
Marketable yield, kg/plot	5.2	8.0	7.9	3.2	-1.8	4.5	5.3	3.6	4.2	0.1
Fruit number	10.9	14.4	14.3	4.5	-3.1	5.7	8.7	6.7	7.8	0.3
Unit weight, gm	107.5	129.1	131.3	61.1	-20.0	123.8	230.2	86.3	116.2	71.8
Length, cm	2.5	3.0	3.0	1.1	0.2	2.2	2.8	1.4	3.1	0.5
Diameter, cm	0.4	0.5	0.4	0.0	-0.3	0.0	0.4	0.2	0.2	-0.1
Plant height, cm	-19.7	1.8	-3.3	16.6	-10.6	-4.1	20.5	11.2	111.7	-4.4
No. of leaves per plant	-12.8	-1.8	-7.1	38.1	-1.9	-17.2	-11.0	-15.1	43.2	-3.0
Soil temperature, °C	0.2	-0.2	-0.5	0.7	0.0	-1.9	-1.6	-1.4	0.3	-0.3

M = mulching; MW = magnetized water; g = gauge; gsm = gram per sq. m.; minimum of 3 fruits were selected for unit wt., length & diameter measurements; (-) Negative values show the reductions

Effect on fruit size and plant characters

Cucumber lengths and diameters were slightly increased due to plastic houses in both planting seasons. Mulching and magnetized water were also found to increase their lengths in both the seasons. Average fruit diameter was also increased slightly by mulching in March planting only.

Plant heights were mainly found to be reduced due to plastic houses during August planting where as they were increased during March planting season. Mulching helped to increase the plant heights in both planting times but it was found to be reduced due to magnetized water. Numbers of leaves per plant were also found to be reduced due to plastic houses. Mulching helped to increase the leaf number where as it was reduced due to magnetized water conditions.

Effect on soil temperature

Soil temperatures at about 5 cm depth were found to be reduced inside plastic houses in both planting times. Slight increases in soil temperatures were observed due to mulching in both planting times. However, it was reduced due to magnetized water, especially in March planting time.

Cost benefit analysis

Assuming the area covered by passage and drain to be 16 percent of the total, cost benefit analysis was done for 150 sq. m. plot (30 m x 5 m) for all growing conditions. Total fixed cost, total operational cost and annualized cost of production for plastic houses and open fields in mulching and non-mulching conditions were presented in Table 8. Considering cucumber yields for ordinary water conditions and market rates during Oct-Dec and May-July averaged at NRs. 16.20 (US \$ 0.213) and NRs. 19.20 (US \$ 0.252; pessimistic estimate; 1 US \$ = NRs. 76.15; Nov 9, 2008) respectively, net annual income were calculated for each condition. Highest net annual income of NRs. 7116.00 (US \$ 93.45) was obtained from 120 gsm Silpaulin with mulching which gives about NRs. 24000.00 (US \$ 315.17) per Ropani and about NRs. 470000.00 (US \$ 6172) per hectare.

Table 8. Cost analysis for 30 m x 5 m area in ordinary water condition

Variables	Open field		200 g		90 gsm		120 gsm	
	Mulch	Non-mulch	Mulch	Non-mulch	Mulch	Non-mulch	Mulch	Non-mulch
Total fixed cost	1455	-	16290	14792	26865	25366	30264	28766
Total operational cost	3394	3675	4781	4946	4902	5112	4950	5270
Annualized cost of production	7418	7350	24223	23204	20103	19948	16818	17116
Income from sale, NRs.	12866	7440	19995	16192	24068	17844	23934	14709
Net profit, NRs.	5448	90	-4228	-7013	3965	-2104	7116	-2406

Note: cost of weeding & irrigation for mulching & non-mulching: NRs. 120.00 & 500.00 resp.; Cost of harvesting and planting/sale varied with volume of harvest; interest & salvage value 10% each; g gauge; gsm gm per sq.m.; Assumed Life: normal plastic (200 g) 1 year, Silpaulin (90 gsm) 3 year, Silpaulin (120 gsm) 7 year; Market rates were NRs. 16.20 (Oct-Dec average) for Aug-Dec and 19.20 (May-July average) for Mar-July planting seasons.

CONCLUSION

- 120 gsm Silpaulin with black plastic mulching is highly profitable for cucumber cultivation
- Effect of magnetized water needs to be tested on other vegetables
- Silpaulins of other thickness should also be tested in future
- Study should be continued with semi-permanent plastic houses with air temperature control

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Performance of Pole Type French Bean in the Western Hills of Nepal

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ABSTRACT

Sixty-four accession of pole type French bean genotypes were collected from different parts of Mustang, Myagdi and Kaski districts of western Nepal and evaluated under observation nursery at Hemja (1000 masl), Kaski during post monsoon of 2000. Eighteen pole bean genotypes introduced from USA and evaluated under observation nursery at Rising Patan (450 masl) Outreach Research (OR) site of Agriculture Research Station (ARS), Lumle during post monsoon of 2000. Trial was conducted in RCBD with three replications. Selected promising entries from observation nurseries were evaluated under co-ordinated varietal trial at Rising Patan, Tanahu; ARS Pakhribas and ARS Lumle during spring season (February to June 2001), summer season (April to August 2001) and pre and post monsoon seasons (April to August and August 2001 to January 2002), respectively. Economically the performances of these genotypes were found almost similar at all locations. The most promising genotypes were Lumle Bean-31 (LB-31 is Rattle Snake), LB-37 (Kentucky Wonder Improved), LB-39 (Kentucky Wonder White) and Four Season in terms of yield and other horticultural traits. Considering over all performance of genotypes, LB-37 was found superior among the tested in terms of marketable fresh pods yield (12 t/ha) resistant to bean rust and other horticultural traits from river basin to mid hills.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) (Synonyms kidney bean, haricot bean, snap bean, navy bean and common bean) is one of the most important legume crops, grown for the pulses as well as fresh vegetable (Rubatzky and Yamaguchi, 1996). It is grown for the tender pod, shelled green beans and dry beans (rajmah). It can adopt under wide range of soil and climatic conditions (Schoon et al 1991). French beans contain high amount of protein, vitamins and minerals. The leaves and stems are also good source of livestock fodder

According to growth habit, French beans can be classified in to two broad groups, determinate (bush type) and indeterminate type (pole type). The determinate type does not need staking where as, indeterminate type requires staking in the cultivation for increasing yield and better quality.

The pole type French beans are cultivated as sole crop, mixed crop or under orchard as an inter crop for tender pods and dry beans. These thrive well under poor soil and management conditions, which are common in the hills of Nepal. The pole type French beans having multiple uses are an important part of farming system in the hills of Nepal. Animal protein is expensive and is not affordable by the majority of the hill farmers; moreover its regular availability in rural areas is difficult. In such condition, French bean are provides cheap and main source of protein in the diet of people living in the hills. These are also soil-restoring crop (fix atmospheric nitrogen) which can be fitted advantageously in the cropping system in order to maintain soil fertility. Due to higher nutritional value and good taste, the fresh bean pods fetch very high market price and are important source of cash generation for poor, subsistence, semi-commercial and commercial scale farmers in the river basin to high hill areas of Nepal. It is therefore, the Agriculture Perspective Plan (APP, 1995) categorized this vegetable crop as a high value crop and thus given due priority in the periodic plan.

Previous works carried out at the Agriculture Research Station (ARS) Lumle revealed that Kentucky Wonder, an indeterminate variety has been very popular among the farmers and known as GHIU SIMI (Lohar et al 1993) and released as Trishuli Simi. However Kentucky Wonder is highly susceptible to bean rust (*Uromyces phaseoli*) and anthracnose disease (*Colletotrichum lindemuthianum*) (Pradhanang and Pandey, et al 1991). Local landraces have poor quality to be used as the vegetable purpose (Bhattarai and Subedi 1996). However, there are several limiting factor to cultivate and production of pole type French beans in the hills of Nepal. Bhattarai et al (1997) reported that the main researchable problems/constraints are as follows:

- 1) Lack of suitable varieties for the wider adoption and large-scale production of the pole type of French bean in the hills.
- 2) The local varieties are not suitable for commercial production and export due to low yield and poor pod quality.
- 3) Lack of suitable technologies on cultural practices, disease management and pest control, which reduced in the yield and market value of pole type French bean.

Hence, this study was conducted to develop the complete package of practices for the pre and post monsoon seasons cultivation prevailing in the country.

MATERIALS AND METHODS

Sixty-four genotypes of pole type French bean were collected from Myagdi, Mustang and Kaski districts in July 2000 and evaluated in observation nursery at Hemja during post-monsoon of 2000 for their economic/horticultural traits. Similarly, 18 genotypes of pole bean were introduced from the USA in August 2000 and total of eighty two genotypes were evaluated in observation nursery at ARS Lumle and OR site Rising Patan during post monsoon of 2000. Selected promising lines from the observation nurseries were evaluated under Co-ordinated Varietal Trial (CVT) at randomised complete block design (RCBD) with three replications at OR site Rising Patan, Tanahun during spring season (Feb, 2001); ARS Lumle and ARS Pakhribas during summer season (April to August 2001). Elite genotypes were again evaluated at ARS Lumle during post monsoon (Aug, 2001) in a RCBD with four replications. The distance of CVT was at 75 cm row-to-row and 45 cm plant-to-plant with 2.05 m² net harvesting area. Fertilizers were applied @ 40:60:30::N:P₂O₅:K₂O kg/ha along with 15 ton compost. All the cultural practices were performed as required. Observations were taken on date of seeding, plant population at establishment, days to fifty percent flowering, days to first harvest, number of picking, days to last harvest, marketable fresh pod yield, pod length, pod diameter, shape, colour and fibre content in fresh pod at harvest (1-low, 2- medium, 3- high), response to bean rust, major insect- pests and socio- economic parameter as a market price and farmer choice in terms of taste were recorded. The data were analysed on MSTAT Software package of the computer.

RESULTS AND DISCUSSION

Performance of promising lines pole bean selected from observation nurseries under CVT at Rising Patan (450 masl), Tanahun during spring season of 2001

Days to fifty-percent flowering: Highly significant effect was observed among the tested genotypes on days to fifty-percent flowering but non-significant result was observed within LB-32, LB-33, LB-35 and LB-39. LB- 32 was found earlier (47 days) where as, Kentucky wonder was found late (64 days) (Table 1).

Marketable fresh pod yield: Highly significant effect was observed among the tested genotypes on marketable fresh pod yield. Genotype Four-seasons produced highest yield (4.5 t/ha) where as, LB-32 produced the lowest (0.7 t/ha) (Table 1).

The marketable fresh pod yield was found less during spring season but the genotypic trend in terms of yield was found similar in subsequent evaluations. However, due to the production in spring season, the fresh pod fetched very high market price (NRs. 40/kg) and the cultivation was found economical.

Fibre content: Kentucky wonder, Four seasons, LB-31, LB-32, LB- 33, LB-37 and LB-39 genotypes were with less fibre (1) where as, the medium (2) in Manoa wonder, LB-38, LB-35 and LB-36 which was most desirable character for consumers points of view (Table 1).

Table 1. Performances of pole type French bean genotypes at Rising Patan (Feb. - June 2001)

S.N	Genotypes	Days to 50% flowering	No. of plant harvested	Pod length (cm)	Pod diameter (mm)	Marketable fresh pod yield (t/ha)	Fiber content
1.	Kentucky Wonder	64	15	12.5	8.6	2.6	1.0
2.	Four Season	56	15	13.7	8.2	4.5	1.0
3.	Manoa Wonder	58	13	10.3	5.3	2.2	2.0
4.	LB-31	60	15	13.5	7.6	2.7	1.0
5.	LB-32	47	15	9.9	8.5	0.7	1.0
6.	LB-33	50	15	11.7	7.0	2.5	1.0
7.	LB-37	54	15	12.2	7.6	3.0	1.0
8.	LB-38	57	15	9.2	7.1	1.8	2.0
9.	LB-39	50	15	14.1	8.3	1.3	1.0
10.	LB-35	49	15	8.0	5.5	1.0	2.0
11.	LB-36	53	15	10.5	8.3	0.9	2.0
	F-value	***	Ns	Ns	Ns	***	**
	CV (%)	6.1	9.3	35.1	18.9	22.3	23.4
	LSD	5.7				0.8	0.5

Note: 1=low, 2= medium and 3=high for fibre content.

The marketable fresh pod yield was less during spring season but the genotypic trend in terms of yield was found similar in subsequent evaluations. However, the fresh pod fetched very high market price (NRs. 40/kg) and the cultivation was found economical in spring season.

Performance of promising genotypes of pole bean under CVT at ARS Lumle Kendra during spring season of 2001

Pod length: Highly significant effect was observed among the tested genotypes on pod length but non-significant result was observed within LB-39, LB-37 and Manoa wonder genotypes. The genotype LB-39 produced the longest pod length (20.3 cm) where as, LB-32 produced the shortest (14.5 cm) (Table 2).

Pod diameter: Significant effect was observed among the tested genotypes on pod diameter except Manoa wonder and LB -39. The genotype Manoa wonder had the highest diameter (11.1 mm) where as, the lowest (8.6 mm) recorded on four seasons (Table 2).

Marketable fresh pod yield: Highly significant effect was observed among the tested genotypes on marketable fresh pod yield but non-significant result was observed within LB-31, LB-37, LB-39, Manoa wonder and four seasons. The genotype LB-31 produced the highest yield (12.3 t/ha) where as, LB-33 produced the lowest (3.5 t/ha) (Table-2).

Fibre content: Significant effect was observed on fibre content in the fresh pod, which was desirable character for marketing and consumers point of view. Genotypes LB-32, LB-37, LB-39, LB-33 four seasons and Kentucky wonder were found the minimum in fibre content (1) and these all are significantly at par where as, the maximum found in Manoa wonder and LB-31 (ie 2) (Table -2).

Table 2. Performance of pole type French bean genotypes at ARS Lumle during spring season (April–Aug 2001)

SN	Genotypes	Days to 50% flowering	Days to 1 st picking	Days to last picking	No. of picking	No. Of plant harvested	Pod length (cm)	Pod diameter (mm)	Marketable fresh pod yield (t/ha)	Fiber content
1.	Kentucky Wonder	55	83	103	2	34	17.4	9.2	7.3	1
2.	Four Season	55	83	103	3	34	18.1	8.6	10.47	1
3.	Manoa Wonder	52	78	103	3	35	19.3	11.1	10.5	2
4.	LB-31	52	78	103	3	36	17.0	9.2	12.3	2
5.	LB-32	55	83	103	3	36	14.5	8.7	5.4	1
6.	LB-33	55	86	99	2	33	17.4	8.7	3.5	1
7.	LB-37	57	83	103	3	35	19.0	9.2	12.0	1
8.	LB-39	55	78	103	3	35	20.3	10.1	12.0	1
	F-value	NS	NS	NS	NS	NS	***	*	**	*
	CV (%)	4.6	9.1	2.2	20.8	6.0	5.5	8.7	24.5	5.7
	LSD						1.7	1.4	4.0	0.6

Rating scale: 1 = lees, 2= medium and 3=high fibre in the fresh pod

Performance of promising genotypes of pole bean under CVT at ARS, Pakhribas, Dhankuta during summer season 2001

Days to fifty-percent flowering: Significant effect

It was observed among the tested genotypes on days to fifty-percent flowering but non-significant result was observed within Kentucky wonder, Four seasons, Manoa wonder, LB-31, LB-33 and LB-39. The LB-39 was found early maturing (72 days) where as, LB-37 was late (77 days) (Table 3).

Pod length: Highly significant effect was observed on the tested genotypes on pod length but non-significant result was observed within LB-39, Kentucky wonder and Manoa wonder. The genotype LB-39 produced longest (21.0cm) where as, LB-32 produced the shortest pods (13.1cm) (Table 3).

Pod diameter: Highly significant effect was observed among the tested genotypes on pod diameter but non-significant result was observed within Manoa wonder, Kentucky wonder and LB-39. Manoa wonder produced the highest diameter (9.9 mm) where as, the lowest diameter recorded in LB-32 (6.9 mm) (Table-3).

Marketable fresh pod yield: Highly significant effect was observed among the tested genotypes on the marketable fresh pod yield. The genotype Manoa wonder produced the highest yielded (13.8 t/ha) and found superior where as, the LB-32 produced lowest (3.3 t/ha) (Table 3).

Fibre content: Highly significant effect was observed on fibre content in the fresh pod. Minimum fiber content observed in LB-31, LB-32, LB-33, LB-37, LB-39, Four seasons and Kentucky wonder. (1) and these all are significantly at par where as, the high fibre content recorded in Manoa wonder (ie 2) (Table-3).

Performance of different eight promising genotypes of pole bean under CVT at ARS, Lumle and ARS, Pakhribas during summer season of 2001

Days to fifty-percent flowering: Significant effect was observed among the tested genotypes on days to fifty-percent flowering but non-significant result was observed within Kentucky wonder, Four seasons, Manoa wonder LB-31, LB-32, LB-33 and LB-39. The genotypes four seasons and Manoa wonder was found earlier (63 days) where as, LB-37 found late (67 days) (Table 4).

Pod length: Highly significant effect was observed among the tested genotypes on pod length but non-significant result was observed within LB-37 and Manoa wonder genotypes. Genotype LB-39 produced the longest pod length (20.6 cm) where as, the shortest pod length recorded in LB-32 (13.8 cm) (Table 4).

Pod diameter: Highly significant effect was observed among the tested genotypes but non-significant result was observed within Manoa wonder, Kentucky wonder and LB-39 on pod diameter. Genotype Manoa wonder produced the highest diameter (10.5 mm) where as, LB-32 produced the lowest (7.8 mm) (Table 4).

Marketable fresh pod yield: Highly significant effect was observed among the tested genotypes on the marketable fresh pod yield but non-significant result was observed within LB-31, LB-37, LB-39, four seasons, Manoa wonder and Kentucky wonder. The genotype Manoa wonder produced the highest yield (12.2 t/ha) whereas, LB-32 produced lowest (4.3 t/ha) (Table 4).

Fibre content: Highly significant effect was observed on fibre content in the fresh pod yield. Minimum fiber content was found in LB-32, LB-33, LB-37, LB-39, Four seasons and Kentucky wonder found minimum (1) and these all are significantly at par where as, the high amount of fibre content was recorded in Manoa wonder and LB-31 (ie 2) (Table 4).

Table 3. Performances of pole type French bean genotypes at ARS Pakhribas during summer season 2001

SN	Genotypes	Days to 50% flowering	No. of plant harvested	Pod length (cm)	Pod diameter (mm)	Marketable fresh pod yield (t/ha)	Fiber content
1.	Kentucky Wonder	73	11	18.9	9.7	11.0	1
2.	Four Season	73	11	16.3	7.9	11.7	1
3.	Manoa Wonder	73	10	20.1	9.9	13.8	2
4.	LB-31	74	11	18.6	7.2	5.8	1
5.	LB-32	77	11	13.1	6.9	3.3	1
6.	LB-33	73	12	15.5	7.6	5.7	1
7.	LB-37	77	10	18.5	7.5	7.0	1
8.	LB-39	72	12	21.0	9.6	8.3	1
	F-value	*	Ns	***	***	***	**
	CV (%)	2.4	8.9	7.3	9.0	13.4	22.12
	LSD	3.1		2.3	1.3	2.0	0.5

Note: 1 =low, 2= medium and 3=high for fibre content.

Table 4. Performances of promising genotypes of pole bean under CVT at ARS, Lumle and ARS, Pakhribas during summer season of 2001

SN	Genotypes	Days to 50% flowering	Pod length (cm)	Pod diameter (mm)	Marketable fresh pod yield (t/ha)	Fiber content
1.	Kentucky Wonder	64	18.2	9.5	9.2	1
2.	Four Season	63	17.2	8.2	11.0	1
3.	Manoa wonder	63	19.7	10.5	12.2	2
4.	LB-31	63	17.8	8.2	9.0	1
5.	LB-32	66	13.8	7.8	4.3	1
6.	LB-33	64	16.4	8.2	4.6	1
7.	LB-37	67	18.7	8.3	9.5	1
8.	LB-39	64	20.6	9.8	10.1	1
	F-value	*	***	***	***	***
	CV (%)	3.5	7.3	9.4	30.9	27.5
	LSD	3.0	2.2	1.0	3.2	1.0

Note: 1 =low, 2= medium and 3=high for fibre content.

Performance of elite genotypes of pole bean at ARS Lumle during post monsoon season of 2001

Days first picking: Significant effect was observed on days to first picking among the tested genotypes. Genotypes LB-26-1 and LB-31 were found early maturing type (78 days) and these all are significant at par where as, four seasons was recorded as late (83 days) (Table 5).

Days last picking: Highly significant effect was observed among the tested genotypes on last picking but non-significant result was observed within LB-31, LB-37, LB-39, Four season and Kentucky wonder genotypes (Table 5).

Number of pickings: Highly significant effect was observed on number of picking among the tested genotypes but non-significant result was observed within LB-31, LB-37, LB-39, four season and Kentucky wonder genotypes. However, the performance of genotypes was found almost similar (Table 5).

Marketable fresh pod yield: Highly significant effect was observed among the tested genotypes on marketable fresh pod yield but non-significant result was observed within LB-31, LB-37, LB-39 and Four seasons. The genotype LB-37 produced the highest yield (11.8 t/ha) where as, genotype LB-26-1 produced lowest yield (4.3 t/ha) (Table 5).

Fibre content: Highly significant effect was observed on fibre content in the fresh pod. Minimum fiber content was observed in LB-37, LB-39, Four seasons and Kentucky wonder (1) and these all are significantly at par (Table 5).

Table 5. Performances of pole type French bean genotypes at ARS Lumle during post monsoon season (August- December 2001)

SN	Genotypes	Days to 50% flowering	Days to 1 st picking	Days to last picking	Number of picking	Marketable fresh pod yield (t/ha)	Fiber content
1.	LB-26-1	57	78	95	2	4.3	2
2.	LB-31	56	80	105	3	10.8	2
3.	LB-37	62	82	105	3	11.8	1
4.	LB-39	58	82	105	3	10.0	1
5.	Four Season	63	83	105	3	9.7	1
6.	Kentucky Wonder	56	81	104	3	7.7	1
	F-value	NS	*	**	***	***	*
	CV (%)	7.7	2.1	2.7	7.3	15.3	26.6
	LSD		3.0	5.0	0.4	2.4	1.0

Note: 1 =low, 2= medium and 3=high for fibre content.

The summary performance of the five elite genotypes of pole bean in different seasons of the years and locations

The average performance of elite genotypes during various seasons and different locations are presented in Table 6. The days to fifty percent flowering ranged from 60 days after sowing (LB-39) to 62 days (LB-37) having the difference of 2 days among the best five genotypes; indicating not much economic importance. The pod length ranged from 16.5 (Kentucky Wonder) to 19.0 cm (LB-39) having difference of 3.5 cm. The pod diameter ranged from 8.2 (LB-31) to 9.5 mm (LB-39) with a difference of 1.3 mm. The marketable fresh pod yield ranged from 7.2 t/ha (Kentucky Wonder) to 9.1 t/ha (Four Season) with a difference of 1.9 t/ha. The pod length, pod diameter, marketable fresh pod yield and fiber content are most important characters and differences were found in elite genotypes. Similarly the fiber content of the tested genotypes was found almost similar in all.

Genotypes showed significant differences in final disease severity of bean rust during spring season at river basin (Table 7) under the natural epiphytotic condition for bean rust. The final disease severity (%) ranged from 25 (Four Season) to 71.7 (LB-35). Disease progress curves of rust on selected genotypes are shown below (Figure 1). Four Season, Manoa Wonder and LB-37 showed similar curve with lower

disease progress than other genotypes. LB-39 was prone to rust disease as exhibited by high disease progress curve.

Figure 1 presents the bean rust disease severity (%) and marketable fresh pod yield on the pole type French bean genotypes during August-December, 2001 at ARS, Lumle under the natural epiphytotic condition for bean rust. The range of disease severity was 20 percent (LB-26-1) to 60% (LB-39). However the yield and other horticultural traits of LB -26-1 were found inferior to the rest of the tested genotypes. The genotype LB-37 was found having comparatively less bean rust severity (36.7%) at pod ripe stage and good in other horticultural traits.

DISCUSSION

The pole bean genotypes LB-31(Rattle Snake), LB-37 (Kentucky Wonder Improved) and Four Season can be grown in river basin areas during spring and autumn seasons and can be fitted well into existing cropping system viz. pole bean-rice and maize-pole bean respectively. Before July 2000, trials of bush and pole type French bean were done in one experiment. Due to this reason, actual performance of bush and pole bean genotypes could not be observed, because pole bean genotypes produced the higher pod yield and have the longer production period than bush type French bean. The pole type French bean requires certain extra operation such as proper staking, wider spacing, more fertiliser etc. for increasing the yield and better quality. Therefore, from July 2000, trials were arranged separately in to two categories

These genotypes can also be grown in mid-hills in pre and post-monsoon seasons. Thus, the availability of fresh bean pod can be extended throughout the year exploring the potential of off-season vegetable production. The average market price of fresh bean pod of spring season, summer season and post monsoon seasons were noted down as @ NRs. 40/kg, 20/kg and 30/kg respectively in local market and also near to research sites. The highest price of spring season was due to unavailability of fresh bean pod during April- May.

New pole bean genotype LB-39 (Kentucky wonder white 9) produced the longest pod length (19.0 cm) followed by LB-37 (17.2 cm) (Kentucky wonder improved as compared to genotypes released/promising in previous years as reported by Shrestha et al (2000) and Lohar, et al (1996). However, farmers preferred LB-37 genotype due to moderate resistant of bean rust and good taste.

Table 6a. Overall performance of elite Pole type French bean genotypes conducted in different seasons during 2001

Genotypes	Location / year / season														
	Rising Patan Feb.- June 2001 spring season planting														
	ARS Lumle (Kaski)						ARS Pakhribas (hankuta)								
	ARS Lumle (Kaski)						ARS Pakhribas (hankuta)								
Days to 50 % flowering	Marketable pod yield (t/ha)	Fiber Content	April – Aug.2001 summer season planting		Aug. – Dec. 2001 post monsoon season planting		Days to 50% lowering		Days to 50% lowering		Days to 50% lowering	Marketable pod yield (t/ha)	Fiber content		
			Days to Fifty % lowering	Marketable pod yield (t/ha)	Fiber content	Days to Fifty % lowering	Marketable pod yield (t/ha)	Fiber content	Days to Fifty % lowering	Marketable pod yield (t/ha)				Fiber content	
LB-31	60	2.7	1	52	12.3	1	56	10.8	2	74	5.8	1	61	7.9	1.4
LB-37	54	3.0	1	57	12.0	1	62	11.8	1	77	7.0	1	62	8.2	1.1
LB-39	50	1.3	1	55	12.0	1	58	10.0	1	72	8.3	1	60	7.9	1.1
Four sseason Kentucky Wonder	56	4.5	1	55	10.4	1	63	9.7	1	73	11.7	1	61	9.1	1.1
	64	2.6	1	55	7.3	1	56	7.7	2	73	11.0	1	62	7.2	1.3

Table 6b. Overall yield performance of elite Pole type French bean genotypes conducted in different seasons during 2001

Genotypes	Rising-Patan			ARS Lumle			ARS Pakhribas			Mean	
	Pod length (cm)	Pod diameter (mm)	Pod length (cm)	Pod length (cm)	Pod diameter (mm)	Pod length (cm)	Pod length (cm)	Pod diameter (mm)	Pod length (cm)	Pod diameter (mm)	Pod diameter (mm)
LB-31	13.5	7.6	17.0	17.0	9.2	9.0	18.6	7.2	16.5	8.2	8.2
LB-37	12.2	7.6	19.0	19.1	9.2	9.1	18.5	7.5	17.2	8.4	8.4
LB-39	14.1	8.3	20.3	20.5	10.1	9.9	21.0	9.6	19.0	9.5	9.5
Four season	13.7	8.2	18.1	18.0	8.6	8.4	16.3	7.9	16.5	8.2	8.2
Kentucky wonder	12.5	8.6	17.4	17.2	9.2	9.0	18.9	9.7	16.5	9.1	9.1

Note: In fiber content 1=low, 2= medium and 3 = high

Table 7. Final disease severity of rust on the pole bean genotypes at Rishing Patan, Tanahun during spring season of 2001

SN	Genotypes	Final Disease Severity (%) ^a
1	LB -32	53.3 (47.0) ^b
2	LB- 35	71.7 (67.6)
3	LB- 36	35.0 (36.3)
4	LB- 37	28.3 (32.0)
5	Four Season	25.0 (29.3)
6	K. Wonder	35.0 (36.1)
7	LB- 5A	30.0 (33.0)
8	Manoa Wonder	26.7 (30.8)
9	LB- 39	63.3 (53.1)
10	LB- 38	43.3 (41.2)
11	LB- 31	40.0 (38.9)
12	LB- 33	30.0 (33.0)
P-value		0.02*
CV%		29.2
LSD at 0.05% level		19.7

Note: ^a = Means of 3 replications. ^b = Values in parenthesis are arcsine transformation. * = significant at 5% level.

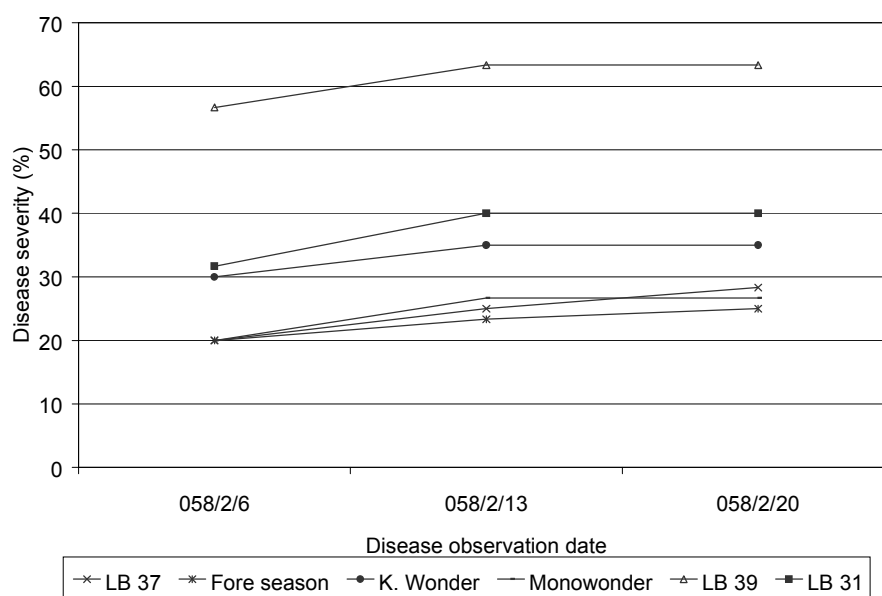


Figure 1. Disease progress curve of rust on selected pole type bean genotypes at Rishing Patan, Tanahun in 2001

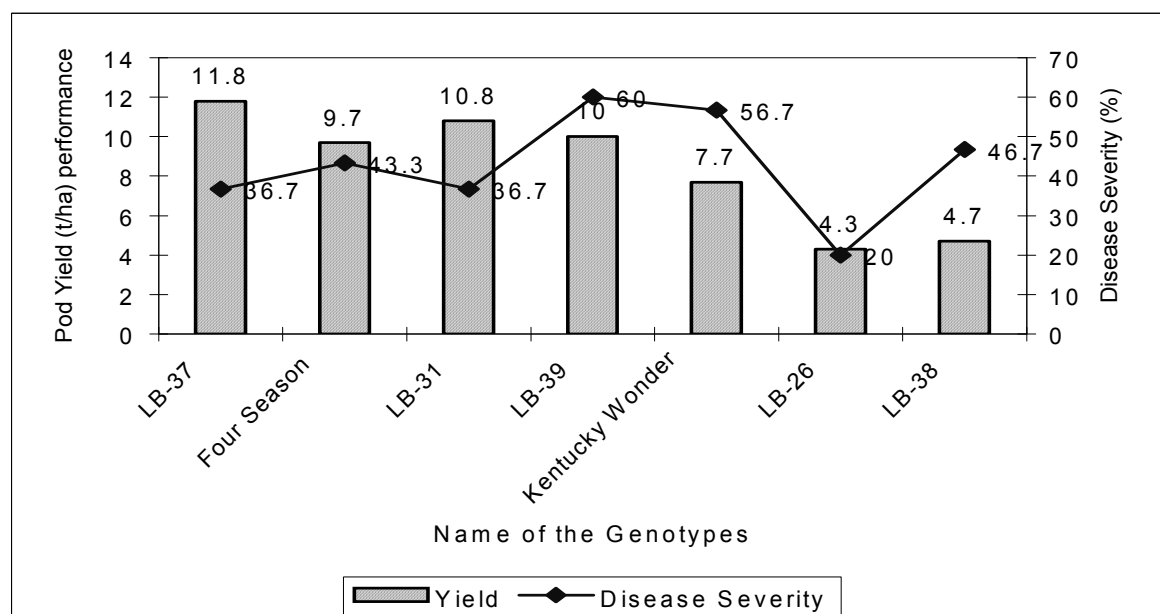


Figure 2. Mean marketable fresh pod yield and percentage disease severity of bean rust on pole type of French bean at pod ripe stage during the post monsoon season of 2001 at ARS Lumle.

Fibre content is an important criteria, which determines price of a particular genotypes of French bean. Genotypes LB-37, LB-39 and four season have low fibre content than LB-31 and Kentucky wonder which fulfil the problem raised by GC et al (1997).

Four season produced the highest marketable fresh pod yield in OR site Risingpatan, Tanahun (2000) and ARS, Pakhribas (2000) i.e. 4.5 and 11.7 t/ha respectively. LB-37 produced the highest yield in ARS, Lumle during 2000 summer and post monsoon season ie 12.3 and 11.8 t/ha respectively. However, average yield over years and locations showed that four season produced the highest yield (9.1 t/ha) followed by LB-37 (8.2 t/ha). The marketable fresh pod yield was found less during spring season but the genotypic trend in terms of yield was found similar in subsequent evaluations but fresh pod fetched very high market price (@ NRs. 40/kg) and the cultivation was found economical.

Under the natural epiphytotic condition LB-37 was found having less bean rust severity and good in other traits during post monsoon season (August to December) at ARS, Lumle. Evaluation of pole bean genotypes for bean rust during post monsoon season at pod ripe stage, the plant height covered by disease and rust severity were found 63.3 and 36.7 percent, respectively in LB-37. Where as the plant height covered by disease was found 76.7 and 43.3 and 100 percent and disease severity 60, 90 and 56.7 percent in Four Season, LB-39 and Kentucky Wonder, respectively. Thus, LB-37 can be regarded as moderately resistant to bean rust.

CONCLUSION

- LB-37 and Four Season can be grown in different seasons in river basin to mid hills of Nepal.
- LB-37 and Four Season are proposed for varietal release.
- LB-37 should be tested in high hills during summer season.

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Clubroot Disease of Brassica Vegetables: Non-Chemical Tools for Its Integrated Management

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ABSTRACT

Clubroot disease caused by a soil borne pathogen, *Plasmodiophora brassicae* Woronin is an economically important disease of brassica vegetables in Nepal. Hundred percent losses have been observed in some of the pockets at Kathmandu and Palung valleys. Loss of hundred million rupees in worth at Palung valley within recent past few years have been reported. Experiments were conducted in inoculated conditions under screenhouse at Khumaltar and under farmers' field conditions at Bhaktapur. Results showed amendment of lime @ 300 kg per ropani (500m²) significantly reduced clubroot severity ($P= 0.0377$) compared to control in the field conditions. Lower clubroot incidence was found in 7-week-old seedlings compared to normal seedling age of 4-week-old. The relationship between seedling age and clubroot showed 86.92 and 96.06 percent variation in infection of tap root and incidence respectively due to seedling age. Of the 16 different fungal agents screened, two isolates of *Trichoderma* spp., T-22 and T-S showed potential biocontrol effect in significant reduction of clubroot severity with the value of 22.1 and 26.6 percent, respectively compared to control with 65.0 percent. Cauliflower, variety 'Kathmandu local' showed moderately resistant reaction (less than 1.5 clubroot index in a scale of 0-4) and radishes were less affected. These tactics could be used in integrated management of clubroot disease thereby reducing clubroot disease by their additive effects. However, these treatments in combination or alone need to be verified under field conditions.

Key words: Clubroot, Lime amendment, seedling age, soil-borne, *Trichoderma*

INTRODUCTION

Brassica vegetables are the most important vegetables in Nepalese diet. Its cultivation is one of the most potential income generating sources for the farmers' livelihood in Nepal, especially to them who have small land holdings. Among brassica vegetables, the most important ones are cauliflower (*Brassica oleracea* var. botrytis L.), and cabbage (*B. oleracea* var. capitata L.). Cauliflower and cabbage in Kathmandu valley and Makawanpur district cover 3479 and 1004 hectares of land respectively. The production of cauliflower and cabbage in Kathmandu valley and Makwanpur districts are 58902 ton and 17979 ton, respectively. These two crops have been contributing 31percent in total vegetable production of Nepal (VDD 2008). Since few years back clubroot disease caused by *Plasmodiophora brassicae* appeared to be economically important disease in potential brassica vegetables cultivating areas, especially, Kathmandu valley and Palung/Daman area of Makwanpur district. Previous studies at one of the locations in Kathmandu showed this disease could cause a loss of 27-81 percent in total biomass and 18-87 percent in curd yield of cauliflower (unpublished data), however 100 percent crop losses also have been observed.

So far, the disease has been appeared in cauliflower, cabbage, broad leaf mustard, knolkhol, broccoli, radish (rare), garden cress, mustard, and turnip. It is one of the most difficult plant diseases to control since the pathogen is wholly confined to the soil. The resting spores released from decomposition of clubs or the root tissue can remain infectious for more than 18 years (Toit 1990, Mitani et al 2003).

Repeated cultivation of crucifers in the same land leads to rapid buildup of the pathogen in the field. Reports showed that monocropping of cauliflower increased the disease incidence from 9 percent in the first year to 50 percent in the following year causing 62 percent yield reduction (Shrestha et al 1995). The disease has been spreading in new areas mainly through the movement of seedlings grown in infested fields.

Traditional controls of clubroot include improving drainage, raising the pH of the soil, and rotating susceptible crops with non-cruciferous crops. There is no potential fungicide available that would be acceptable on an economical and ecological basis (Ludwig-Mullar 1999). Although, 6-7 years absence of cruciferous crops in the field might help in reducing the disease significantly preventing buildup of inoculum of *P. brassicae* (Toit 1990), but it is still not practicable for small land holding growers who are compelled to cultivate brassica vegetables intensively for their livelihood. Because of soilborne nature of the pathogen and longer viability of its resting spores even in absence of brassica hosts, it is very difficult to control once established in the field. No single control method will provide good and sustainable control of such soil borne diseases, and thus, integrating different methods to manage the disease is a must (Wang and Lin 2005). Because of their non target effects in the ecosystem and hazardous nature, and food safety concerns, world wide efforts are on to move towards the use of ecologically safe and environmentally friendly methods of protecting crops from pests and the pathogens. Although synthetic pesticides are necessary at present but are not a long term solution to crop protection. Besides, it is becoming more expensive and often loses their effectiveness due to development of resistant strains.

So the studies were conducted on different aspects for ecofriendly management of clubroot disease, which could be implemented in integrated management of this disease.

MATERIALS AND METHODS

The experiments were conducted in different years under screenhouse and farmers field conditions at Bhaktapur. Meteorological data of Khumal complex were collected from Agricultural Environment Unit, Khumaltar.

Inoculum preparation

Clubs from infected cauliflower plants were collected and grated with tap water. The suspension was strained through muslin clothes to remove plant tissues. Spore concentration was determined by using haemocytometer. The final concentration of spore load was adjusted to 5×10^5 /ml.

Liming of the soil

Experiment was conducted during 2005-2006 as lime amended verses non- amended in the farmers' field at Bhaktapur where there was epidemic history of clubroot disease in the previous year. The soil samples were checked for initial pH value before the application of lime. Two doses of agricultural (Dolomite) lime were applied at the rate of 200 kg and 300 kg per 500 m² three weeks before transplanting. After amendment, watering was done in the plots to provide enough moisture. Seedlings of Milkyway variety of cauliflower raised at Khumaltar was used to make sure seedlings free from the clubroot pathogen. Recommended dose of chemical fertilizer and FYM (20 t/ha) were applied. Other agronomical practices were given as per need. Disease severity was assessed using 0-4 scale, where 0 for no visible clubbing and 4 for entire root system converted to club (Takahashi and Yamaguchi, 1988). Data were analyzed by t-test for comparison of the lime amended and non amended plots.

Inoculations of pathogen at different age of seedlings

The experiment was conducted with artificial inoculation of resting spores under screenhouse conditions at Khumaltar during 2000-2001 using cauliflower variety, Kathmandu local. Seedlings were grown in

steam sterilized soil in order to have ages of 4, 5, 6, and 7 weeks old and transplanted in 10 inch ceramic pots with two plants per pot. Following transplanting, 50 ml. of resting spore suspension was drenched around at the base of the seedlings. The experiment contained three replications, each with 10 pots. The pots were arranged in randomized complete block design (RCBD). Two months after each plant was uprooted for the assessment of severity and the incidence of the disease. For measuring disease severity, 0-3 rating scale was used. The scale is described as 0 for no visible gall or club in the root system and 3 for severe clubbing on lateral and tap root. Data was analysed with 'MSTAT C' and relationship between seedling age and disease incidence or severity were determined.

Culturing and inoculations of bio-control agents

Experiment was conducted during 2005-2006 in artificially inoculated conditions under screenhouse using cauliflower seedlings var. Kathmandu local and Milkyway respectively. *Trichoderma* spp. available in the collection of Plant Pathology Division, some isolated from clubroot infested field and one isolated from the commercial product named PlantShield were tested. Altogether 12 isolates of *Trichoderma* spp., and one *Gliocladium virens* (isolated from SoilGard) were included in the test.

Steam sterilized field soil was inoculated with resting spore suspensions (10^5 spores/ml) of *Plasmodiophora brassicae* at the rate of 1:10 (v/wt) and thoroughly mixed. *Trichoderma* spp were colonized in rice husk and mixed well with inoculated soil at the rate of 1:30 (*Trichoderma* in rice husk: inoculated soil). In the following day, 4-week-old seedlings were transplanted after treating in Krilaxyl suspension (0.15%) for downy mildew control. The pots were held in trays and arranged in complete randomized design. Each isolate of *Trichoderma* replicated three times. Each replication contained 5 plants. Response to clubroot disease was assessed 10 weeks after transplanting. Data were scored using 0-4 scale of Takahashi and Yamaguchi (1988) and analysed with Mstat C.

Screening of Brassica genotypes for resistance

The experiment was conducted in artificially inoculated conditions during 2006-2007 under screenhouse conditions. There were 32 genotypes in 2006 and 24 in 2007. The sources of seed were Research Station, local market, Agro Enterprises, NGOs, and local farmers. Seedlings were grown in steam sterilized soil on plastic trays. At 5-week-old stage, 600 ml of resting spore suspension was drenched in each tray (to give the ratio of 1:30 of inoculum and soil). The spore load of suspension was 2×10^5 /ml. Clubroot severity was assessed 7 weeks after inoculation by uprooting the plants. Depending on the seedlings established, 12-24 seedlings per genotype were assessed. Clubroot severity assessment was done with 0-4 scale (Takahashi and Yamaguchi 1988).

The genotypes were grouped into the following groups based on the disease nature and clubroot severity.

Based on clubroot Scale, 0-4

Resistant = club severity below 1

Moderately resistant= 1-1.5

Susceptible = above 1.5

RESULTS AND DISCUSSION

Effects of liming of the soil

In 2006, the initial pH of the soil of experimental field was 4.9. It increased to 5.3 and 5.6 three weeks after lime application at the rate of 200 kg and 300 kg /500 m² respectively. Dosage of lime application at the rate of 200 kg/ropani was not significant in reducing clubroot severity in both the years. Application of 300 kg/500 m² was effective in reducing clubroot severity in the given field (Table 1). Raising of soil pH to 7.2 is one of the most documented treatments for clubroot disease management. In present study lime was applied regardless of target pH value (because majority of the farmers are not intended to apply lime in their fields). Studies revealed the effectiveness of liming thereby increasing pH level that

suppresses the zoospore germination, but the effectiveness could be affected by virulence of the pathogen, inoculum density in the soil types and the liming materials (Murakami et al 2002; Toit 1990). Furthermore, availability of calcium and magnesium may be concerned with the development of clubroot in certain pH level of soil. Moisture level in soil also plays an important role in changing pH of the soil after lime incorporation. The previous experiment conducted in the infested field at Banasthali also significantly reduced disease incidence as well as severity by lime application (Timila and Shrestha 2000).

Table1. Effect of lime application in clubroot severity in the field conditions at Bhaktapur in 2005 and 2006

Treatment	2005 (0-4)		2006 (1-6)		Remarks
	Severity index	P value (0.05)	Severity index	P value (0.05)	
Lime, 200 kg/500m ²	1.63	0.1408 NS	3.07	0.3975 NS	
Lime, 300 kg/500m ²	-	-	2.63	0.0377 S	
Untreated control	2.57	-	3.3	-	

Seedling age effects

Incidence and clubroot severity were found to be affected by the age of seedlings. The incidence of clubroot was found lower when transplanted 7-week-old seedlings compared to normal seedling age of four weeks old. It was followed by 6-week-old seedlings in response to clubroot incidence and the severity. Mean percent of infected plant with tap root, clubroot severity and clubroot incidence were higher in the seedlings ages of 3, 4, 5 and 6 weeks compared to 7-weeks-old (Figure 1). There were no statistical differences among different ages of seedling at $p=0.05$, however, the difference in clubroot severity and incidence were obvious. The relationship between seedling age with tap root infection percent and clubroot incidence showed that the age of seedlings could cause 86.92% and 96.06% variation in infection of tap root and incidence of disease plants respectively (Figure 2). Age related resistance play an important role in reducing certain soil borne diseases, such as Phytophthora blight of pepper (Kim et al 1989), which could be true for clubroot disease also. However, it could not be implemented in the case of short duration varieties of cauliflower.

Effects of *Trichoderma* spp.

Clubroot severity was higher during 2005 than in the year 2006 with all the isolates of *Trichoderma* spp. In both years, significant differences were observed among the isolates of *Trichoderma* species in reaction to clubroot severity (Table 2), but in clubroot incidence there was no significant difference. One isolate isolated from naturally clubroot infested field (at Bhaktapur) and T-22 isolated from the commercial product of PlantShield was found significantly effective in reducing clubroot disease. Both of those isolates were at par in severity as well as in incidence. Another isolate, T 69, isolated from soil ranked third in reducing clubroot severity as well as incidence. The three isolates were with disease severity less than 45 percent in both the years. The higher disease severity in the second year of experiment (2006) could be due to varietal difference as well as the higher temperature (maximum 28.2°C and minimum of 20°C) than in 2005 (maximum of 27.9°C and minimum of 19.7°C). As observed in the farmers' field, Kathmandu local variety was less affected than Milkyway. It could also be due to moisture level of the soil due to uneven watering during experimental period.

Most of the success stories of biological control are from the studies conducted in controlled conditions. However, researchers reported the effectiveness of some isolates of *Trichoderma* spp. in reducing the clubroot severity in Chinese cabbage and the cauliflower (Cheah et al 2000, Cheah and Page 1997) in the field conditions. Similarly *T. harzianum* was effective in reducing Clubroot disease in the field conditions in cauliflower crop (Timila and Shrestha 2000). Those effective isolates should be tested under field conditions.

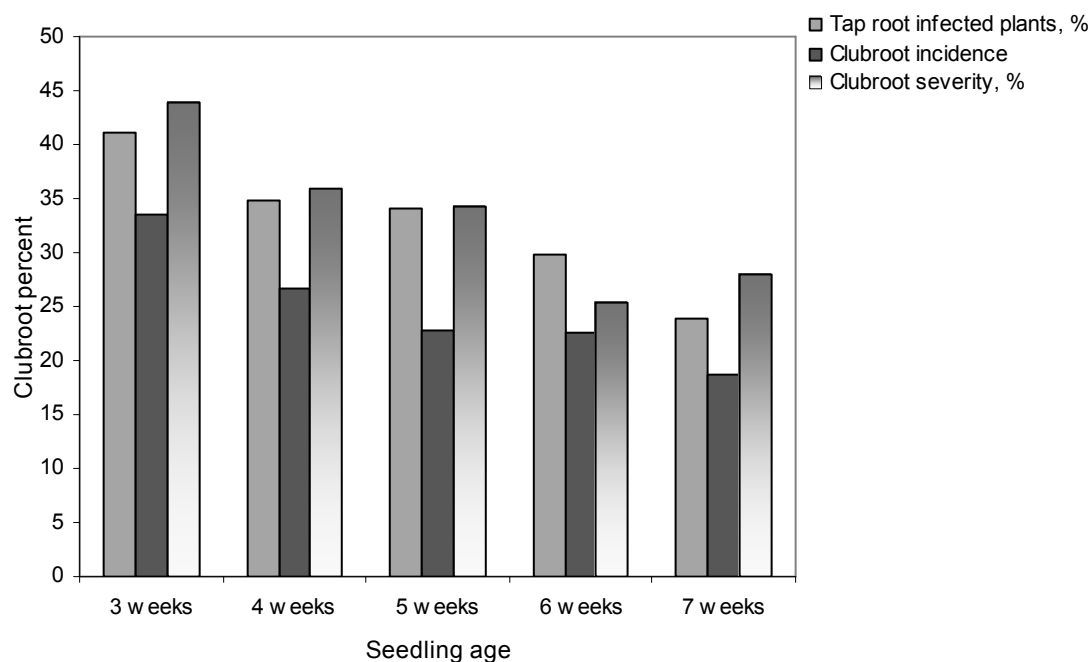


Figure 1. Effects of seedling age in tap root infection, clubroot incidence and severity on cauliflower under greenhouse conditions (mean values of two years, 2000-2001).

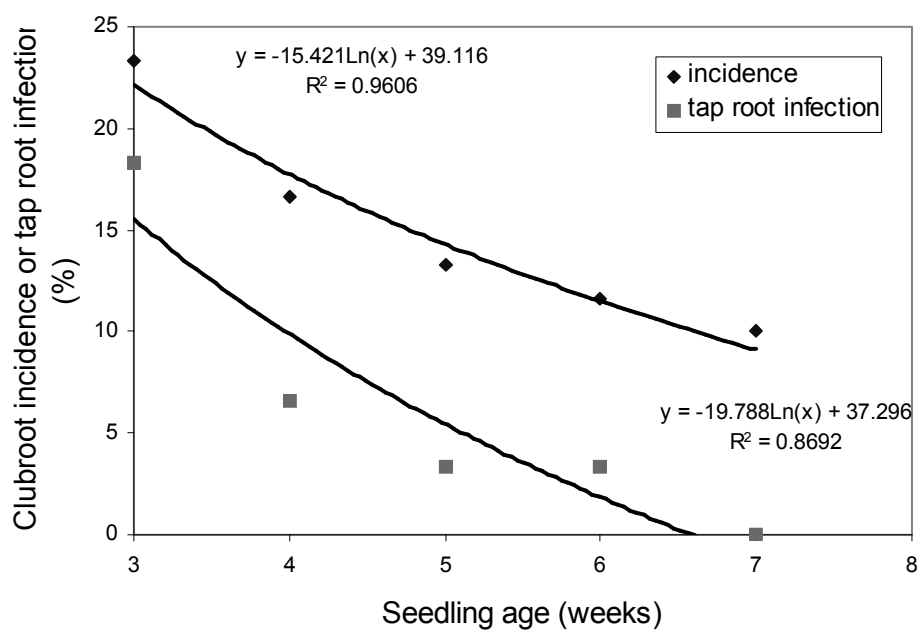


Figure 2. Relationships between seedling age and tap root infection / clubroot incidence

Table 2. Effects of *Trichoderma* spp. on severity and incidence of clubroot disease of cauliflower (Variety Milkyway) under screenhouse conditions at Khumaltar, 2006-2007

Biological agent isolates	2005		2006		Source of Isolates
	Club root severity %	Club root incidence %	Clubroot severity %	Clubroot incidence %	
TA-23	-	-	97.78 a	100.00	PPD
T- A2	48.25 abcd	100.00 a	91.11 a	100.00	PPD
Untreated Control	50.00 abcd	93.33 a	72.22 b	100.00	-
T-59	40.00 bcd	93.33 a	70.00 b	100.00	PPD
<i>Gliricladium virens</i>	48.25 abcd	93.33 a	66.66 bc	100.00	SoilGard (USA)
<i>T. harzianum</i> (Niprot)	30.00 d	65.00 b	63.31 bc	100.00	Niprot
<i>T. viride</i> (Niprot)	58.25 ab	100.00 a	60.55 bcd	100.00	Niprot
<i>T. viride</i> (Sanjeevani)	70.00 a	100.00 a	57.87 bcd	93.33	Sanjeevani
<i>T. koningii</i>	53.25 abc	100.00 a	56.66 bcd	100.00	PPD
T-69	30.00 d	73.33 ab	47.77 cd	80.00	PPD
T-22 (PlantShield)	2.00 e	10.42 c	42.21 d	80.00	PlantShield (USA)
T-S	12.75 e	30.33 c	40.55 d	100.00	PPD clubroot infested Soil)
T-60	44.5 abcd	78.33 ab	-	-	PPD
T-58	43.25 abcd	86.67 ab	-	-	PPD
<i>Chaetomium</i> sp.	33.00 cd	85.00 ab			PPD
CV %	11.35	17.75	17.15	13.5	
P value	0.000	0.000	0.0000	0.4777	

Mean with the same letter are not significant at P=0.05 with Duncan's Multiple Range Test. PPD – Plant Pathology Division

Screening of *Brassica* genotypes for resistance

The preliminary screening of different varieties of brassica genotypes collected from different locations showed various degree of reactions to clubroot disease. Most of Broadleaf mustards were susceptible, and cauliflower, Kathmandu local was resistant. Similarly, almost all radishes were free of diseases showing resistant reaction. Broad leaf mustard variety Marpha chaudapat was less affected than other varieties of broad leaf mustard. In the case of cauliflower, Jyapu cauli (three months), the variety from Dhankuta reacted susceptible where as from Kathmandu reacted resistant. Figure 3 explains the frequencies of the number of tested varieties in different disease reaction categories. However, there are no varieties reported resistant with satisfactory level of resistance. Slight variation in susceptibility to clubroot was reported within cabbage and cauliflower accessions (Manzanares-Dauleux et al 2000). They also found two Kale lines with higher level of resistance thought to be useful for developing resistant cauliflower and broccoli hybrids.

It was the first attempt in Nepal to screen on locally cultivated brassica vegetables against club root. Disease reaction of different brassica vegetables is encouraging. It is expected that there could be variation in clubroot resistance within Kathmandu local variety of cauliflower of which seed was produced at different agroecological conditions of the country.

The results showed that lime amendment at the rate of 300 kg/ha for raising the pH of the soil, use of aged seedlings not less than 7 weeks old and use of *Trichoderma* sp and T-22 as biocontrol agents have potential in reducing clubroot severity. Use of lime is already proven tool for minimizing clubroot in the field. However other experiments were conducted under screenhouse conditions but these ecofriendly tools could be effective in the field conditions alone or in combination with other compatible measures. Their level of effectiveness in the field conditions should be first tested. Concerning screening for resistance also, there is prospects in finding resistance sources. More local and exotic varieties should be

tested for direct variety adoption (if found resistant) or for resistance sources for varietal improvement of genotypes such as cauliflower and broad leaf mustard. All these tactics could be promising potential tools for integrated management of clubroot disease.

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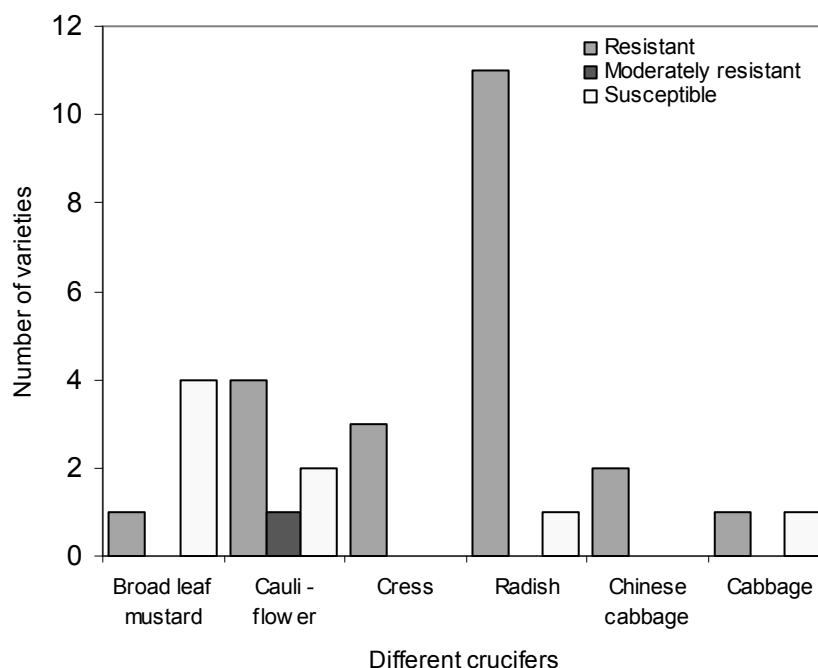


Figure 3. Frequency of different varieties of crucifers in clubroot disease reaction categories (<1 = resistant; 1-1.5 = moderately resistant and above 1.5 = susceptible, in disease scoring scale of 0-4).

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Effect of Bio-Pesticides on Larval Parasitoid, *Cotesia Plutellae* of Diamond Back Moth, *Plutella Xylostella* in Cauliflower

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ABSTRACT

The laboratory experiment was conducted at ARS, Pokhara from mid March to May, 2004 and 2005 to know the effect of bio-pesticides on larval parasitoid, *Cotesia plutellae* of diamond back moth. The experiment was laid out in CRD with eight treatments such as Margosom @1.5 ml/liter, Margosom @ 2.0 ml/liter, NPV 100LE @ 0.5ml/liter, NPV , 100LE @ 1.0ml/liter, Bt-BIO-LEP @ 2.5g/liter, alternate of BIO-LEP and NPV for three times, water spray @ 600 liter/ha and dichlorvos76EC @ 1ml/liter. The treatments were replicated thrice. Dichlorvos76EC (Nuvan) was applied as per farmers practices starting from fourth week after transplanting of cauliflower till harvest at weekly interval and all bio-pesticides were applied in March with four to three sprays at fortnight interval in low and high doses, respectively. Thirty to forty newly formed pupae were collected from each treated plots and kept in Petri dishes for adult emergence. There were three to four lots of rearing after each application of the treatments. The number of parasite adult male and female were recorded from each rearing. The average number was converted into per cent emergence and statistically analyzed. Two years mean data on parasitism revealed that significantly higher parasitism was recorded from insecticide free plots (75.68%) and four sprays of Margosom @1.5 ml/liter (73.15%) as compared to that of lower emergence of 15.07 percent in chemical insecticide dichlorvos 76EC@1ml/lit for 10 times at weekly interval. More than 56.49 percent parasite emergence was found in all bio-pesticides and doses indicating that the tested doses of Margosom, Bt. and NPV were found safer to the tested species of parasite.

Key words: Bio-pesticides, Bt., *Cotesia plutellae*, Diamond back moth, emergence, Margosom, parasitoid, NPV

INTRODUCTION

The larval parasite, *Cotesia plutellae* (Hymenoptera: Braconidae) has been reported to have significant role in suppressing the population density of diamond back moth, *Plutella xylostella*, a major insect of cole crops especially in late season cabbage and cauliflower in mid-hills. This insect occurs with high intensity during March - April in the hills. The association of the parasite species with its host insect larvae in the field around Pokhara shows its potentiality in natural bio-control of host insect. The rearing results obtained during 1998 and 1999 have shown comparable variation in the emergence of parasite adults when pupae were collected from heavily, moderately and safely treated farmers field and reared in laboratory condition and found 38.3, 56.0 and 75.0 percent parasitism, respectively indicating the lowest population in farmers practice (Anonymous 1999). The highest parasitism record of 71.70 percent has been reported from Gujarat (Sanumukh and Patel 2005). Similarly, Dhaliwal and Arora (1998) from Gujarat and Karnataka, India mentioned that *Cotesia plutellae* was found effective to check the population of diamond back moth on cabbage. Talekar et al (1992) suggested an integrated approach of *Diadegma semiclausum* introduction, *Cotesia plutellae* conservation and limited sprays of Bt along with trainings for not applying insecticides against this insect for the highlands of Taiwan. Mass rearing of *Cotesia plutellae* indicated 43 to 96 percent recoveries of adult parasitoid from July to June showing the possibility of year round production in laboratory condition in Kathmandu (Anonymous 2002). Parasitoids in general are reported to be very sensitive to chemical pesticides. They can easily be killed

by insecticides even at low doses applied over the pest but the studies on adverse effect of bio-pesticides seems insufficient, however, Michelbacher and Smith (1943) indicated that the Polyhedrosis virus applied over the alfalfa caterpillar killed parasitized host before the *Apanteles medicaginis* can complete its development. In our condition, most of the farmers use schedule sprays of chemical insecticides irrespective of group and formulations to control this insect. There is general trend of applying repeatedly for up to 15 times at weekly interval. Such practices may affect the natural existence of bio-control agents in the agro-ecosystem. Considering the potential existence and significant role of this species to suppress diamond back moth population, the present study was carried out to determine the adverse effect of bio-pesticides on *Cotesia plutellae* aiming at its conservation in the field.

MATERIALS AND METHODS

The laboratory experiment was conducted from 15 March to May, 2004 and 2005 at Agriculture Research Station, Malepatan, Pokhara. The design of the experiment was Completely Randomized Design (CRD) with eight treatments and three replications. Detailed of the treatments has been presented in table 1. The chemical insecticide dichlorvos 76 EC (Nuvan) @ 1ml/liter of water was started to apply from 25 days after transplanting of seedlings and was continued for 10 times at weekly interval. Other bio-pesticide formulations were applied on March first week onwards and repeated for 4 and 3 times at fortnight interval in low and high doses respectively. Dichlorvos 76EC (Nuvan) was applied as per farmers practice starting from fourth week after transplanting of cauliflower and other treatments in March when insect movement was there in the field. Drift residues were checked by making 1.5 m wide bunds in between plots Thirty to forty newly formed pupae were collected from treated plots and were kept separately in wire net containers in room temperature for adult emergence. There were three to four batches of rearing after each application of the pesticides. The number of parasite male and female were visually separated, counted and recorded from each rearing. The average number of the total rearing was then converted into per cent emergence of parasite and per cent data were statistically analyzed. Means were compared by Duncan's Multiple Range Test (DMRT).

Table 1. Treatment details

Treatments	Doses and frequencies of spray
T1 .Margosom 0.15%ww	1.5 ml/liter 4 times at 15 days interval
T2. Margosom 0.15%ww	2.0 ml/lit 3 times at 15 days interval
T3. NPV-Spodo100 LE	0.5 ml/lit 4 times at 15 days interval
T4. NPV-Spodo100 LE	1.0 ml/lit 3 times at 15 days interval
T5. (Bt.) Bio-LEP	2.5g/lit 3 times at 15 days interval
T6 .Altered use of Bt BIO-LEP.and NPV –Spodo 100LE	2.5g- 1ml- 2.5g 3 times at 15 days interval
T7. Water spray (insecticide free)	600 lit/ha 10 times at weekly interval
T8. Control (dichlorvos 76EC) Nuvan	1 ml/lit 10 times at weekly interval

RESULTS AND DISCUSSION

Effect of treatments on parasite emergence

The mean data presented in the table 2 clearly show that the emergence of parasitoid from the plots treated with three spray of Margosom 0.15% @ 1.5 ml/liter of water at 15 days interval over the cauliflower plants and pure water spray @ 600 liter/ha) at weekly interval were statistically at par resulting in 77.24 and 76.60 percent parasitism when pupae reared in the year 2004. The three sprays of Bt ie.BIO-LEP @ 2.5g/liter of water at the same interval (T5) gave second lowest percent record of 49.92 percent. All bio-pesticides gave significantly higher per cent emergence of parasite ranging from 49.92 to 77.24 as compared to that of minimum in dichlorvos 76EC (Nuvan) @ 1 ml/liter repeatedly for 10 times at weekly interval (12.36%). The over all results obtained from first year data showed significant difference within bio-pesticide treatments. The parasitism calculated from rearing of pupae collected

from the plots treated with BIO-LEP (Bt.) @ 2.5 g/lit for 3 times at 15 days interval was found the minimum of 49.92 percent among bio-pesticides. Low dose of NPV @ 0.5 ml/liter and high dose of Margosom @ 2 ml/liter were also statistically at par resulting in 63.80 and 58.59 percent parasitism, respectively.

The mean parasitism obtained from rearing of pupae in the year 2005 showed that the emergence of parasite adults was maximum in pesticide free plots ie water spray @ 600 liter/ha at weekly interval (74.76%). The percent parasitism obtained from all bio-pesticides was statistically similar to each other. Significantly minimum parasitism of 17.77 percent was found in weekly spray of dichlorvos 76EC @ 1 ml/liter of water (T8). Except dichlorvos 76EC all bio-pesticides and water treatments showed non-significant results (Table 2).

Two years mean results revealed that significantly minimum number of *Cotesia plutellae* emerged from pupae collected from the plots treated with dichlorvos 76EC@ 1 ml/lit for 10 times at weekly interval resulting only 15.07 percent. Percent data obtained from water spray (T7) and Margosom 1.5 ml/liter (T1) were 75.68 and 73.15, respectively were at par to each other. Above 58.99 percent parasite emergence was found in all bio-pesticides and their tested doses except in dichlorvos.

In both the years, the results showed similar trend that the tested common insecticide (Nuvan) and frequencies of sprays was detrimental to naturally existing parasite, *Cotesia plutellae* and other bio-pesticides seemed safer to this species (Table 2). The results suggest that effective integration of tested bio-pesticides with this parasite can be useful for long-lasting diamond back moth management in cole crops.

Table 2. Mean parasitism of *Cotesia plutellae* L on diamond back moth, *Plutella xylostella* pupae during 2004 and 2005

Treatments	Mean parasitism (%)		
	Year: 2004	Year: 2005	Mean
T1. Margosom 0.15% @ 1.5 ml/lit 4 times at 15 days interval	77.24a	69.10a	73.15a
T2. MargoSom 0.15% @2.0ml/lit 3 times at 15 days interval	58.59abc	65.03a	61.88b
T3. NPV-spodo100LE @0.5ml/lit 4 times at 15 days interval	63.80abc	72.40a	68.10ab
T4. NPV-spodo100LE @1.0.ml/lit 3 times at 15 days interval	67.48ab	73.33a	70.41ab
T5. Bio-Lep (Bt.) @2.5g/lit 3 times at 15 days interval	49.92c	68.07a	58.99b
T6. Altered use of Bt. and NPV 3 times at 15 days interval	55.11bc	63.26a	59.19b
T7. Water spray @ 600 lit/ha 10 times at weekly interval	76.60a	74.76a	75.68a
T8. Control (Nuvan @1ml/liter 10 times at weekly interval)	12.36d	17.77b	15.05c
CV	18.98	14.48	12.14
LSD(0.05)	15.73	16.09	9.74
F-test	**	**	**

Means with a common letters in columns are not significantly different by DMRT

**= significant at (0.01)

Sex ratio

Since *Cotesia plutellae* is bi-parental species thus male and female population exists in the nature. Mean sex ratio (Male: Female) calculated from six to eight rearing in both the experimental years presented in table 3 shows that no effect of the treatments have been observed in male and female population ratio. Almost equal proportions of male and female emergence of adults have been found in all batches and treatment applications. This sex ratio indicates the potentiality of parasitizing the next generation larvae of host insect. During the course of experiment it was also noted that the parasitoids were 3 to 5 days late to emerge from pupae than the host insect moths under laboratory condition (Table 3).

Table 3. Male: female sex ratio of *Cotesia plutellae* emerged from pupae of diamond back moth

Treatment details	Mean sex ratio of three rearing		
	Year 2004	Year 2005	Mean
T1.MargoSom 0.15 % @ 1,5 ml /lit 4 times at 15 days interval	1:1.16	1:1	1:1.13
T2.MargoSom 0.15 % @ 2.0ml/lit 3 times at 15 days interval	1:1.06	1:0.4:1	1:1.03
T3.NPV-Spodo100LE @ 0.5ml/lit 4 times at 15 days interval	1:1	1:1.2	1:1.1
T4.NPV-Spodo100LE @ 1.0.ml/lit 3 times at 15 days interval	1:1.1	1:1	1:1.05
T5.Bio-Lep (Bt.) @ 2.5g/lit 3 times at 15 days interval	1:0.4:1	1:1.8	1:0.2:1.2
T6.Altered use of Bt. and NPV 3 times at 15 days interval	1:1.09	1:1.13	1:1.11
T7.Water spray @ 600 lit/ha 10 times at weekly interval	1:1	1:1.24	1:1.2
T8. Control (dichlorvos 76EC @ 1ml/lit 10 times at weekly interval)	1.3:1	1:1.6	1.15:1.3

Field population trend of *Cotesia plutellae* observed in the previous year's estimation coincided with the present laboratory study. The data confirmed its density in the field associating with diamond back moth which shows the opportunity to explore it in diamond back moth pest management. It also indicates the need of further screening of safer pesticides groups or formulations for its conservation in natural agro-ecosystem. Such steps can promote shifting from chemical to eco-friendly pest management practices which can be cost effective and sustainable in the long run.

CONCLUSION

Based on the experimental results it can be concluded that:

- Commercially available bio-pesticide products like Bt. (BIO-LEP), Neem (Margosom) and NPV-Spodo 100LE were found non toxic to larval parasite, *Cotesia plutellae* of diamond back moth, *Plutella xylostella*.
- The schedule spray of the common insecticide, dichlorvos (Nuvan) @ 1ml/liter of water and frequency of sprays as farmers applying for more than 10 times at weekly interval seemed most toxic to tested parasite species.
- During March-April, effective population with equal proportions of male and female of *Cotesia plutellae* was found to exist in cabbage and cauliflower field at Malepatan, Pokhara which suggest the need of its conservation.

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Management of Tomato Fruit Worm through Bio-Control Method during Spring Season Production in Western Hills of Nepal

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ABSTRACT

Tomato fruit worm has been identified as one of the most important biotic constraints in hills of Nepal especially during the spring season. Tomato being a high value commodity, it is grown under heavy pesticidal protection during that season as an off-season produce. Prophylactic sprays of pesticides in higher doses at farmer level is hampering in multidimensional ways. In view of addressing these problems mass multiplication of the most virulent bio-control agent, *Trichogramma chilonis* on the surrogate host eggs of grain moth and their augmentative field release was carried out to generate eco-friendly fruit worm management practices in tomato production. The mass multiplication of bio-control agents in IPM lab Lumle and the efficacy of laboratory cultured bio-control agent against fruit worm were carried out in Mayatari, Syangja under non replicated trial on spring season tomato production var. (N-162) for two years (2005-06). The result revealed that mass multiplication of *H. armigera* egg parasitoid *Trichogramma chilonis* on the surrogate host eggs of *Corcyra cephalonica* was successfully undertaken in IPM lab at Lumle station. On an average 49.23 percent induced parasitization on *Corcyra* eggs and 1:1.33 parasitized egg to adult ratio was observed in controlled laboratory condition. The augmented release of *Trichogramma chilonis* as a bio-control agent is also effective in managing tomato fruit borer due to increased rate of parasitization in the field. The *Trichogramma* release plot produced 64.80 percent marketable fruit yield of total production as compared to 35.40 percent in control plot. Interestingly, of the total harvested fruits 4.70 percent were infested by borer in release plot as against 36.80 percent in control plot.

Kew words: Bio-control, *Trichogramma chilonis*, tomato fruit worm

INTRODUCTION

Tomato fruit borer (*Helicoverpa armigera*) has been identified as one of the most important biotic constraints in the hills of Nepal especially in the spring season tomato production. Tomato fruit worm is considered as the national priority entomological research problems in tomato (Manandhar 1997). This pest is polyphagous in nature and feeds on tomato, chickpea, pigeon pea and cotton. It was experienced to be problematic only in spring season tomato from March to May but it has been observed these days in rainy season tomato as well. Hence, the active period of the pest has been extended. A larva of this pest bores into the fruit and feeds upon the inner content and economic value of the product is lost. In the absence of control measures, the fruit damaged by this insect is ranging up to 100 percent. Tomato being a high value crop, it is grown under heavy pesticidal protection. Tomato production in the hills in spring season is market oriented. Past efforts to manage this pest were concentrated on use of pesticides as prophylactic sprays and at higher doses. Fruits are sprayed just before harvest. Waiting period between spray and marketing is extremely short that is one or two days only. Misuse of pesticides has been another threat to consumers. Similarly, misuse/overuse of pesticide has adverse effect on bio-control agents leading to the outbreak of the secondary pests and causes environmental pollution hence the hampering in multidimensional ways. There are many reports on resistance gained by this pest to so many pesticides

Biological control of pest is one of the highly appreciated pest management technique. It has a great significance especially in the control of insects. Laboratory mass multiplication of bio-control agents on the artificial diet combination of controlled condition and augmentative release of the bio-control agents to the target pests are an important component of bio-control method. Unfortunately, very little work has been done so far in Nepal in the exploration of the indigenous bio-control agents, their production and utilization in natural context (Annual Technical Report 1995/96, Entomology Division, Nepal Agriculture Research Council). At LARC initial studies conducted to explore the existence of indigenous bio-control agents have shown that fruit worm is attacked to an appreciable level by egg parasitoid.

There are so many natural enemies of pests in the biological system. Among them *Trichogramma* wasps are usually well known because there are so many members that are important natural enemies being either predator or parasitoid of agricultural pests. *Trichogramma* wasps (family Trichogrammatidae) are important egg parasitoids and are useful in the management of some key caterpillar or worm pests. Among them *Trichogramma chilonis* has of considerable importance. The scope and importance of laboratory reared indigenous egg parasitoid for the management of tomato fruit worm is well recognized based on the results found in India and elsewhere. Several species of *Trichogramma* were evaluated for control of lepidopteron pests but *Trichogramma chilonis* gave the highest parasitism. *Trichogramma chilonis* is mass produced in the Philippines by both government and private sector to control many lepidopteron pests, especially borers such as tomato fruit worm. *Trichogramma* pupae are glued to trichocards and clipped to plant parts at several locations in the field report.

The female wasp lays one or more eggs in an egg of the host insect, and one or several parasitoids may develop. *Trichogramma* species pupate within the host egg. Adult wasps emerge seven to ten days after the egg is deposited. Over 50 wasps have been recorded emerging from a single horn worm egg. Development is favored by warm temperatures and many generations may be produced each season. *Trichogramma* overwinter in the host egg, emerging as adults the following season. *Trichogramma* are particularly good natural enemies of caterpillars because they parasitize and kill the pest in the egg stage before crop is damaged.

It is reported that the augmented release of *Trichogramma chilonis* as a bio-control agent is effective in managing tomato fruit borer due to increased rate of parasitization in the field. The average ratio of parasite-larvae in the released plot was found to be 6:1 as compared to 1:1 under natural condition. More than 50 percent increase in marketable fruit yield and 19-88 percent decreased in bored fruit yield were found in *Trichogramma* released plot as compared to control one (Manandhar et al 2000). There is a higher incidence of *Trichogramma* at lower altitudes than at the higher altitude. Naturally occurring populations of *Trichogramma* species are known to be important mortality agents of many crop pests. Naturally occurring parasitoids of *Helicoverpa armigera* had been surveyed at different locations of Lumle research command area and identified as *Trichogramma achaeae*, *T. nagaraja* and *T. nagarkatti* (CABI Bioscience insect identification services, UK, 1997). The mortality caused by these species of *Trichogramma* is now considered when spray decisions are made in this major vegetable crop. Most insect parasitoids only attack a particular life stage of one or several related species. The immature parasitoids develop on or within a pest feeding on body fluids and organs eventually leaving the host to pupate or emerging as an adult. The life cycle of the pest and parasitoid natural enemy can coincide or that of the pest may be altered by the parasitoids to accommodate its development. Insect parasitoids have an immature life stage that develops on or within a single insect host ultimately killing the host hence the value of parasitoids as natural enemies.

Therefore, alternative bio-rational measures are necessary for managing the major pests of vegetable crops. These methods should be cost effective, sustainable, ecologically sound and environmentally friendly. Now a day the IPM is drawing attention globally for successful crop production against major pest and diseases of the vegetable crops. The laboratory mass multiplication and augmentative field release of the bio-control agent against *Helicoverpa armigera* was carried out at lab to farmer's field condition

respectively considering the important component of IPM. Therefore these activities were performed in lab to land to generate eco-friendly fruit worm management in tomato especially in spring season production in western hills of Nepal.

MATERIALS AND METHODS

Laboratory mass multiplication of *Trichogramma chilonis* was carried in IPM laboratory of Regional Agricultural Research Station, Lumle since 2004 to to-date on the host insect's eggs of *Corcyra cephalonica* as a normal phenomenon. The moths were multiplied in the artificial diet combinations of oven dried crushed maize grain, peanut and streptomycin sulphate at controlled laboratory condition (28-30°C Temperature and 65-70% RH) of Regional Agricultural Research Station Lumle. The rearing box was simply designed by ply wood having dimensions of 48 cm length, 32 cm width and 15 cm height with rectangular shape. The upper portion working the lid of the rearing box was adjusted by four circular holes covered by fine meshed white nylon net. The inner approximately 5 cm height of rearing boxes were filled with artificial diet combinations. The eggs of grain moths are sprayed over the diet. After the one month of egg inoculation fully developed adults were emerged inside the rearing boxes. They were trapped by suction pipe or recently vacuum cleaner. The pulled adults were kept in plastic bucket for oviposition. The laid white eggs were accumulated in the lower portion of the plastic bucket. Eggs of *Corcyra cephalonica* reared in maize flour were collected, treated by ultra violet rays for two hours, fixed to tricho-cards by adhesive glue, and exposed to *Trichogramma chilonis* by keeping in test tube for parasitization. The upper portion of the test tube was covered by cotton plug. The tricho-cards were incubated at 30 °C for hatching. They were preserved for 7-10 days at 12°C as a source of regeneration process.

The efficacy of laboratory produced egg parasitoid *Trichogramma chilonis* in managing tomato fruit borer (*Helicoverpa armigera*) was assessed at Mayatari, Syangja. The popular variety of tomato (N-162) was seeded on second week of February. Three weeks old seedlings of tomatoes were transplanted in first week of March. Seven hundreds forty plants per plot were planted in 0.75m x 0.45m distance in row to row and plant to plant respectively giving a gross plot size of 250 sq. m. Crop was grown in the manure and fertilizer level of 2 ton/ha of farm yard manure and 150:100:100 kg/ha N:P:K respectively. Out of total nitrogen 60 percent was used for top-dressing equally dividing into two equal parts and top-dressed 25 and 50 days after transplanting. Rest of the fertilizers and compost were used as basal application. Plants in all plots were staked with split bamboo. Rest of the cultural practices like weeding, hoeing, earthing up etc were carried out as per standard practices. Non replicated trial was conducted where plots receiving *Trichogramma* and control were maintained at a distance of 200 m apart. *Helicoverpa armigera* moths were monitored with pheromone septa as an indicator for their occurrences. When the moths were entrapped in pheromone trap, the laboratory produced *Trichogramma chilonis* were released in the field @ 2500 parasites per ropani basis at weekly interval for six times during the whole cropping duration.

The end, plot-receiving *Trichogramma* was compared with the control one in terms of the percentage of marketable, bored and rotten fruits. The collected data were analyzed in MSTAT-C software package.

RESULTS AND DISCUSSION

Laboratory mass multiplication of *Helicoverpa armigera* egg parasitoid, *Trichogramma chilonis* on the surrogate host eggs of grain moth (*Corcyra cephalonica*) was successfully undertaken in controlled laboratory condition at RARS, Lumle. On and average 49.23 percent induced parasitization on surrogate host eggs of *Corcyra cephalonica* through bio-control agents was observed in controlled laboratory condition (30°C and 70% RH). All the parasitized eggs did not produce their adults. On and average the parasitized egg to adult ratio of 1:1.33 was observed in controlled laboratory condition. The augmented release of *Trichogramma chilonis* as a bio-control agent was found effective in managing the tomato fruit borer due to increased rate of parasitization in the field. Among the 100 eggs collected from each plots, 68% parasitization was observed in released plot as against 26 percent in control one. The

result also revealed that *Trichogramma* release plot produced more marketable fruit yield (64.80%) and less bored fruits (4.70%). While approximately 32 percent more infestation of bored fruits and 29.40 percent less marketable fruit yield of tomato was observed in control plot as compared with the release one (Table 3).

Table 1. Laboratory mass multiplication of *Trichogramma chilonis* on the surrogate host eggs of *Corcyra cephalonica*

Date of incubation	No of C. eggs per tricho-card (2 cm x 1 cm)	Total no. Parasitized	of emerged eggs Un-parasitized	% parasitization
10, Mar, 2006	1500	825	675	55.00
10, Apr, 2006	1500	916	584	61.06
10, May, 2006	1500	856	644	57.06
10, Jun, 2006	1500	884	616	58.93
10, Jul, 2006	1500	722	778	48.13
10, Aug, 2006	1500	662	838	44.13
10, Sep, 2006	1500	778	722	51.86
10, Oct, 2006	1500	525	975	35.00
10, Nov, 2006	1500	690	810	46.00
10, Dec, 2006	1500	528	972	35.20
Mean	1500	739	761	49.23

Table 2. Laboratory culture ratio of parasitized *Corcyra* eggs to *Trichogramma* adults

Test tube no.	No. of parasitized <i>Corcyra</i> eggs	No. of emerged adults	Egg to adult ratio
1	100	135	1:1.35
2	100	123	1:1.23
3	100	131	1:1.31
4	100	140	1:1.40
5	100	135	1:1.35
Mean	100	133	1:1.33

Table 3. Efficacy of laboratory produced *Trichogramma chilonis* in managing the tomato fruit borer at Shankhapur, Syangja

Trt com	White eggs	Black eggs	Total fruit yield ton/ha	Marketable fruit yield ton/ha	Bored fruits ton/ha	Rotten fruits ton/ha
Control	100	26	48.30 (100.0)	17.10 (35.40)	17.75 (36.80)	13.44 (27.80)
Release	100	68	48.19 (100.0)	31.23 (64.80)	2.25 (4.70)	14.70 (30.50)
Mean	100	47	48.24 (100.0)	24.16 (50.00)	10.00 (20.80)	14.07 (29.20)
Std dev	-	-	0.078	9.991	10.96	0.89
SE	-	-	0.055	7.06	7.75	0.63

* Values in parenthesis are percentage of fruit yield.

CONCLUSION

Laboratory mass multiplication of *Helicoverpa armigera* egg parasitoid, *Trichogramma chilonis* on the surrogate host eggs of grain moth (*Corcyra cephalonica*) was successfully undertaken at IPM lab at Lumle station. The average of 49.23 percent induced parasitization on surrogate host eggs of *Corcyra cephalonica* through bio-control agents was observed in controlled laboratory condition (30°C and 70% RH). All the parasitized eggs did not produce parasitoid adults. The average parasitized egg to adult ratio of 1:1.33 was observed in controlled laboratory condition of RARS, Lumle.

The augmented release of *Trichogramma chilonis* as a bio-control agent was found effective in managing the tomato fruit worm due to increased rate of parasitization in the field. The *Trichogramma* release plot produced 64.80 percent marketable fruit yield of total production as compared to 35.40 percent in control plot. Interestingly, of the total harvested fruits 4.70 percent were infested by borer in release plot as against 36.80 percent in control plot.

The different IPM approaches including bio-control method should be promoted in normal as well as off-season vegetable production systems at subsistence and commercial level.

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Production of Hybrid Vegetables in Nepal: Opportunities and Constraints

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ABSTRACT

Vegetable production and marketing was started long ago in Nepal. In the beginning, vegetable production and marketing was in limited area. The objective of the study was to review the status of hybrid vegetable production in Nepal. The methodology of the study was to collect primary and secondary data. Primary data was collected from the 10 percent commercial vegetable growers in Panchkhal of Kavre and Hemja of Kaski district. Farmers cultivated different types of crops in their patch of land in order to get better production in different types of cropping pattern in low land. The cropping patterns were rice-wheat, rice-potato-tomato, rice-potato-cauliflower, rice-potato-cabbage and rice-potato-cucumber/beans, cowpea and tomato-cucumber. Commercial vegetable growers were cultivating different types of hybrid vegetables in the study area. Tomato, cauliflower, cabbage, chilli, cucumber, coriander, bitter gourds, zucuni, radish, cow pea, beans and ladies figure were the major types. In the study area, different types of hybrid vegetable seed were sold by the different agro vets. Commercial vegetable producing farmers were using hybrid vegetable seed because the production was homogeneous, marketable, market durable and high yielding. Seed Entrepreneurs Association of Nepal has recorded the different types of hybrid vegetable seed, 6573kg, worth amount Rs 4405237. Farmers of Panchkhal and Hemja reported that the F1 seed has sometime germination problem. They have a lot of complains on the price of seed. Sometime, some type of hybrid seed cost more than Rs75000 per kg. The major constraint of hybrid seed was not fruiting as previous year comparison. Policy makers should enforce the rule that farmers should have the guaranty and insurance on their crops when they grow vegetable by using the hybrid seed. Agro vets and seed entrepreneurs should take the responsibility on failure of crops due to seed quality. The net profit was Rs 8346 in open condition and Rs 50361 under plastic tunnel in comparative cost of cultivation of tomato. The household income was derived from hybrid vegetable 38 percent, cereal crops 25 percent, open pollination varieties vegetable 20 percent, labor 11 percent and other 7 percent.

Key words: Hybrid, vegetable, production, plastic tunnel

INTRODUCTION

Vegetable production and marketing was started since long time in Nepal. In the beginning vegetable production and marketing was in limited area. Local farmers were producing seasonal vegetables such as cauliflower, cabbage, broad leaf mustard, tomato, potato and onion around the periphery of Kathmandu. Subsistence farmers mainly grew local landraces for their own consumption as they were habituated for the local taste. Slowly the demand of vegetable consumption increased day by day. Cereal crop fields around high way and periphery of Kathmandu and Pokhara converted into vegetable producing fields. In the recent years farmers are producing vegetables by using Open-pollinated varieties (OPV), hybrids and local landraces. Commercial vegetable growers mainly focused on growing hybrid vegetables because the production was homogeneous, high yielding, marketable size and durability. OPV vegetable growers grow vegetables mostly for the seed production purpose because of their less bulky and perishability and therefore, they give less emphasize for the fresh vegetable production.

In developing countries, recently researchers and extension workers have given a lot of efforts on hybrid vegetables production. In case of Nepal, in cereal crop specially in maize, researchers have developed hybrid variety and the adoption ratio is increasing at farmers level. When we argue about the hybrid vegetable production in Nepal, the source of hybrid seed is very limited in limited species. Some researchers involving in hybrid vegetable seed production have identified some parental lines in tomato. According to the farmers it was very difficult to get hybrid tomato seed in Nepal. Whatever the hybrid vegetable seeds found in Nepalese market were imported from different countries. Some of the vegetable hybrid seed found in Nepalese market was imported from Japan, Korea, USA and India. Nepalese vegetable producing farmers prefer hybrid seed as they have found better yields. But the farmers often do not know that such types of hybrid seed imported from other country can be cultivated in all the Nepalese agro ecological condition as well as the source of seed is regular. Off course, there may be many opportunities as well as constraints of availability of vegetable hybrid seed including guaranty of the germination and purity of it. Some of the qualitative requirement may exist in the production or not?. These important sectors have to be tested and verified in the research stations and farmers field according to the agro ecological conditions and market preferences. Otherwise it may create a lot of problems. Recent evidence indicates that farmers of Lauki of Sunasari District refused to produce the cabbage variety called "pride of India" because of the size of cabbage is around 5 kg and they are not marketable size. About 2 kg of weight cuds are marketable size. Some hybrid varieties regarding its quality taste and quantity of production has not evaluated very strongly (Budhathoki et al 2002).

Area and production of vegetable crops are recorded to be 140500 ha and 1127884 Mt with a productivity of 8028kg/ha in the fiscal year 1991/92 (Annual Progress Report, Vegetable Development Directorate 2005/06). Since the productivity is gradually increasing but the expected productivity has not met the requirements. Therefore, the productivity has to increase by using various technologies to uplift the income of the poor farmers. It is reported that there are over 200 types of vegetable species are found in Nepal. Among them nearly 50% of them are grown for home consumption and market sales. Vegetables are generally grown in two seasons that is summer and winter. Hybrids vegetables are common on only few of these vegetable species in Nepal. Some of these species are tomato (*Lycopersicon esculentum*), cauliflower (*Brassica oleracea var botrytis*), cabbage (*Brassica oleracea var. capitata*), French bean (*Phaseolus vulgaris*), onion (*Allium cepa*), garlic (*Allium sativum*), asparagus (*Asparagus officinalis*), cucurbits, guards, brinjal and radish (*Raphanus sativus*).

In the peri-urban areas in Nepal, resource poor farmers having small land holding cultivate the vegetables in their kitchen gardens and commercial purpose. Some of these farmers have started to cultivate hybrid vegetables. Hybrid vegetables using modern technologies are highly profitable to grow in the off-seasons. Evidence shows that about a ton of rainy season hybrid tomato in a ropani could be produced under a plastic house that gives the value of NRs 75,000 within a four-month period (Poudel et al 2002).

The cultivation of rainy season tomato is now becoming very popular in the hills of Nepal. During rainy season, there is no supply of tomato to the local markets from Terai and India. It is mainly unfavorable conditions for tomato to grow during rainy seasons due to high temperature fluctuation and flooding in the terai region of Nepal. There is regular demand of tomato in the market through out the year, so consumers have to pay high price during the off-season (rainy season) when the tomato can not be produced in the Terai region. Considering these facts, some tomato varieties (*NCL-1*, *BL 410*) were recommended in the past for rainy season (May-August) and post monsoon (August-February) production in both open field and plastic house condition (Budhathoki and Bhattarai 1994). The production of rainy season tomato is a good opportunity to increase the income of resource poor farmers in road assessable areas of Nepal. It also helps in cash generation for vegetable collectors, traders and enterprises. Recently a Japanese hybrid (F1) tomato variety called "Umi" was cultivated by a farmer who harvested high amount of tomato from roof garden in Katmandu valley (Budhathoki et al 2004)

RATIONALE OF THE STUDY

Hybrid vegetable production is one of the important commercial crops in Nepal. Being one of the most profitable production options, the demand of hybrid vegetable production is increasing day by day in Nepalese market. The increasing demand of hybrid vegetable is due to urbanisation, diffusion of health education (that propagates the need of tomato in human diets), increasing income, the influence of tourist in many towns and change in the food habit of people. Demand increased for hybrids have opened the way for increasing potential for commercial tomato farming and for earning opportunity for income generation of farmers, traders and other stakeholders in value chains in Nepal. The adoption of rainy season tomato cultivation by marginal and small farmers not only increases their income but also offers good potential for additional direct and indirect employment opportunity. Tomato provides high return per unit of land in comparison to other vegetable crops (Munakami and Neupane 1992). At present, hybrid vegetable cultivation is increasing at farmer's field and a few farmers are trying to adopt this technology. In the 10th five-year plan, it has given due priority on the rainy season tomato production in potential area for local urban markets as well as for export where transportation facilities are available (NPC 2002). The Agricultural Perspective Plan (APP 1995) pointed out "the research program includes not only production research but also large emphasis on the marketing and processing". The priority research should focus useful information and solution to practical and specific problems and support extension services.

The objectives of the study were to: review status of hybrid vegetable production in Nepal; analyse the opportunities and constraints of hybrid vegetable production; and suggest the improvement strategies for hybrid vegetable production in Nepal.

METHODOLOGY

Primary data collection

The study employed various tools and techniques such as focus group discussion, key informant survey (KIS), direct field observation and sample household survey. The study was undertaken in Kathmandu, Kaski, Kavreplanchok, Dang, Salyan, Banke and Rupandehi districts. These districts were purposively selected for the study as they were the potential for hybrid vegetable production and marketing. In each district agro vets and other key informants were interviewed for hybrid seed sources and their marketing. The household survey for hybrid vegetables was focused on only tomato crop due to resource and time constraints. Kavreplanchok and Kaski districts were selected purposely for household survey of farmers for hybrid tomato production. Panchkhal VDC in kavreplanchok and Hemja VDC of Kaski district were selected purposely for the sample survey of plastic tunnel tomato production. In each VDC, 10 percent of the hybrid tomato producing farmers were randomly selected for the interview.

Source of secondary data

Secondary data were collected from the See Entrepreneurs Association Nepal (SEAN), annual reports, proceedings and journals including other publications published in different years from Vegetable Development Directorate of Department of Agriculture, Horticulture Division, NARC and other institutions. Government policy and planning documents are also reviewed and referred wherever possible.

FINDINGS

Socio economic characteristics

Socio economic characters of the study area was multi farming system where farmers were growing maize, millet, fruits , vegetable, agro forestry in maize millet cropping system in upland. In the low land, there was rice wheat based system where farmers grow rice- wheat, rice –vegetables. Besides these, farmers raise livestock such as buffalo, cattle, goats and chicken in order to home consumption, cash

generation and farm yard manure. General socio economic information such as household's size, education status, land holding, own land, lease in land, number of parcel, tomato production, tomato price and farm get price of tomato were compared in between Panchkhal and Hemja (Table 1).

Opportunities for hybrid vegetable production

Household's size: Average households size at Panchkhal was 6 where as in Hemja, it was 6.6 which was relatively higher as compare to national figure 5.5.

Education status: In the study area of Panchkhal, 9 percent respondents were illiterate, 45 percent had received primary education and 46 percent had received secondary and higher secondary education where as in Hemja, 64 percent respondents had received primary education and 18 percent each received secondary and higher secondary education.

Land holding: Average landholding in Panchkhal was 0.53 ha of which *khet land* was 0.33 ha, *bariland* 0.2 ha where as in Hemja average land holding was 0.5 ha of which 0.39 ha was *khetland*, 0.11 ha *Bariland* and average own land was 0.49 ha.

Average area and production of tomato: In Panchkhal, the average area of tomato production was 0.17 ha where as in Hemja, it was 0.06 ha. Farmers were producing 17360 kg of tomato per hector at Panchkhal site where as 21060 kg tomato per ha was produced at Hemja site. Average price was Rs. 22/kg in Panchkhal which was produced on open condition but in Hemja site, it was Rs. 16/kg of tomato produced under plastic tunnel. The productivity of cabbage is higher in Hemja because the farmers apply chicken manure.

Table 1 Socio economic characteristic

SN	Socio economic parameters	Panchkhal Under open condition	Hemja Under plastic tunnel
1	Average family size per household	6.0	6.6
2	Average size of landholding hectors	0.53	0.5
	<i>Khetland</i>	0.33	0.39
	<i>Bariland</i>	0.20	0.11
3	Average own land	0.34	0.49
4	Average lease in land	0.06	0.2
5	Average number of parcel	3.9	5.1
6	Average tomato production area (ha)	0.17	0.06
7	Average tomato yield kg/ ha	17360	21060
8	Average farm get price of tomato Rs /kg	22	16
9	Average area of cauliflower (ha)	0.11	0.14
10	Average cauliflower production Kg/ha	3180	57240
11	Farm get price of cauliflower Rs / kg	14.5	10.50
12	Average cabbage production area (ha)	0.5	0.11
13	Average yield of cabbage production (Kg per ha)	2660	41240
14	Average farm get price of cabbage (Rs /kg)	8	7.40
15	Average cucumber production area per ha	0.7	0.06
16	Average yield of cucumber production (Kg per ha)	4450	33100
17	Average farm get price of cucumber (Rs /kg)	9.5	8

Cropping pattern

Farmers cultivate different types of crops on their patch of 1 and in order to get better production in different types of cropping pattern in low land (*khetland*). *Khetland* cropping pattern was rice-potato-

tomato, rice-potato-cauliflower, rice-potato-cabbage and rice- potato-cucumber/pumpkins, beans, cow pea.

Types of hybrid vegetable varieties sold in different agro- vets

Commercial vegetable growers were cultivating different types of hybrid vegetables in the study area. The major one include *tomato, cauliflower, cabbage, chilly, cucumber, coriander, bitter gourds, zucchini, radish, cowpea, beans* and brinjals. Table 2 presents different types of hybrid vegetable crops sold by the agro-vets for cultivation in Nepal.

Table 2. Major hybrid vegetable varieties sold by Agro-vets for cultivation in farmers fields

SN	Commodity	Hybrid varieties
1	Tomato	Nutan ,Nabin, Manisa, Nonva, AS,S,US, Nabin2000, Loahar, umi, Karina, Gem, RK, Sunder, Surachha, Ankur, US1080m, Bises, Gaurab, Rabiya, Rupali, Rashmi, Centuri, Avinas, BSSRaja, US4 , Thimas 16, 9802, 9502, Snehalata, Ramiga, wisari, Goriya, Resso- 1, Gressco-4, MS53, , Astama717, Bss2214, NS815, Namita, NS2535, Dalia, Amita, 112, 2535 and N162.
2	Cauliflower	Snow crown, snow lady, US, Snow cub, snow crown, snow queen, snow king, snow mist, White top, Hempsayua 60, Barsa, Megha, sumil45, white king, Madhuri, SA, Silvercub 60, Remi, Early white 85 days, NS60nN, San crown, white flash, milky way, gro gress, dome, King, queen and NS2535.
3	Cabbage	Green coronet, T621, Green stone, New tops, Supper comment, Snow green, Snow misake, White island, White king, NS 60N, Horderson, Sk9-321, supper cordinae, supper green, Jenith, green crown, Dc65, Field man, Korotate, YT Jenith, Nepal bulb, Rebal
4	Cucumber	Ninja, Nepadosi, Canen, Casinja, Nepatusi, US, Minja, Maya, US6125, Molani, Rani, Palimi, Ramu, Gresscova , Kijapur crown, Macine, Sibra, Basmati, Dynasty, Gauri and Number 2.
5	Chilly	Namdhari, sone face, Karma747, CMN, US5, NS1701, Angareca, Kama 777, Pushajula, solder1, Nonhamps, Californiya wonder, Kena 557, Kampasa1711, Angrarico, NS555
6	Coriander	Nonhamps, TakF1, Biju, Ransar
7	Bitter gourds	Biso, white long, Chaman, Puman, Jhalari, US33, Long white, White long, Green, Long, G2, Sarada, PSCL, Tiguti, Posier gourd, Chenan, NS, Pali, Punam, NS34
8	Zucchini	Blum house, green ball, sunny house, Blum home, green house, green ball, Randobi
9	Radish	Tokita, Taki, all season, Cannon, Mahi -11, Japanise white.
10	Ladies finger	Minga, Swasti, Tulsi 152, Simi, Najuka, Arka anamika and Parwani Krunti

Tomato: In the study area, different types of hybrid vegetable seed were sold by the different agro vets. Commercial vegetable producing farmers were using hybrid vegetable seed because the production was homogeneous, marketable and high yielding. Tomato was one of the most income generating vegetables for the farmers. In another study, ten promising tomato varieties were grown under plastic tunnel for the evaluation of off-season production during rainy season (July to October). All the varieties grew well under plastic tunnel and produced very good quality fruits (Annual Report, Horticulture Research Division 2002). In a four month, farmers were getting more than Rs 50,000 from one ropani of land in the Panchkhal of Kavrepalanchok district. Farmers were using different varieties of hybrid tomato seed such as Nutan, Nabin, Manisa, , AS,S,US, Nabin 2000, Loahar, Umi, Karina, Gem, RK, Sunder, Surachha, Ankur, US1080m, Bises, Gaurab, Rabiya, Rupali, Rashmi, Centuri, Avinas, Raja, US4, Thimas 16, 9802, 9502, Snehalata, Ramiga, Ns815, Wisari, Goriya, Resso- 1, Gressco-4, MS53, , Astama717, Bss2214, NS815, Namita, NS2535, Dalia, Amita, N-162,112, 2535 and N162 (Table 1). These hybrid seeds were imported from India, Korea, Japan and European countries.

Cauliflower: Cauliflower is one of the highly demandable vegetables in Nepalese kitchens. Due to the agroecological diversity, cauliflower can be grown throughout the year in Nepal. In addition, there are different types of hybrid varieties available in the market that can be grown in both off-season and normal seasons. These varieties are Snow crown, silver cub, snow lady, US, Snow cub, snow crown, snow queen, snow king, snow mist, white top, Hempsayua 60, Barsa, Megha, sumil45, white king, Madhuri, SA, Silvercub 60, Remi, white curd, Early white 85 days, NS60N, San crown, white flash, milky way, gro gress, ,dome, King, queen, NS2535, Dalia, Amita, N-162,112, 2535 and N162. These hybrid cauliflowers are being popular in farmers' fields due to their homogeneous types product and marketable size.

Figure 2. Price of different types of hybrid vegetable seed

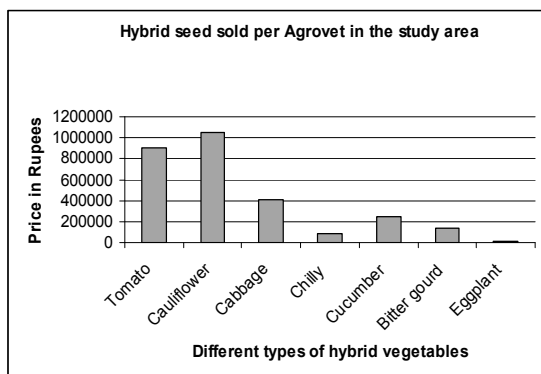
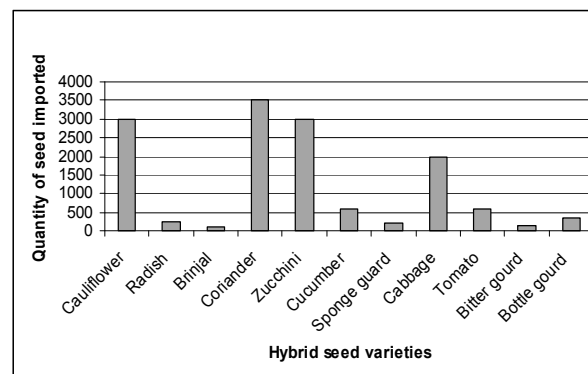


Figure 3. Quantity of hybrid vegetable seed



imported

Cabbage: There are many hybrid varieties of cabbage such as Green coronate, T621, Green crown, Green stone, New tops, Supper comment, Tikiya, Snow green, Snow misake, White island, White king, NS 60N, Horderson Silver cub, Sk9-321, supper cordinae, supper green, Jenith, green crown, Dc65, Field man, Korotate, YT Jenith, Nepal bulb and Rebal. Green coronate hybrid is popular or preferred in Kaski and Snow misty in Kavre. In Dang, Kathmandu, and Dhading, other different types of hybrids seeds such as Green corotate, T621, Green crown, Green coronet, Green stone, New tops, Supper comment, Tikiya, Snow green, Snow misake, White island, White king, NS 60N, Horderson Silver cub, Sk9-321, supper cordinae, supper green, Jenith, green crown, Dc65, Field man, Korotate, YT Jenith, Nepal bulb, Rebal were sold from the agro-vets.

Cucumber: In cucurbit family, many new hybrid varieties are in the seed market such as Ninja, Nepadosi, Canen, Casinja, Malini, Nepatusi, US, Minja, Maya, US6125, Molani, Rani, Palimi, Ramu, Gresscova, Kijapur crown, Macine, Sibra, Basmati, Dynasty, Ninja, Gauri, ,Number 2, Ramita and Manisha. Malini, NS704 and Majestic cucumber hybrids were popular in Hemja VDC of Kaski. Farmers are interested to grow other different types of hybrid vegetables and their varieties such as chilly, Coriander, Bitter gourds, Zucchini, Radish and Ladies Finger.

Hybrid vegetables seed marketing in Nepal

Seed Entrepreneur Association Nepal (SEAN), Tripureswar has recorded the different types of hybrid vegetables. The information supplied by them indicates that about 6,573 kg of F1 seed worth Rupees 4,405,237 was sold by different Agro-vets in the year 2007. Information was collected from different seed business Agro-vets of Dang, Salyan, Rupandehi, Kaski, Kathmandu, and Kavre districts (Table 6). During the interviewed, entrepreneurs reported that on an average each agro-vat sold cauliflower seed worth Rs 100,000 per year and tomato was more than Rs 80,000 followed by Cabbage Rs 40,000 (Figure 2). Different types of hybrid seed was imported from different countries such as Japan, Thailand, India, USA, Korea, China and European countries. Among them, Coriander was 3500 kg followed by cauliflower and Zucuni 3000 kg each (Figure 3).

Table 3. Type of hybrid vegetable seeds, quantity, and countries

SN	Hybrid (F1) vegetable seed varieties	Quantity sold (kg)	Amount (Rs)	Imported country
1	Tomato	409	898708	India, Thailand, Japan, Korea
2	Cauliflower	727	1052498	Japan, China, Korea
3	Cabbage	452	405808	India, Korea, Japan, China
4	Chilly	145	83085	India
5	Cucumber	381	246477	India, China, Thailand
6	Coriander	218	113080	India
7	Bitter gourd	357	137520	Japan , India
8	Radish	247	22491	India, China
9	Zucchini	503	260049	India, China, Japan, Koriya
10	Ladies finger	4	13600	India
11	Water Mellon	200	16000	
12	Bro cauli	4	240000	
13	Capsicum	72	329568	
14	Flesh bean	2505	94563	
15	Carrot	16	17744	Japan , India
16	Chinese spines	5	200000	China
17	Eggplant	10	14542	India
18	Cowpea	200	173393	India, China
19	Long gourd	107	56357	India
20	Sponge gourd	11	29754	India
Total amount		6573	4405237	

Source: SEAN

Comparative cost of cultivation under plastic tunnel and open condition

Comparative cost of cultivation of tomato on open condition and under plastic tunnel was calculated. As a result in open condition the net return was Rs 8346 per Ropani where as under plastic tunnel the net return was Rs 50361 per Ropani. Table 4 illustrates the Comparative cost of cultivation of hybrid tomato under plastic tunnel and open condition.

Table 4. Comparative cost of cultivation under plastic tunnel and open condition

Cost of cultivation of tomato per Ropani	Unit per Ropani	Labor cost Rs /unit	Panchkhal (Amount in Rs)	Unit per Ropani	Labor cost Rs /unit	Hemja (Amount in Rs)
Seed cost (gm)	10	29.3	293	10	15	150
Land preparation no of manpower	6	231	1386	5	180	900
Bullock cost (pair)	1	300	300	0		0
Plantation	4	200	800	3	200	600
Fertilizer(kg)						
N	3		128		5	140
P	5		128		10	350
K	4		128		3	78
Farm Yard Manure /kg	17	20	340	42	25	1050
Irrigation /hour	6	200	708	2	150	300
Insect pest			3500			900
Weed management cost	4	200	800	2	150	300
Plastic tunnel cost						4204
Total cost			8511			8972
Total return			16857			59333
Net profit			8346			50361

Source Field survey, Note: 1hacter =30 Ropani

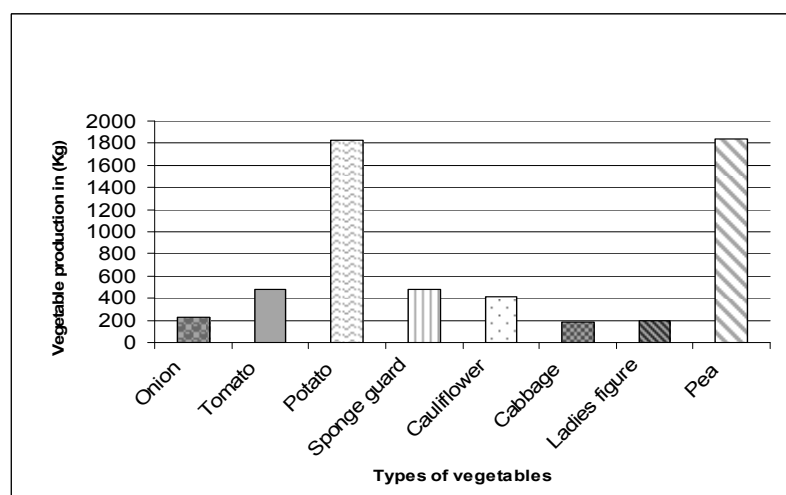


Figure 4. Production of different vegetables

Table 5. Average quantity of hybrid seed sold per agrovet in the study area

SN	Hybrid vegetable seed	Average quantity sold (kg)	Total amount (Rs)
1	Tomato	13	898708
2	Cauliflower	16	1052498
3	Cabbage	11	405808
4	Chilly	5	83085
5	Cucumber	11	246477
6	Coriander	20	113080
7	Carrot	2	17744
8	Chinese spines	5	200000
9	Bitter gourd	10	137520
10	Eggplant	2	14542
11	Cowpea	10602	173393
12	Long gourd	7	56357
13	Radish	17	22491
14	Zucchini	17	260049
15	Sponge gourd	3	29754
16	Ladies finger	4	13600
17	Water Mellon	200	1600000
18	Brow cauliflower	4	240000
19	Capsicum	48	329568
20	Flesh bean	250	94563

Status of vegetable production in the study area

In the study area farmers were cultivating different types of vegetables for commercial purpose as well as household consumption. Highest production were pea and potato about 1800 kg each per households fallowed by tomato, sponge guard and cauliflower about 400 kg each per households. Incase of onion bulb and other vegetable production were about 200 kg per households. Figure 4 illustrates the different types of vegetable cultivation in the study area.

Different types of vegetables cultivation

In the study area farmers were cultivating different types of vegetables for commercial purpose as well as households consumption. The household income was derived from hybrid vegetable 38 percent, cereal crops 25 percent, OPV vegetable 20 percent, labor 11 percent and other 7 percent. (Table 3). Figure 5 illustrates the income derived from different sources.

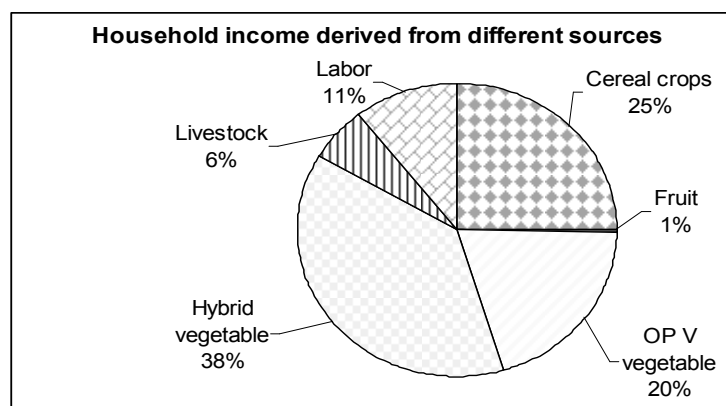


Figure 5. Income derived from different sources

Types of hybrid vegetable seed varieties sold in different agro- vets

Commercial vegetable growers were cultivating different types of hybrid vegetables in the study area. Tomato, cauliflower, cabbage, chilly, cucumber, coriander, bitter gourds, zucchini, radish, cowpea, beans and ladies' finger were the major types (Table 3).

Hybrid vegetable seed marketed in Nepal

Agro entrepreneur Association of Nepal has recorded the different types of hybrid vegetables seed 6573kg worth amount Nepalese Rupees 4405237 that has procured by the farmers from different agro vets in 2007. Seed business information was collected from the agro vets of Dang, Salyan Rupandehi, Kaski, Kathmandu, and Kavre districts.

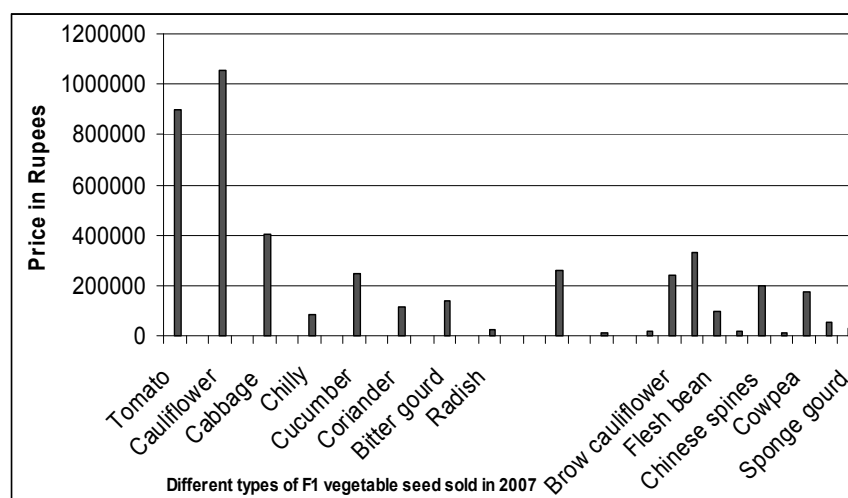


Figure 6. Price and quantity of different types of hybrid vegetable seed

Constraints of hybrid vegetable production

Farmers of Panchkhal and Hemja reported that the hybrid F1 seed have some problems of germination during some time. Despite the problem, the farmers do cultivate hybrid vegetables because of their high yielding characters, short duration, homogeneous product and marketable size. Their major complained was price of seed which is very high. Some times, certain types of hybrid seed cost more than Rs75000 per kg. In addition, there is no regular supply of same type of hybrids by the Agro-vets. Farmers have to depend on Agro-vets for whatever they supply the seeds and related information. Farmers expressed their view that there is no quality control, monitoring, and compensation of the poor germination of the seeds. Furthermore, the important problem of the hybrids is that farmers have to purchase seeds every year from market (Agrovets), making them highly dependable to markets. If farmers use second generation seed (F1), the

expected yield would be drastically declined the production due to segregation which is common of F1 hybrids.

Farmers also explained that there is a limited technical support and information from public extension offices and farms in the production and marketing of hybrid vegetables. As a result, farmers mainly depend on Agro-vets for technical support and in many cases Agro-vets have no technical expertise to guide farmers in improved cultivation of hybrids. Diseases and insect pests are also reported to be some problems in hybrid cultivation. Furthermore, market for hybrids is highly vulnerable, as vegetable products are highly bulky, perishable and difficult to store due to lack of proper storage facilities. Poor marketing and price information support are also some of the constraints faced by the hybrid growers.

CONCLUSION

Hybrid vegetables are mainly grown by commercial vegetable growers. These hybrids are grown both in off-season and on-season. Hybrids are most popular in cauliflower, cabbage and tomato. Hybrid tomato grown in plastic house is highly profitable during off-season. Many farmers have enhanced their income and livelihood from off-season hybrid vegetables production, as they can be produced in shorter duration and fetch higher prices in off-season. Diversity of agro-ecological conditions offer high potential to grow vegetables in different parts of the country even during normal seasons. However, there are some problems in hybrid vegetable production. Most important ones are high costs of seeds, irregular supply, poor quality control and weak technical support from public R&D agencies in its cultivation and promotion. Current research and extension system on hybrid vegetables is weak despite its greater potential in generating income and improving the livelihood of small-scale farmers, who have limited land size and no alternative options other than farming. There is a need of suitable policies to enforce the rule that farmers should have the guaranty of reliable seed sources and insurance on their crops if it fails. Agro vets and seed business entrepreneurs should take the responsibility on failure of crops if it is due to seed quality. There is a need of increased research investment in domestic hybrid vegetable seeds and crop management systems so that proper technical support can be provided to farmers through extensions, NGOs and farmers groups. However, this will also require increased public-private partnership as well as enhanced capacity of extension systems to deliver reliable and timely technical inputs and information to farmers. Increased emphasize in market development and marketing research is also needed to promote growth of hybrid vegetable production in Nepal.

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Consumer's Willingness to Pay for Organic Vegetables in the Kathmandu Valley

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ABSTRACT

Consumers' willingness to pay for organic vegetables and their level of knowledge has been studied in 2008 at local markets and specialized markets (The Organic Village, Bhat Bhateni Super Market, and Summit Hotel) of Kathmandu Valley by selecting consumers of both inorganic and organic vegetables through simple random sampling and data have been taken using structured questionnaire administered through interview. Three organic vegetables are given emphasis during the study namely tomato, cauliflower and broadleaved mustard. Results reveal that most of the consumers have heard of organic products and some of them consume organic vegetables. Further, a majority of the consumers consider price as an important factor for organic product consumption and have attached a higher importance for labeling. Generally organic vegetables are either home delivered or sold through specialized shops. Most of the organic consumers have university degree, high level of personal and family incomes, small family size and have better knowledge about the existence of organic products. Significant difference has been noted in between educational levels and consumption of different types of tomato ($\chi^2=19.22$, $p<0.01$), cauliflower ($\chi^2=16.92$, $p<0.05$) and broadleaved mustard ($\chi^2=11.08$ ns). Most of the consumers are willing to pay about 10 percent additional price to the organic vegetables over inorganic while they are willing to pay about 20 percent more price to the organic vegetables if they are labeled. Despite the level of awareness, still the organic market is running in the trust basis and there is no way to prove the authenticity of the organic products. An appropriate national agriculture policy, giving a prominent place to organic farming addressing the issues related to its coverage, financial support during the conversion period, creation of linkages among the farmers, processors, traders and consumers, inspection and certification of organic products and increasing the public awareness of the benefits of organic agriculture, should be designed and should be followed with concrete action.

Key words: Organic vegetables, vegetable marketing

INTRODUCTION

Land and environmental degradation are the common concerns all over the world. Green revolution which was able to solve food hunger prevalent in many countries around the globe has now been no more remunerative as it has exacerbated the problem of land degradation and environmental quality. Concerns are accumulating that inorganic production practices led to over exploitation of the natural resource base concomitantly degradation in soil health and fertility, shrinking land and water resource and overall environmental quality (Bhatta 2006). Profitability motivated conversion of "green revolution" into "greed revolution" with scant regard to the prudent use of the natural resource base, affecting both soil and water quality has put the scar on the sustainability of productivity in almost all parts of the globe. Now the time has come to follow the practices of ever green revolution: the best and sustainable way is to adopt organic farming.

Organic farming can be defined as an approach to agriculture where the aim is to create integrated, humane, environmentally and economically sustainable agricultural production systems. Maximum reliance is placed on locally or farm-derived renewable resources and the management of self-regulating ecological and biological processes and interactions to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed.

With increasing purchasing power of the consumers, globalization and the need to nurture the nature and the human health, people are now becoming more aware towards healthy, safe and quality food products. Environment and health address the question of “consumerism”, its influence on human health and on the long-term maintenance of the planet's resources (Silverstone 1993). According to Browne et al (2000), the growing interest in “ethical” production has been both consumer-driven and trade-driven. Most of the consumers in the developed countries prefer to buy and consume organic products. It is also widely recognized that consumption of organic food products is the best remedy to prevent the numerous health hazards caused by conventionally produced food products; the global market has experienced exceptionally high growth in organic foods especially in the United States, Europe, and in other countries (Piyasiri and Ariyawardana 2002). However, in developing countries like Nepal, the market for organic products is not well developed and no market statistics are available (Bhatta et al 2008). The organic market in Nepal is characterized by scattered consumers, low level of awareness about the organic products, lack of credence on organic products, lack of market regulation, spuriously available markets for organic products etc (Bhatta et al 2008).

Growth of organic market requires awareness of the consumers', traders' and producers' about the quality of organic products, availability of sound infrastructure, pro-active policy of the government and most importantly consumers' willingness to pay for the organic products. Studies regarding consumers' willingness to buy organic products have been widely done in the developed countries. They reveal that purchase motives are attributed to environmental and health consciousness, safety and quality concerns and exploratory food buying behaviour, as well as to specific product attributes such as nutritional value, taste, freshness, and price (Tregear et al 1994, Grunert and Juhl 1995, Davis et al 1995, Roddy et al 1996, Worner and Meier-Ploeger 1999, Browne et al 2000; Fotopoulos and Krystallis 2002). Some empirical evidences regarding consumers' preference for differentiated quality attributes are given by Okechuku (1994), Elliott and Cameron (1994), Bower and Baxter (2000) and Lans et al (2001).

Study that focuses on market research and consumers' willingness to pay for organic vegetables has not done in Nepal. Therefore, present study focuses on the consumers' level of awareness about the existence of organic vegetables in the market, their consumption behavior and willingness to pay for organic vegetables in the key market centers of Kathmandu valley.

RESEARCH METHODOLOGY

This study was conducted in some of the organic and inorganic vegetable markets within the Kathmandu Valley. Consumers consuming organic and inorganic vegetables have been included as the respondents. Organic consumers were selected from key organic markets such as The Organic Village (TOV), Bhatbhateni Super Market, Sale ways Supermarket and Summit Hotel while inorganic consumers were selected from local markets of Kathmandu valley such as Kotesor, Gatthaghar, Chapagaun, Balaju, Banesor and Lagankhel. Random selection approach while selecting consumers was attempted as much as possible. The consumers were randomly approached at the market and asked for their participation in an interview. This procedure was applied due to lack of alternatives. However, not all of the selected consumers agreed to interviews and replacement of previously selected consumers had done frequently. The non-response variables were simply ignored in the process of data analysis.

A total of 90 consumers (60 from local markets and 30 from organic markets) were selected. Out of the selected consumers, 24 (26.7%) were males and 66 (73.3%) were females. Structured questionnaire was designed to collect primary information administered through interview. Such questionnaire had

maximum of closed ended questions in which coding was done prior the interview. The questionnaire included in its first part a number of criteria that influence consumers when buying food. In the second part respondents were asked to indicate if any food products they buy were organic and to state how much more they were willing to pay. Emphasis had been given to three important vegetables viz., tomato, cauliflower and broadleaved mustard on the market demand basis in the valley. Collected information were subjected to statistical analysis using simple statistical tools such as frequency, tabulation, chi-square test etc.

RESULTS AND DISCUSSION

Awareness about organic products

Level of awareness about good quality and healthy food products always comes in the fore front while making decision on consumption. A majority of the consumers (92.22%) expressed that they had heard of organic vegetables (Fig 1). Only 7.78 percent of the respondents had not heard about organic vegetables. Sharma (2005) also reported that 63% of the respondents knew about organic agriculture and organic products while 37% of the respondents did not. Piyasiri and Ariyawardana (2002) have advocated that organic product marketers should develop awareness among the consumers in order to promote consumer-buying behavior.

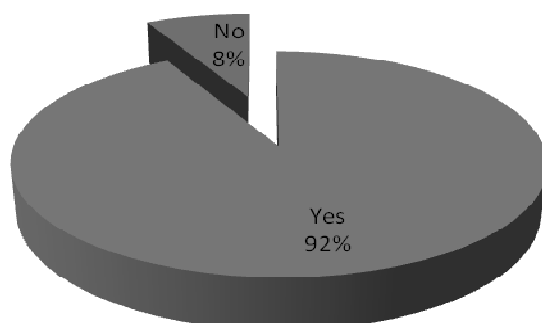


Fig 1. Consumers' familiarity with organic vegetables

Matter regarding how well informed consumers are about organic vegetables revealed that majority of the consumers (54.4%) were somewhat informed followed by 43.3 percent who were very well informed (Table 1). Somewhat informed about organic products here implies that consumers have vague knowledge about organic products. The sources of information to the consumers were colleagues, own education, some NGOs, media etc. It was also noted that government efforts towards giving information to the consumers was found nugatory.

Table 1. Percentage of consumers as per the information about organic vegetables

How informed	Number of respondents	Percent
Very well	39	43.3
Somewhat	49	54.4
Not informed	2	2.2
Total	90	100.0

When asked about how often consumers prefer to buy organic vegetables equal percentage of respondents replied 'always' and 'sometimes' (42% each) followed by 11 percent rarely and 5 percent never (Fig 2). Those who prefer to buy organic vegetables, however, don't mean that they have been consuming organic vegetables yet they have preference over organic vegetables. Sharma (2005) reported that 2 percent of consumers know about organic vegetables and did consume it, 28 percent know but

seldom consumed, 33 percent know but did not consume and 37 percent did not know and did not consume such products.

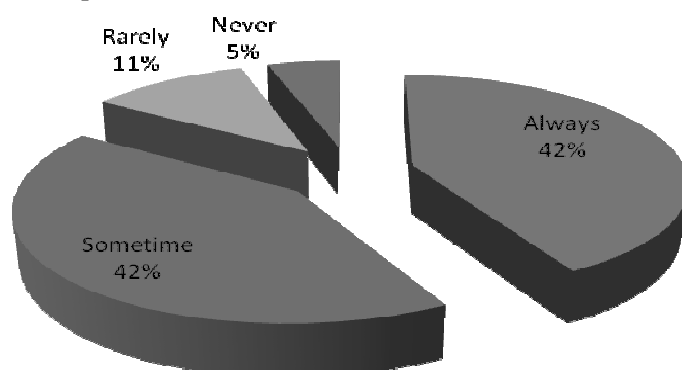


Fig 2. Preference to buy organic vegetables

There are various reasons that motivate consumers to purchase organic vegetables. Consumers purchase organic vegetables from the market for health, safety, taste, environmental concern along with other reasons. The reason behind purchasing organic vegetables from the market revealed that most of the consumers (53%) purchase organic vegetables due to health and safety reasons. Similarly, 35% of the consumers purchase organic vegetables due to health reasons and 12 percent of them purchase organic vegetables due to the fact that organic vegetables taste better than inorganic ones (Fig 3). This signifies that consumers give first preference to their health and its safety and then can think about other concerns of inorganic production.

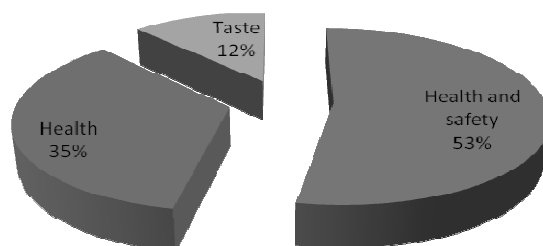


Fig 3. Reasons for purchasing organic vegetables

Consumption of different types of vegetables

It is evident that large chunk of the respondents with university degree consumed organic tomato (Table 2) and it was significantly different as per educational levels of the respondents ($P < 0.01$).

Table 2. Educational levels and consumption of different types of tomato

Tomato Type	Education levels					Total
	No formal education	Primary	Secondary	Higher secondary	University	
Organic	1	0	0	1	26	28
Inorganic	4	5	3	10	22	44
Both	2	0	0	5	10	17
Total	7	5	3	16	58	89
Chi-Square value	19.224**					

**Significant at 0.01 level of probability

Similarly that most of the respondents with university degree consumed organic cauliflower (Table 3) and also broadleaved mustard. With the use of chi-square test, it is conspicuous that there was significant discrepancy ($P < 0.05$) between education and consumption of different types of cauliflower, however, it fails to show significant discrepancy in between consumption of different types of broad leaved mustard and levels of education.

Table 3. Relation between education and consumption of different types of cauliflower

Cauliflower type	Education levels					Total
	No formal education	Primary	Secondary	Higher secondary	University	
Organic	3	0	1	2	24	30
Inorganic	1	5	2	8	17	33
Both	3	0	0	6	14	23
Total	7	5	3	16	55	86
Chi-square value	16.920*					

*Significant at 0.05 level of probability

It was found that majority of the respondents (46.1%) considered price factor as being somewhat important followed by 38.2 percent who considered it to be extremely important (Table 4).

Table 4. Distribution of consumers as per the importance of price factor in making decision

Importance of price factor	Frequency	Percent
Extremely important	34	38.2
Somewhat important	41	46.1
Neutral	9	10.1
Somewhat unimportant	5	5.6
Total	89	100.0

Similarly, majority of the respondents (71.1%) considered labeling of organic vegetables extremely important. This is followed by 21.1 percent of the consumers that regard labeling somewhat important (Table 5). Some of the respondents (4.4%) even didn't know about labeling and its importance in organic markets.

Table 5. Percentage distribution of consumers according to how important they regard labeling of organic vegetables

How important	Frequency	Percent
Extremely important	64	71.1
Somewhat important	19	21.1
Neutral	3	3.3
Don't know	4	4.4
Total	90	100.0

It is found that large numbers of the consumers with personal income more than NRs. 11,000 do consume organic tomato (Table 6). Similar results have been attached with consumption of organic cauliflower and broadleaved mustard. This shows clear tendency in consuming organic vegetables by higher income group. Quite similar results have been obtained in consuming different types of vegetables as per family income. One of the consumers' behavior studies conducted in Argentina and Denmark reports that organic consumers belong to relatively higher income strata, have knowledge about organic products and their quality and they are health conscious (FAO 2001).

Table 6. Relation between personal income and tomato type

Personal income (NRs.)	Tomato type			Total
	Organic	Inorganic	Both	
<3000	1	1	0	2
3000-5000	1	3	0	4
5000-8000	2	3	3	8
8000-11000	6	5	5	16
>11000	16	14	2	32
Total	26	26	10	62

Willingness to pay for organic vegetables

Willingness to pay for organic vegetables as compared to inorganic vegetables has been found out and it has been deciphered that majority of the respondents (62.7%) would like to pay 10-20 percent more price as compared to inorganic vegetables. Similarly 25.3 percent of the respondents were willing to pay 20-30 percent more (Table 7) followed by 8.4 percent who would like to pay 40-50 percent more.

Table 7. Willingness to pay for organic vegetables by the consumers

Willing to pay	Frequency	Percent
10-20% more	52	62.7
20-30% more	21	25.3
30-40% more	3	3.6
40-50% more	7	8.4
Total	83	100.0

A majority of the respondents with university degree would like to pay up to 20-40 percent more for organic products if they will be labeled (Table 8). Similarly majority of the respondents interviewed would like to pay less than 20 percent for the labeled organic product irrespective to the educational status. Similarly eight respondents with university level education would like to pay 40-50 percent for the labeled organic products. The reason why the consumers with higher level of education would like to pay more for labeled organic products is that they have heard about organic farming and they also know that organic agriculture is somewhat expensive during the formative stage. However, another important issue influencing the market development is determination of factors limiting the willingness to buy organic products. The most frequently mentioned reasons not to pay for organic vegetables were high prices of organic products, lack of knowledge, lack of truthfulness, lack of advertisement, spuriously available market and lack of government support. A price premium of 20 percent over conventional products seems to be the maximum accepted in many countries. Market studies show that majority of the consumers of Denmark would like to pay 10 percent extra for organic food, in France 30-35 percent and in Japan 10-20 percent (FAO 2001).

Table 8. Willingness to pay for labeled products by the respondents of different educational levels

Education	Additional pay for labeled products				Total
	<20	20-40	40-60	>60	
No formal education	5	1	0	0	6
Primary	4	1	0	0	5
Secondary	3	1	0	0	4
Higher secondary	12	4	0	0	16
University	18	20	8	5	51
Total	42	27	8	5	82

Willingness to consume organic vegetables if prices were reduced revealed that majority (77.78%) of the consumers were very much willing to consume organic vegetables followed by 22.22 percent who were willing to consume organic vegetables (Fig 4).

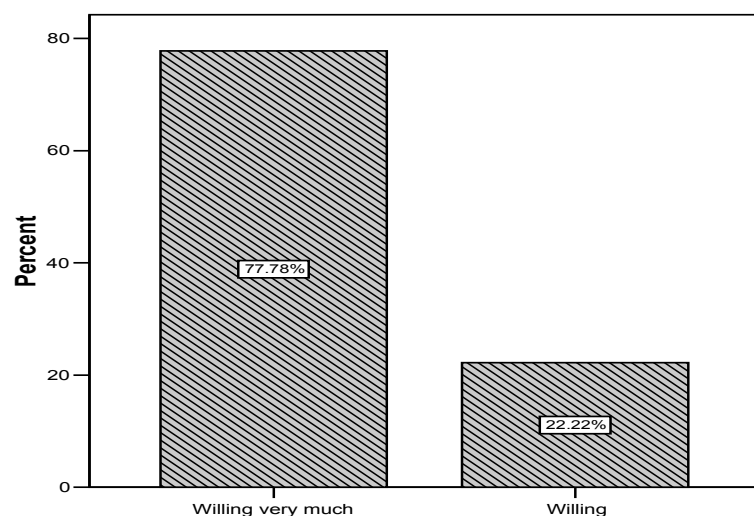


Fig 4. Willingness to consume organic vegetables if prices are reduced

The percentage distribution of consumers according to their willingness to purchase organic vegetable provided they knew that organic vegetables are safer to human health than inorganic vegetables deciphered that most (88.89%) of the respondents were willing very much to consume organic vegetables while 11.11 percent were just willing (Fig 5).

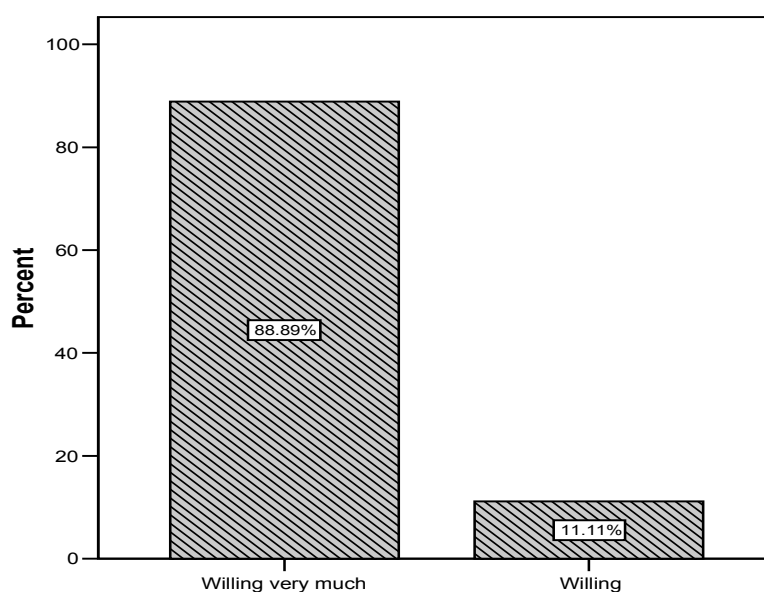


Fig 5. Willingness to purchase organic vegetable provided it is known that organic vegetables are safer to health

CONCLUSION

Organic farming has been in existence ever since man started farming. Over the years organic methods gave way to "so called modern" methods, characterized by the use of synthetic chemical inputs. Today, however, there is renewed interest in organic farming and it is being termed by many the "alternative"

method of farming. This renewed interest is a direct result of high energy prices, increased fertilizer costs, and concerns about health, pesticide residues and the environmental impacts of chemicals. Over the past few years consumers have changed their perceptions regarding organic food items. This change is a direct result of consumer awareness of food safety issues, particularly those involving chemical residues. The consumer survey investigated that majority of the consumers know about organic products, however, they define differently. Those having higher educational levels have found having great deal of knowledge about to the term 'organic'. They are the ones who have been consuming organic products and always considering quality of organic products. The consumers with higher level of education would like to pay more for labeled organic products. It could be pinpointed that consumer awareness effectively advances the demand for organic products and there is a high potential to introduce organic products to the markets in the Kathmandu valley. Therefore, along with introducing organic products, marketers should also direct proper awareness programs among consumers in promoting the demand for organic products. The government should also increase investment in research regarding various aspects of organic agriculture.

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Study on Soil amendments to Manage Rhizome Rot Disease of Ginger

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ABSTRACT

Field experiments were carried out in 2004/05 to 2006/07 at Ginger Research Program Kapurkot, Salyan to assess the effect of various organic soil amendments to minimize the rhizome rot disease of ginger. Six different organic soil amendments were evaluated in a randomized complete block design (RCBD) with three replications. The soil amendments were agri lime, neem cake, mustard oil cake, agri lime + mustard oil cake, 'Timur' powder and 'Bojho' powder. Ginger variety, Kapurkot-1 was used in this experiment. All recommended package of practices were followed as and when needed. Combined analysis revealed highly significant rhizome yield. Highest rhizome yield was recorded as 24.0 t/ha from treatment where Timur (*Xanthoxylum armatum*) powder @ 50 kg/ha was applied followed by Neem (*Azadirachta indica*) cake applied @ 2 t/ha (19.0 t/ha). The highest disease incidence (68.2%) was noticed in plots where treatments were not applied (control).

Key words: Ginger, rhizome rot, soil amendments

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important high value spice as well as industrial and cash crop grown east to west and terai to mid hill (500-1600 masl) in Nepal. Salyan, Nawalparasi, Palpa, Illam and Pyuthan are the leading ginger producing districts of Nepal. Annual ginger production in Nepal is 152,704 ton with the average productivity of 12.20 t/ha. A sizable quality of ginger produced in the country is exported to India mostly in the form of fresh as well as processed ginger (Sutho). The National average productivity of ginger is low (12.2 t/ha). The yield potential of ginger is reported to be up to 50 t/ha under favorable agro climatic condition. It indicates that there is tremendous scope to increase the yield per unit area and ultimately the production as well as productivity. However, rhizome rot disease is most serious disease in most of the ginger growing areas of the country. Up to 80 percent yield losses has been estimated under field conditions. This disease is considered as a major bottle neck for ginger production. Seed treatment with Indofil and Bavistin + soil treatment with Ridomil + organic amendments showed the highest disease control (47.2%) followed by soil solarization with seed rhizome treatment (38.7%) as compared to check as reported by Sharma (1998). Losses due to rhizome rot are colossal in view of its total crop loss that they cause (Sharma and Anandraj 2000, Adhikari et al 1985). High humidity, high temperature, poor drainage, and continuous dampness of the field favour the rapid spread and development of rhizome rot disease. Tiwari et al (2004) reported *Trichoderma*-incorporated with neem cake (2 t/ha) coupled with 30 days solarization was highly effective and recorded 100 percent control of this disease. Pruthi (1993) advised that the rhizome rot disease can be effectively controlled when seed rhizome is dipped in 0.25 percent Ridomil at planting followed by drenching with 0.01 percent Ridomil 3 months later. Sharma et al (1980) reported that rhizome rot (*Pythium aphanidermatum*) in the field can be effectively controlled by Diathane Z-78 (zineb) followed by Captan and Difolation. According to Dohroo et al (1984) wet rot (*P. plerotium*) and dry rot (*Fusarium equiseti*) can be controlled with antagonists. Therefore, the experiment on study of soil amendments to minimize the rhizome rot disease in ginger was carried out to find the effect of various organic soil amendments to reduce the rhizome rot disease severity on ginger.

MATERIALS AND METHODS

Field experiment was conducted at Ginger Research Program Kapurkot, Salyan during 2004/05 to 2006/07. Seven different soil amendments like agri. lime, neem cake, mustard cake, agri. lime + mustard oil cake, Timur (*Xanthoxylum armatum*) powder and Bojho (*Azadirachta indica*) powder were applied @ 4, 2, 2, 2 + 2 (mt), 50 and 80 kg/ha, respectively including control where compost @ 20 t/ha was applied. Variety Kapurkot Aduwa-1 was used in this experiment. Experiment was laid out and planted during the first week of Baisakh. Plot size was 3 x 1.5 m² (4.5 m²), 30 x 30 cm row to row and plant to plant spacing was provided. Total 50 seed rhizome per plot was planted. Seed rhizome was treated in the solution of Indofil-M-45 @ 2.5 g/l water + 1g Bavistin/lit water before planting. All the soil amendments were used in the furrow made by Kutto before seed rhizome planted. Observations like date of planting, germination percent, plant height, number of tillers per plant, fresh ginger yield and number of damaged plant by rhizome rot disease per plot were taken. Experiment was laid out in randomized complete block design with three replications. All other package of practices was given as recommended.

RESULTS AND DISCUSSION

Fresh rhizome yield revealed significant result in the experiment conducted during 2004/05. Highest yield (20.22 t/ha) was obtained from the treatment in which Timur powder @ 50 kg/ha was applied followed by the treatment, Neem cake (@ 2 t/ha) that yielded 17.52 t/ha. Lowest rhizome yield (14.52 t/ha) was obtained from the treatment, control. Number tillers per clump and leaf number per plant also indicated significant results (Table 1).

Table 1. Effect of soil amendments on plant characters and rhizome yield (2004/05)

Treatments	Plant ht. (cm)	Tiller no./ plant	Leaf no. / plant	Rhizome yield (t/ha)
Control	59	5	14	14.52
Agri lime @ 4 t/ha.	61	4	12	15.58
Neem cake @ 2 t/ha.	68	4	14	17.52
Mustard oil cake @ 2 t/ha	59	4	12	12.89
Agri. Lime + mustard oil cake @2 t/ha	70	4	10	13.44
Timur Powder @ 50 kg/ha	61	6	12	20.22
Bojo dust @ 80 kg/ha	61	4	14	16.63
Mean	63	4	10.1	16.0
F test	0.27	0.02*	0.01*	0.04*
CV%	8.04	14.5	13	15.7
LSD.	11.72	1.12	2.29	4.42

Experiments conducted during 2005/06 also gave significant result of rhizome yield. Highest fresh yield (22.74 t/ha) was obtained from the treatment, Timur powder followed by Neem cake (18.52 t/ha). Lowest yield was found in control. Tillers per plant and plant height also indicated the significant result (Table 2)

Table 2. Effect of soil amendments on plant characters rhizome rot disease incidence (20662/63)

Treatments	Plant ht. (cm)	Tiller no./ plant	Leaf no. / plant	Rhizome yield (t/ha)
Control	56	4	14	14.74
Agri lime @ 4 t/ha.	57	4	12	15.78
Neem cake @ 2 t/ha.	67	4	14	18.52
Mustard oil cake @ 2 t/ha	63	4	12	13.85
Agri. Lime + mustard oil cake @2 t/ha	69	4	11	13.56
Timur Powder @ 50 kg/ha	63	6	13	22.74
Bojo dust @ 80 kg/ha	60	4	13	17.04
Mean	62	4	13	17.0
F-test	0.02*	0.01*	0.06	0.01*
LSD	7.87	0.95	2.31	3.22
CV%	7.1	12.5	1.2	10.9

Analysis of rhizome yield of experiment carried out during 2006/07 resulted significant differences. Highest yield was obtained 27.7 t/ha from the treatment Timur powder followed by Neem cake (21.26 t/ha). Lowest yield (14.9 t/ha) was recorded in control. Plant height and tillers/plant also gave significant result (Table 3).

Table 3. Effect of soil amendments on plant characters and yield of ginger (2006/07)

Treatments	Plant ht. (cm)	Tiller no./ plant	Leaf no. / plant	Rhizome yield (t/ha)
Control	57	4	14	14.89
Agri lime @ 4 t/ha.	61	4	12	19.16
Neem cake @ 2 t/ha.	65	4	14	21.26
Mustard oil cake @ 2 t/ha	60	4	12	20.04
Agri. Lime + mustard oil cake @2 t/ha	58	4	11	20.26
Timur Powder @ 50 kg/ha	63	5	16	27.7
Bojo dust @ 80 kg/ha	61	4	13	18.96
Mean	62	4	13	21.0
F-test	0.3	0.03*	001*	0.02*
LSD	9.36	1.02	1.38	5.93
CV%	8.5	13.8	5.9	16.4

Combined yield analysis of three years revealed highly significant results. Tillers number per clump, and leaf number per plant also gave highly significant result. Highest combined rhizome yield of three years was calculated 24.0 t/ha from the treatment Timur powder applied @ 50 kg/ha followed by Neem cake applied @ 2 t/ha. Lowest combined yield (15 t/ha) was noted from the treatment control (Table 4)

Table 4. Effect of soil amendments on plant characters and rhizome yield of ginger (combined analysis of three years)

Treatments	Plant ht. (cm)	Tiller no./ plant	Leaf no. / plant	Rhizome yield (t/ha)
Control	57	4	14	15
Agri lime @ 4 t/ha.	60	4	12	17
Neem cake @ 2 t/ha.	67	4	14	19
Mustard oil cake @ 2 t/ha	61	4	12	16
Agri. Lime + mustard oil cack @2 t/ha	69	4	11	16
Timur Powder @ 50 kg/ha	62	6	14	24
Bojo dust @ 80 kg/ha	61	4	14	18
Mean	62	4	13	18
F-test	0.51	<0.01*	<0.01*	<0.01*
LSD	3.87	0.59	1.08	2.65
CV%	10	14.7	8.8	15.8

The highest disease incidence (68%) was observed in treatment, control followed by 34.88 in treatment, agri-lime @ 4 t/ha. Lowest incidence of disease 10.87) was noted in Timur dust @ 50 kg/ha application. It was followed by the treatment, agri-lime @ 2 t/ha + mustard oil cake (Table 5)

Table 5. Effect of soil amendments on incidence of rhizome rot disease of ginger at GRP, Salyan (2004/05-2006/07)

Treatment	Plant stand (Av. of 3 years)	Disease severity (Av. of 3 years)	Disease Severity (%)
Control	44	30	68.2
Agri-lime @ 4 t/ha	43	15	34.88
Neem cake @ 2 t/ha	45	10	22.2
Mustard oil cake @ 2 t/ha	43	9	20.9
Agri-lime + mustard oil cake @2 t/ha	41	8	19.5
Timur powder @ 50 kg/ha	38	7	18.4
Bojho dust @ 80 kg/ha	46	5	10.87

August and September are the major months in which rhizome rot disease in ginger spreads very fast because of favorable environment such as high temperature and humidity during this period.

CONCLUSIONS

The mean of three years results showed highly significant rhizome yield by the application of Timur dust @ 50 kg/ha and minimized rhizome rot disease incidence in ginger at Kapurkot agro-climatic conditions. This treatment could be recommended for commercial ginger cultivated area. However, this experiment should be conducted in multi-locations in the farmers' field with rhizome rot disease history for verification of the results.

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***In Vitro* Plant Regeneration of Large Cardamom (*Amomum subulatum* Rox.)**

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ABSTRACT

In vitro plant regeneration techniques are used for large scale production of disease free plant materials. Laboratory experiments were conducted for two consecutive years (2005/2006 to 2006/2007) in National Citrus Research Program, Paripatle to develop a complete protocol for *in vitro* plant regeneration of large cardamom. For *in vitro* proliferation, the stem explants were tested in MS medium (1962) supplemented with three different levels of NAA and five levels of BAP in a completely randomized design with seven replications. For shoot elongation and root multiplication, the explants were tested with three levels of GAA and NAA in a completely randomized design with fourteen replications. The effect of BAP was found highly significant while NAA had no effect on shoot formation. The best treatment in terms of response frequency and mean number of auxiliary shoots per explants (11.71 shoots per explant) was MS medium supplemented with 2 mg/lit BAP and 0.1 mg/lit NAA. The effect of GAA and NAA was found significant on the length of shoot and mean number of roots. Longest plantlets (4.11 cm) were observed in MS medium supplemented with GAA 0.5 mg/lit medium. Largest number of roots (24.79) was observed in medium with NAA 1 mg/lit. The *in vitro* generated plantlets were acclimatized in different media in a completely randomized design with three replications. Highest percentage (98.4%) of plant recovery at plastic removal date was recorded in sand medium. The effect of different media was found significant on number of tillers and plant height in the sixth month. Highest number of tillers per plant (5.77) was observed in sterilized mixture of top soil and compost. Likewise highest mean plant height (60 cm) was observed in sterilized top soil.

Key words: *Amomum subulatum*, *in vitro* regeneration, large cardamom

INTRODUCTION

Large cardamom (*Amomum subulatum* Roxb.) is the main cash generating crop in the eastern hills and has been identified as a priority agro-industry development commodity for the region (APP 1995). Nepal ranks first and produces more than 50 percent of the world's total large cardamom production. Over 95 percent of the total production of large cardamom is exported (Ojha 1992). Besides being an important commodity that brings in foreign exchange to the country, large cardamom cultivation has many environmental advantages. The tree species planted with cardamom intercept rain and decrease its intensity, check surface run-off and reduces soil erosion. The non-perishable high value and low volume nature of the final product of large cardamom has a special advantage to the farmers of the eastern hills living in the interior hill areas as it can be easily transported to the major marketing centers. Because of the multi-faceted advantages of large cardamom cultivation, its popularity has increased across the mid hills of Nepal.

In Nepal, splitting of rhizome suckers is the main method of propagation (Hartkamp 1993) but this can spread virus diseases like *Chhirkey* and *Foorkey*. Seed propagation produces saplings free from these viral diseases (Purseglove et al 1981). Due to poor and irregular germination, use of seed, however, have been confined to a few specialized nursery growers in Nepal (Ojha 1992). The current situation of planting material supply is almost the same as reported by Hartkamp (1993) more than a decade ago. Recent statistics showed that large cardamom growing districts have been expanding each year and reached to 40 at the end of fiscal year 2002/03 (GCDS 2003). At present, Cardamom Development Centre, Fikkal is supplying large cardamom saplings to the newly identified locations for large cardamom cultivation. The supply of planting material, if not dealt with great caution, there is great chance of spread of prevailing diseases. *In vitro* propagation facilitates mass scale production of virus free saplings. The rapid propagation *in vitro* is usually achieved through shoot bud/ shoot proliferation and through somatic embryogenesis. This study was conducted for two consecutive years (2005/2006 to 2006/2007) in National Citrus Research Program (NCRP), Paripatle to develop an effective micro propagation protocol for *in vitro* plant regeneration of large cardamom. The acclimatization works were further carried out in the screen house of Agricultural Research Station (ARS), Pakhribas.

MATERIALS AND METHODS

Shoot proliferation

The experiment was carried out using MS medium (Murashige and Skoog 1962) containing 3% sucrose. The effect of five different levels of BAP and three levels of NAA was tested in a completely randomized design (CRD) with seven replications. The pH of the media was adjusted to 5.8 with 1N NaOH. Growth regulators were added and the media was solidified by adding 6 gm agar per lit medium before autoclaving at 121°C for 15 min. Aliquots of 36 ml of sterilized media were dispensed into glass culture vials. Seven explants per treatment were cultured on seven culture vials and incubated at $22 \pm 2^\circ\text{C}$ under 16 hours light for 3 weeks. In another experiment, explants from the first experiment were sub cultured on sterilized fresh MS medium containing the same concentration of BAP and NAA. The number of shoots per explants was recorded after 4 weeks. This procedure was continued up to seventh sub cultures for precision.

In vitro shoot elongation

Multiple shoots obtained from shoot proliferation were used for *in vitro* elongation. These explants with multiple shoots were tested on MS medium with three levels of growth hormone GA₃ (0, 0.5 and 1 mg/lit medium) in a completely randomized design (CRD) with 14 replications. The initial length of the shoots was recorded. The cultures were incubated at 22°C under 16 hours light for four weeks before measurement of final shoot length.

In vitro root multiplication

The explants with multiple shoots were kept in MS medium supplemented with three levels of root induction hormone NAA (0, 0.5 and 1mg/lit medium) in a completely randomized design (CRD) with 14 replications. The cultures were incubated at 22°C under 16 hours light for four weeks before measurement of number of roots.

Acclimatization

The roots of *in vitro* generated saplings were gently washed in running tap water and transferred to 2.5x1.5 ft wooden containers containing different media. The experiment was laid out in a completely randomized design (CRD) in three replications with sterilized top soil, coconut husk (madhumas), sand and mixture of topsoil and compost in the proportion of 1:1 as four different treatments. The number of saplings per unit treatment was 56. The plantlets were covered with plastic sheet to retain high humidity for four weeks in screen house. The recovery percentage of plantlets after removal of plastic was taken and observation on the number of leaves, tillers and plant height was carried out in the regular interval of 15 days for six months.

RESULTS AND DISCUSSION

Shoot proliferation

Callus cells were observed within one week of culture however auxiliary shoot buds differentiated after two weeks. The analyzed data on the number of shoots per explants showed significant difference among treatments. The effect of BAP was found highly significant ($P < 0.001$) while NAA had no effect on shoot formation (Table 1). Mean number of shoots per explants increased with subsequent subcultures. Interaction between NAA and BAP was not found significant in any subcultures. Highest number of shoots per explant was recorded in 2.0+0.1 mg BAP+NAA / lit medium in all the subcultures.

Table 1. Response of BAP and NAA on shoot formation of explants of large cardamom

Trt. No.	Hormones (BAP+NAA mg/lit)	Mean No. shoots			Remarks
		1st sub culture	2nd sub culture	7th sub culture	
1	0.0+0.0	1.42	1.857	2.57	Yellowish leaves, growth undesirable
2	0.0+0.1	1.571	1.571	3.71	Medium growth, few roots
3	0.0+0.2	1.14	1.429	2.71	light green plants, more roots
4	2.00+0.0	2.42	3.00	6.43	yellowish plants, few roots
5	2.00+0.1	3.42	3.71	11.71	Tall plants, roots present
6	2.00+0.2	3.14	3.42	8.14	Desirable growth, roots present
7	4.0+0.0	2.57	3.28	8.43	Yellowish leaves, medium growth
8	4.0+0.1	3.00	3.42	10.14	Medium growth, yellowish leaves
9	4.0+0.2	2.14	3.42	8.57	Yellowish leaves
10	6.0+0.0	2.85	3.28	10.86	Stunted growth, yellowish leaves
11	6.0+0.1	2.28	2.57	7.29	Stunted growth, yellowish leaves
12	6.0+0.2	3.00	2.85	7.57	Dwarf plants
13	8.0+0.0	3.00	3.57	10.43	Yellowish growth
14	8.0+0.1	2.71	3.29	9.29	Growth unsatisfactory
15	8.0+0.2	2.42	3.29	8.71	Growth unsatisfactory
Mean		2.47	2.93	7.84	
P (BAP)		<.001	<.001	<.001	
P(NAA)		0.447	0.913	0.812	
P(BAPXNAA)		0.057	0.334	0.068	
LSD (BAP)		0.616	0.867	2.18	
LSD (NAA)		0.477	0.672	1.69	
LSD (BAPXNAA)		1.067	1.502	3.77	
CV (%)		3.7	5.1	4.5	

In vitro shoot elongation

The effect of different concentration of growth hormone was found significant on the length of *in vitro* generated plantlets. Longest plantlets were observed in MS medium supplemented with GAA 0.5mg/lit medium (Table 2).

In vitro root multiplication

Fine roots were observed at the basal ends of explants after two weeks in the root induction medium. The effect of different concentration of NAA was found significant on the number of roots. Largest number of roots was observed in medium with NAA 1 mg/lit (Table 3). Similar results were observed in the *in vitro* regenerated plantlets from meristematic cells (Subedi and Paudyal, Forthcoming).

Table 2. Response of GAA on *in vitro* shoot elongation of large cardamom

Trt. No.	Levels of GA ₃ (mg/lit medium)	Mean shoot length (cm)	Difference from control	Remarks
1	0	1.57	-	
2	0.5	4.11	2.54**	Pale color
3	1	2.46	0.27	Pale color
	Mean	2.68		
	F Value	*		
	CV %	16.6		
	LSD (.01)	2.09		

** Significant at 1% level

Table 3. Response of NAA on *in vitro* root multiplication of large cardamom

Trt. No.	Levels of NAA (mg/lit medium)	Mean No of roots	Difference from control	Remarks
1	0	10.86	-	Long yellowish
2	0.5	23.83	12.57**	Short green
3	1	24.79	13.93**	Short green
	Mean	19.69		
	F Value	**		
	CV %	12		
	LSD (.01)	5.43		

** Significant at 1% level

Acclimatization

Out of 672 *in vitro* generated plantlets, 97 percent were acclimatized in different media. Highest percentage (99.48%) of plantlets recovery at plastic removal date was observed in sand and lowest (95.8%) in media with sterilized mixture of top soil and compost. The effect of different acclimatization media was found significant on plant height and number of tillers and leaves (Table 4) when observation was taken on sixth month of acclimatization. Highest mean number of tillers per plant (5.77) was observed in media with mixture of compost and top soil and lowest in sand (1.27). Highest mean plant height was observed in media with top soil (50.9 cm) followed by media with mixture of topsoil and compost (33.8 cm).

Table 4. Response of different acclimatization media on growth of *in vitro* generated large cardamom saplings

Trt. No.	Acclimatization medium	Mean plant ht. (cm)	Mean No. tillers	Mean No. leaves	Remarks
1	Coconut husk	25.8	2.25	7.37	Pale stunted
2	Sand	15.6	1.27	5.9	Pale stunted
3	Top soil	50.9	3.95	14.23	Green vigorous
4	Top soil + compost	33.8	5.77	19.73	Yellowish, more tillers
	Mean	31.5	3.31	11.81	
	F -Value	**	**	**	
	CV %	3.6	17.4	25.4	
	LSD (.01)	12.9	1.7	5.9	

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Quality Parameters Assessment of Orthodox and Green Tea Production in Nepal

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ABSTRACT

Grades of orthodox and green tea produced by different processors were analyzed using different quality parameters. Chemical constituents were found to be varied among different processors as well as among different grades of same processors. The ash content varied from 5.37 to 7.44 percent, water soluble ash from 48.49 to 70.62 percent, acid insoluble ash from 0.01 to 0.52 percent, alkalinity of soluble ash from 1.35 to 2.25 percent and hot water extract from 1.92 to 4.85 percent. Some tea samples were found to be sub-standard as compared to the specifications of Nepal standard for tea. Among the different samples analyzed for the chemical parameters, five samples were found to have higher crude fiber, one sample had lower caffeine content and lower hot water extract in addition to higher crude fiber content. All other samples were found to meet the specifications of Nepal standard for tea.

Keywords: Green tea, orthodox tea, tea leaves, tea tasting, tea withering,

INTRODUCTION

Tea is the most popular and important beverage in the world. In China, tea is known for about 3 thousand years. In Nepal, drinking tea has become the regular habit of most Nepalese people. Tea plants were planted first time in Nepal about 142 years ago in Ilam district. As of today, Nepal is one of the producers of finest teas in the world. Tea is a prime crop of the east Nepal, mostly cultivated in Ilam, Jhapa, Panchthar and Dhankuta districts and small quantities are produced in Terathum, Taplejung, Sankhuwasabha, Nuwakot, Sindhupalchok, Ramechhap and Kaski districts. The area under tea cultivation in Nepal was about 16,420 hectares in 2006/07 consisting of more than 85 tea estates, 38 tea processing factories (NTCDB 2065). In 2006/07, over 15.16 million kg of tea was produced in the country. Of the total tea plantation, hill plantation is estimated at 7424 hectares consisting of more than 35 tea estates, around 5,584 small farmers and about 15 tea-processing factories. Nepali orthodox tea, which is produced in 3,000 ft. to 7,000 ft. altitude are famous for their aroma, bright liquor and subtle, slight fruity flavour. Nepal is producing more than 1.97 million kg of Orthodox tea. Nepal exports more than 90 percent of its orthodox tea to Japan, Germany, USA and India and earns more than NRs 123.6 million annually. The National Tea and Coffee Development Board has been providing training, marketing and technical services to the tea growers and manufactures. The national tea policy was introduced in 2000 to boost the growth of tea industry in Nepal. Orthodox tea producers have taken initiative to prepare and implement code of conduct in product, processing and marketing of tea.

Types of tea

Tea is mostly produced from two species of *Camellia*: *C. sinensis* and *C. assamica* and their hybrids. Sometimes, other species such as *C. taliensis* and *C. irrawadiensis* are also used to produce tea. Different method of processing is employed to produce black, green or oolong tea. Green tea constitutes about 20 percent, oolong tea 2 percent and black tea constitute rest of the tea manufactured in the world. Enzymes are inactivated at the out set to prevent of the leaf polyphenols in green tea. In black tea production, oxidation of catechins to yield the right proportion of theaflavins and thearubigens is promoted. Oolong tea is only partly oxidised. Green tea is mostly consumed in Japan and China but in India and Nepal

mostly black tea is consumed. In Nepal black (C.T.C.) and Orthodox (partly oxidised leaf tea) tea is mostly produced but in recent years, production of green tea has also been started in small scale in eastern hills.

Tea quality

One of the most important characteristics of tea quality is its aroma. The formation of aroma is determined by the mechanisms of tea leaf processing. Optimum qualities of theaflavin (TF) and thearubigen (TR) and their ratio are also important quality parameters. Also, higher the soluble substances content in tea leaf, greater the possibilities of obtaining a good quality tea. However, organoleptic examination has been the prime quality control tool for tea. The most quality attributes of tea are flavour, aroma and colour which are dependent on of the quality of tea leaves to induce certain endogenous biochemical changes.

Tea and health

There has been increasing research in recent years to explore the potential benefits of tea on human health. Ever since tea was discovered in China, it has been thought that tea has wide-range of health benefits and now scientific research findings have supported these ancient beliefs. Besides, tea as an all-natural product is virtually calorie-free (if taken without milk or sugar). Recent research suggests that tea may reduce the risk of cancer and may improve cardiovascular health and reduce LDL "bad" cholesterol levels in the blood. Drinking tea contributes to oral health by strengthening teeth enamel (tea naturally contains fluoride) and by inhibiting plaque-causing bacteria in the mouth. It is also thought that tea increases bone mineral density (BMD), boost the immune system by increasing the amount of white blood cells in the body and aid in digestion and improve overall digestive health.

Tea is made up of three major chemical components: polyphenols (polyphenols in tea are called flavonoids), caffeine and essential oils. The first two chemicals are good for health. The polyphenols in tea are thought to have antioxidant properties helping to neutralize the free radicals that can cause cancer and to help to inhibit the absorption of cholesterol into the blood stream. The caffeine in tea acts as a gentle stimulant to the heart and circulatory system (helping to keep arteries soft and prevent atherosclerosis), increases concentration, alertness and accuracy, enhances the senses of taste and smell, and stimulates the digestive juices and the metabolism (helping to eliminate toxins from the body). Though health benefits of tea are not yet fully proven, the results of modern scientific research and studies are very positive, indicating that there may be some truth to what the Chinese have believed for centuries.

MATERIALS AND METHODS

For research purpose, tea leaves were collected from the plantation of farmers' field (Small Tea Producers, Fikkal, Ilam) and processed in their processing plant. Two types of leaves were collected i.e. fine plucking (two terminal leaves along with bud) and course plucking (5-6th terminal leaves along with stem). Both types of leaves were plucked separately at 15 days interval.

In case of green tea, tea leaves immediately plucking were subjected to steaming for controlling enzymatic reaction. The leaves were collected in the bamboo baskets in such a way that they get crushed by over loading the basket during transportation.

The tea leaves that were plucked as mentioned above were spread loosely in a weathering tray a depth of 4 to 5 inches. Fans were installed to pass air over the green leaves to withers. The objective of the withering process is to get rid of the moisture content in the green leaves and prepared the leaf to withstand the strain of rolling without breaking up. Withering time was 12 hours for first and second flush and 20 to 22 hours for rainy season flush. After withering tea leaves were subjected to rolling.

The objective of rolling was to give a twist to the leaves. Rolling was done only once for 30-35 minutes in batch type roller.

The cell juice contains tannins, caffeine, proteins and other chemical substances, which ultimately give the characteristic colour to the tea liquor during infusion. For batch type of roller it takes 100 kg of leaves. Time taken for rolling is 30 to 35 minutes. If first rolled is twisting the tea leaf no necessary for second rolling. If necessary for second rolled it takes 20 minutes.

The rolled leaves were spread on fermenting beds and left to ferment for a period of 1.30, 2 to 2.30 hrs. The leaves were loosely spread to a thickness of 1/2 inch. Fermentation time for first and second flush tea leaves was 1.30 to 2 hours and for rainy season leaves was 2.30 hours.

The fermented leaves were subjected to firing in a drier machine. The objectives of this process were to arrest fermentation and slowly desiccate the leaf and reduce the moisture without scorching the tea. The leaves were passed through the driers and remained within the drier for 23 minutes at the temperature range of 230⁰-235⁰F.

After firing different grades were sorted out using sorting machine fitted with wire mesh trays that revolve or vibrate. The tea was passed over wire mesh of varying sizes so that the whole leaf (SFTGFOP, FTGFOP), broken leaf (STGBOP), fannings (STGOF), and dust (GOF) grades fall at different place. Different types of tea thus produced were analyzed for moisture, total ash, water-soluble ash, acid insoluble ash, alkalinity of soluble ash, water extracts, crude fiber and caffeine following AOAC methods (AOAC 1984).

For the preparation of tea for tasting, pots and cups made of the finest china clay were used. 2.5 gm samples of each type of tea was weighed and put into the pots. Four ounces of water which has just come to the boiling stage were poured over it. Pots were then covered with lid and tea was infused for five minutes and then tea liquor was poured out into a cup. The tea liquor thus prepared was tasted by hired professional tea tester from Darjeeling. Parameters for tasting tea are briskness, strength, quality, colour, flavour, brightness.

RESULTS AND DISCUSSION

Although the main quality evaluation of orthodox tea is organoleptic test, the analysis of composition of the chemical consistence can be used in case of absence of the skill cup tester and the present work has focused on the quality evaluation of the tea samples based upon the chemical composition. Different grades of orthodox and green tea produced by different processors were analyzed for their chemical and physical properties. The results are presented in table 1. The composition of major chemical constituents like total ash, acid insoluble ash, caffeine, crude fiber were determined where as physical properties like hot water extracts and the moisture were also determines. The total ash content was found to be varied from 5.37 to 7.44 percent with the average 6.07 percent (standard deviation of 0.45). The water soluble ash (% total ash) has found to be 48.49 percent in an average with standard deviation of 5.57. In case of acid insoluble ash some samples were found to have as much as 0.52 percent where as other samples were found to content as low as 0.01 percent. The average value of hot water extract for both the green and formatted tea was found to 40.72 percent where the minimum value for a green sample was 29.64 percent and maximum value of 46.14 was found in SFTGFOP -1 (Clonal) grade of orthodox tea.

Crude fiber content also varied among the same grade of different processors ranging form 10.60 to 16.70 percent with the average value of 15.74 percent. The caffeine content was found to be varying from 1.92 to 4.85 percent. The samples no. 2, 5, 6, 10 and 16 showed high crude fiber (>15%) which indicated coarse plucking. Similarly, sample no. 6 indicated low caffeine content and sample no. 16 indicated low water extract (below 35%). According to the Food Act 2023 and Food Regulation 2027, minimum

standards for tea: crude fiber not more than 15 percent, boiling water extract not less than 35 percent and caffeine content not less than 2.0 percent (Nepal Rajpatra, Part 3, Sector 50, No. 42, of 23rd magh 2057). Therefore, samples nos. 2, 5, 6, 10 and 16 were of sub-standard.

CONCLUSION

The results clearly indicated that there were variations in chemical composition of the different grades of the tea from different processors and at the same time the composition of same grades among different processors also varied. Since the chemical composition is largely affected by the clonal differences, the processing method and the equipment, the grading practices, it seems that different factors affecting the composition of the processed tea shows to be strictly monitored to meet the government specification.

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Table 1. Chemical and physical properties of different grades of orthodox and green tea produced by different processors

S. NO.	Sample	Tea Estates	Moisture %	Total ash %	Water soluble ash %	Alkalinity soluble ash %	Acid insoluble ash %	Water extract %.	Crude fibre %	Caffeine %
1	SFTGFOP-1 (clonal)	NST Fikkal	8.15	6.25	67.58	2.03	0.02	46.14	14.58	4.85
2	STGBOP (clonal)	„	8.11	6.41	65.34	1.93	0.02	45.49	16.70	2.29
3	STGOF (clonal)	„	8.42	5.79	69.30	1.61	0.02	43.40	11.95	3.23
4	GOF (clonal)	„	8.44	6.06	55.77	1.39	0.52	43.08	11.30	2.70
5	SFTGFOP	Kanyam	8.44	6.13	66.06	1.67	0.02	38.21	15.93	2.27
6	STGBOP	„	8.35	5.97	58.81	1.45	0.05	38.68	15.47	1.92
7	STGOF	„	8.54	5.70	62.75	1.43	0.02	40.35	13.77	3.04
8	PD	„	8.70	6.30	48.49	1.55	0.48	39.66	12.14	2.21
9	Kanchanjanga Org.tea	Kanchan	6.49	7.44	60.63	2.25	0.01	41.00	13.05	3.66
10	SFTGFOP-1 (Clonal)	NST Fikkal	8.40	6.12	66.26	1.63	0.03	37.02	15.37	2.82
11	STGBOP (Clonal)	„	8.21	6.03	65.65	1.67	0.02	40.89	15.01	2.85
12	STGOF (clonal)	„	8.50	5.73	67.20	1.55	0.04	42.97	12.98	3.24
13	GOF (clonal)	„	8.33	5.57	67.81	1.45	0.09	43.43	12.23	3.31
14	Sencha	Nepal Green	7.69	5.37	70.62	1.35	0.01	42.35	12.32	2.55
15	Mowplong	„	7.44	5.87	68.11	1.74	0.01	43.11	10.60	2.76
16	Green	„	6.70	5.92	62.98	1.80	0.02	29.64	15.65	2.30
17	1,2 Leaves, Fikkal	NSTP	7.09	6.09	63.29	1.79	0.01	38.72	14.96	2.46
18	BOPSM	Tokala	7.08	6.54	57.57	1.76	0.07	38.73	13.26	3.49
	Maximum		8.70	7.44	70.62	2.25	0.52	46.14	16.70	4.85
	Minimum		6.49	5.37	48.49	1.35	0.01	29.64	10.60	1.92
	Average		7.95	6.07	63.57	1.67	0.08	40.72	13.74	2.89
	STDEV		0.69	0.45	5.57	0.24	0.15	4.13	1.82	0.69

Note: All data are on dry basis.

Survey on Occurrence and Distribution of Weeds in Tea Lands of Nepal

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ABSTRACT

A survey of weeds in tea lands was conducted in Jhapa, Illam, Panchthar, Dhakuta, Terahthum and Nuwakot districts during summer, rainy and winter seasons of 2002/03, 2003/04, 2004/05, 2005/06. Tea planters and Tea Estates were interviewed. The major weeds in tea lands are *Clerodendrum viscosum*, *Polygonum chinense*, *Polygonum perfoliatum*, *Melastoma hirta*, *Urena lobata*, *Ageratum conyzoides*, *Ageratum houstonianum*, *Eupatorium odoratum*, *Artemisia vulgaris*, *Urtica dioica*, *Lantana camera*, *Imperata cylindrica*, *Mikania* spp., *Pogonatherum crinitum*, *Cynodon dactylon*, *Mimosa* spp. etc.

INTRODUCTION

Weeds are important pests that can reduce productivity in tea. The infestation of weeds in tea lands were found severe in young tea lands and nurseries rather than old matured tea lands. Weeds encompass all types of undesirable plants ie trees, broadleaved plants, grasses, sedges, aquatic plants and parasitic plants. They interfere and compete tea crop for (1) nutrients (2) sunlight (3) space (4) soil moisture (5) acts as alternate host for disease (6) acts as secondary alternate host for insects (7) reduce production and quality of tea products (8) reduce the labour efficiency (9) hazardous to human health and animals (De Silva 2003).

Mimosa pudica, *Amaranthus spinus*, *Solanum khasianum*, *Urtica dioica* etc restrict branching and development of frame in young tea and reduce plucking efficiency due to creepers and thorny. *Melastoma hirta* and *Urena lobata* are alternate hosts of red spider. *Ageratum conyzoides*, *Eupatorium odoratum*, *Artemisia vulgaris* etc may affect quantity and quality of tea production and it also acts as hosts of nematodes in nursery (Haira 2001). According to the FAO report, generally an increase in one kilogram of weed growth corresponds to reduction in one kilogram of crop growth (Rao 1983).

MATERIALS AND METHODS

Surveys were done in Chiya Bistar Yojna, Fikkal; Berne Tea Estates, Berne; Tokla Tea Estate, Kakarbhita; Giri Bandhu Tea Estate, Birtamod; Bardashi Chiya Bagan; Haldibari Tea Estate, Haldibari; Himalaya Goodrick Tea Estate, Damak; Kanyam Tea Estate; Illam Chiya Kaman; Saktim Chiya Bagan; Chiya Bistar Yojna, Lalikhark; Kanchanjunga Tea Estate; Everest Chiya Bagan, Panchthar; Chiya Bistar Yojna, Hile; Guranse Tea Estate, Hile; June Chiya Bari, Dhankuta; Chiya Bistar Yojna, Solma; Hariyali Tea Garden, Thangnam; Rara Tea Estate, Terahthum; and Chiya Bistar Yojna, Ranipouwa, Nuwakot. A survey team visited the target tea lands and interviewed with the tea planters using informal approach. Near about 65 sites of small and big tea plantations and tea estates participated during the survey program. Survey was conducted during summer, rainy and winter seasons. During observation of tea lands, several narrow and broad leaved, annual, biennial and perennial weeds were observed in tea lands. Weeds were identified in tea lands through tea planters' interaction, group discussion, observation and literature review.

RESULTS AND DISCUSSION

The weeds found in tea lands are given in tables 1, 2, 3 and 4. Of them, the major weeds in the hills are: *Imperata cylindrica*, *Ageratum houstonianum*, *Ageratum conyzoides*, *Pogonatherum crinitum*, *Urtica dioica*, *Polygonum chinensis*, *Polygonum perfoliatum*, *Epatorium odoratum*, *Lantana camara* and *Melastoma hirta*. Similarly, the major weeds in terai are: *Borreria hispida*, *Ageratum conyzoides*, *Imperata cylindrica*, *Clerodendrum viscosum*, *Crysopogon aciculatus* and *Mimosa* sp.

During the survey, herbicides such as Oxyfluorfen, Duuron, Glyphosate, Paraquat, Glufosinate Ammonium, 2, 4-D and MCPA were found being applied in different tea plantations and estates.

Table 1. Occurrence and distribution of narrow-leaved weeds, 2002/03-2005/06

Local name	Common Name	Botanical Name	Severity season	Hill/Terai (H/T)
Siru	Cogon grass (P)	<i>Imperata cylindrica</i>	All	H/T
Banso	Knot grass	<i>Paspalum distichum</i>	All	H/T
Kharuki	-	<i>Pogonatherum crinitum</i>	All	H/T
Dubo	Bermuda grass (P)	<i>Cynodon dactylon</i>	All	H/T
Chitre Banso	Crab grass (A)	<i>Digitaria sanguinalis</i>	All	H/T
Chioure Banso	-	<i>Eragrostis unioides</i>	All	H/T
Junge Banso]	-	<i>Eragrostis tenella</i>	All	H/T
Lazzawoti	Sensitive plant, Thorny (P)	<i>Mimosa pudica</i>	All	H/T
Lazzawoti	Sensitive plant, Thornless (P)	<i>Mimosa invisa</i>	All	H/T
Kaligedi/Bhukul	Black nightshade (B)	<i>Solanum nigrum</i>	All	H/T
Abhijalo]	Lightening weed (A)	<i>Drymaria cordata</i>	All	H/T
Kans/Khar	Thatch grass (P)	<i>Saccharum spontaneum</i>	All	H/T
Kode Ghash	Goose grass/wild finger millet (A)	<i>Eleusine indica</i>	All	H
Sawon Ghans	Carpet grass	<i>Axonopus compressus</i>	All	-
Titepati	Mug wort (P)	<i>Artimesia vulgaris</i>	All	H/T
Ounue	Fern (A)	<i>Ptreidium</i> spp.	All	H
Mothe	Purple nut grass (P)	<i>Cyperus rotundus</i>	Rainy	H/T
Mothe	Umbrella (P)	<i>Cyperus iria</i>	Rainy	H/T
Chichiri	Prickly chaff flower (P)	<i>Achyranthes aspera</i>	All	H/T
Mothe Hjar	-	<i>Kayllingia brevifolia</i>	-	-
Sama	-	<i>Echinochlia crussgalli</i>	-	-
Kodo Banso	-	<i>Paspalum scrobiculatum</i>	-	-
Kuro/Chhimura	Love grass (P)	<i>Crysopogon aciculatus</i>	All	H/T

A - Annual, B - Biannual, P - Perennial

Table 2. Occurrence and distribution of broad-leaved weeds, 2002/03-2005/06

Local Name	Common Name	Botanical Name	Severity season	(H/T)
Latnaulo	Joint weed (A)	<i>Polygonum chinense</i>	Rainy	H
Nilo Gandhe	Bedding plant (A)	<i>Ageratum houstonianum</i>	All	H/T
Gandhe	Bill goat (A)	<i>Ageratum conyzoides</i>	All	H/T
Banmara (Kali Jhar)	Siam weed (P)	<i>Epatorium odoratum</i>	All	H/T
Oudase	-	-	-	-
Bagrakote (Aaloo pate)	(A)	<i>Borreria hispida</i>	-	T
Armale	Pimprenal (A)	<i>Anagalis arvensis</i>	-	-
Dhungri Phool	Lantana (P)	<i>Lantana camara</i>	All	H/T
Bethe/Bathuwa (Seto)	Lambs quarter (A)	<i>Chenopodium album</i>	Winter	
Bethe/Bathuwa (Kalo)	Goose foot (A)	<i>Chenopodium murale</i>	Winter	H/T
Kane jhar	Day flower (P)	<i>Commelina benghalensis.</i>		H/T
Dudhe Jhar	Asthma weed (A)	<i>Euphorbia hirta</i>	Rainy	H/T
Latte/Ludhe	Pig weed (A)	<i>Amaranthus viridis</i>	Winter	H/T
Latte/Ludhe	Spiny pig weed (A)	<i>Amaranthus spinous</i>	Winter	H/T
Guma	Spider wort (B)	<i>Leucus aspera</i>	All	T
Chariamilo	Yellow wood sorrel (A)	<i>Oxalis corniculata</i>	Rainy	H/T
Chariamilo	Pink sorrel (A)	<i>Oxalis corymbosa</i>	Rainy	H/T
Chariamilo	(A)	<i>Oxalis latifolia</i>	Rainy	H/T
Tapare Jhar	Coffee weed (P)	<i>Cassia tora</i>	All	H/T
Bhati/Kale Jhar/Ghentu	Vent (P)	<i>Clerodendrum viscosum</i>	All	H/T
Pire	Smart weed	<i>Polygonum sp.</i>	-	-
Dhoje Bansa	-	<i>Arundinella benghalensis</i>	-	H
Thakal	Cananda thistle (A)	<i>Circium arvense</i>	Winter/Summer	H
Boki Jhar	Cud weed (B)	<i>Gnaphalium sp.</i>	Summer	-
Pyaouli	Bur clover	<i>Medicago deaticulatus</i>	Summer	-
Sisnu	Stinging nettle (P)	<i>Urtica dioca</i>	All	H
Majhi Jhar	-	<i>Hedyotis spp.</i>	-	-
Dhwan Phool	-	<i>Ipomoea spp.</i>	-	-
Gumma Pate	-	<i>Leucas lanata</i>	Summer/Rainy	-
Nalu Kuro	-	<i>Urena lobata</i>	-	-
-	-	<i>Melastoma hirta</i>	All	-
Kande Lahare	Mile-a-minute (A)	<i>Polygonum perfoliatum</i>	Rainy	H/T
-	Climbing hempvine(P)	<i>Mikania micrantha</i>	Rainy	H/T

A - Annual, B - Biannual, P - Perrenial

Table 3. Common narrow-leaved weeds in the hills and terai tea lands

Botanical Name	Common Name	Habitat	Seasons
<i>Imperata cylindrical</i>	Cogon grass(P)	H/T	All
<i>Paspalum distichum</i>	Knot grass	H/T	All
<i>Pogonatherum crinitum</i>	-	H/T	All
<i>Cynodon dactylon</i>	Bermuda grass(P)	H/T	All
<i>Digitaria sanguinalis</i>	-	H/T	All
<i>Eragrostis unioloideis</i>	-	H/T	All
<i>Eragrostis tenella</i>	-	H/T	All
<i>Mimosa spp.</i>	Sensitive Plant (P)	H/T	All
<i>Solanum nigrum</i>	Black night Shade (B)	H/T	
<i>Mimosa invisa</i>	-	H/T	All
<i>Crysopogon aciculatus</i>	Love grass (P)	H/T	All

Table 4. Common broad-leaved weeds in the hills and terai tea lands

Botanical Name	Common Name	Habitat	Seasons
<i>Ageratum houstonianum</i>	Bedding plant (A)	H/T	All
<i>Ageratum conyzoides</i>	Bill goat (A)	H/T	All
<i>Epatorium odoratum</i>	Siam weed (P)	H/T	All
<i>Lantana camara</i>	Lantana (P)	H/T	All
<i>Chenopodium spp.</i>	Lambs quarter (A)	H/T	Winter
<i>Commelina benghalensis</i>	Day flower(P)	H/T	Rainy
<i>Euphorbia hirta</i>	Asthma weed (A)	H/T	-
<i>Amaranthus spinous</i>	Spiny pig weed (A)	H/T	Winter
<i>Oxalis corniculata</i>	Yellow wood sorrel (A)	H/T	Rainy
<i>Oxalis corymbosa</i>	Pink sorrel (A)	H/T	Rainy
<i>Oxalis latifolia</i>	(A)	H/T	Rainy
<i>Clerodendrum viscosum</i>	Vent (P)	H/T	All
<i>Polygonum perfoliatum</i>	Mile-a-minute (A)	H/T	Rainy
<i>Mikania micrantha</i>	Trailing/Climbing hempvine (P)	H/T	Rainy
<i>Cassia tora</i>	Coffee weed (P)	-	All

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Floriculture Research in Nepal

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ABSTRACT

This paper presents review on floriculture researches carried out to date so as to make the future research strategy and plans for boosting up the floriculture in Nepal. Altogether 14 research and technical papers were cited for the study. Particularly, it has found that research emphasis was given to major cut flowers and these were done by different organizations and institute during last decade. Most studies were concentrated on survey rather than agronomic and post-harvest studies. Floriculture Association Nepal (FAN), a non-governmental organization, had made several efforts for the floriculture development in the country. Since 1994, a dozen of studies have been brought on the marketing and at policy level. Besides, Institute of Agriculture and Animal Science (IAAS), Rampur has done research; especially in cut flowers viz. gladiolus, rose and carnation with respect to crop husbandry and post-harvest aspect. Similarly, National Agriculture Research Council (NARC) has mandatory to cut flower research and two projects on gladiolus are underway. The paper has presented information on the following headings: current research status, challenges for floriculture research, development and research needs for the floriculture development.

INTRODUCTION

Presently, Nepal's floriculture business transacted at worth NRs. 230.0 million. Now about 80 percent of flower demand is met by internal production (AEC/FAN 2007), while few years ahead, there was the condition of importing by same percentage in Nepal. Further, commercial cut flower production in Nepal has been started since early 1990. But, this enterprise has been growing up rapidly and expected to be further extended to 1000 ha by next few year. Thus, floriculture has enormous potential for the significant contribution to the national economy of Nepal in the future (Yanai et al 2007).

Despite floriculture being flourishing industry with great possibility, this sector is at very earlier stage of establishment. This industry has been commenced solely in the private sector as well as personal initiatives of the growers and entrepreneurs in Nepal, virtually without research and development support (Tamang 2006). Number of problems associated with the agronomic, pathological, edaphic, and post-harvest have been raised along the increase acreage of ornamental crops and confronted this sector. Hence need of research has been felt over the time; however, a due emphasis has not being given in the research mandatory of government institutions and organizations to date. Nevertheless, some works on the floriculture research has been culminated in the past by some organizations and individuals. Owing these considerations, this study was carried out to review research accomplishments to date, so as to make the future research strategy and plans for boosting up the floriculture in Nepal.

METHODOLOGY

The article was prepared based on the review of some relevant researches and investigations done in Nepal. Altogether seven research papers and seven investigation articles carried out by different institutions/organizations and individuals were extensively reviewed to prepare this paper. The

information were critically reviewed, and concretely presented. Some suggestions are also made on this regard.

RESULTS AND DISCUSSION

Agro-husbandry

A study on the date of planting in gladiolus has been carried out under M.Sc. thesis at the Institute of Agriculture and Animal Science (IAAS), Rampur in 2000. The results revealed that December and January planting as the optimum time for gladiolus cut flower in Chitwan conditions. In the study, five cultivars: American Beauty, Pacifica, Friendship, Eco Wonder and Her Majesty were evaluated and cv. American Beauty performed promising in terms of growth, flowering behavior and flower yield followed by Pacifica, Friendship, Eco Wonder and Her Majesty, respectively. As the best performer cultivar, American Beauty was earliest in emergence (25 days), but it took longer days (85.5 days) for spike initiation as compared to Her Majesty (71.5 days) and Pacifica (77.8 days). Cultivar Friendship and Pacifica had longer spike length (respectively 83.2 cm and 80.9 cm) than those of American Beauty (74.2 cm) and Eco Wonder (73.2 cm). The study concluded that cultivars: American Beauty and Pacifica were found better for the commercial cut flower production in Chitwan condition (Regmi 2000).

With respect to soil fertility, a study on "the effect of nitrogen and phosphorus on growth and development of gladiolus cut flower production" was carried out under M.Sc. thesis at IAAS, Rampur in 2002. The results showed that nitrogen and phosphorus and their interaction significantly affected the leaf development. Similarly, higher level of phosphorus with medium level of nitrogen increased the corm yield and 100 kg/ha phosphorus with 50 kg/ha nitrogen resulted to maximum number of florets production. Similarly, another study was done on "the effect of plant growth regulators on yield and quality of spike production of gladiolus" under M.Sc. thesis at IAAS, Rampur in 2006. The effect of plant growth regulators such as Indole Acetic Acid (IAA), Gibberellins (GA₃) and Kinetin with their four concentrations (0, 100, 500 and 1000 ppm) on growth and yield of gladiolus cv. American Beauty were evaluated. The results concluded that IAA @ 100 ppm was found the most effective for spike production and consistently gave the highest number of cormel (643.0 /m²), longest spike length (103.03 cm) and rachis length (51.5 cm), whereas kinetin @ 1000 ppm was resulted the best for the production of corms. Moreover, IAA @ 100 ppm showed the maximal plant height (106.03 cm) and cent percent sprouting. Effect of GA₃ @ 500 ppm as well as 1000 ppm had resulted to the highest corm diameter (5.6 cm) and the highest number of fully opened floret (6.5 nos). Similarly, the effect of kinetin @ 1000 ppm was come to the best for quality corm and spike production.

IAAS, Rampur has also carried out another study on the effect of pruning on flowering in different cultivars of rose during 1993 to 1994. Under the study, a lot of variation of responses to pruning was noticed on different cultivars in terms of days to first flowering, flower yields and number of flushes, while cultivars: Message, Kiss of Fire and Theresa were come into earlier flowering categories and the yields of flower per plant was highest of Edith Nalli Perkins (13.9 nos.) followed by Theresa (12.8 nos.) and Noritu (11.3 nos.).

Another study on "the effect of media on number of leaves and root production and growth of stem length for the establishment of orchids in Chitwan" done by IAAS, Rampur has come up with some recommendations for managing the media for orchids. The results revealed the media Sphagnum moss and Coal quite superior for the effect on number of leaves and root production; and growth of stem length of tissue cultured orchid as compared to media; Sphagnum moss + Brick + Coal, Sphagnum moss + Brick and Brick + Coal (Pun 1995).

Nepal Agriculture Research Council (NARC), an apex body for agriculture research in the country, has research mandatory on cut flower and made some initiatives for the last few years. In this connection, Horticulture Research Division, Khumaltar has been doing a research on the project entitled "Collection,

evaluation, date of planting and bulb production of gladiolus cut flower since 2002. Similarly, a project on gladiolus is underway at Agriculture Research Station, Pakhribas for last three years. The results suggested narrower spacing for increased spike and corm yield, while wider spacing resulted into quality flower and larger corm production. Dormancy in gladiolus corm is the major limitation for off-season production since the results showed chilling treatment as the most effective for earlier initiation of root (44.2 days) as well as shoot initiation (56.2 days) as compared to scale removal and water soaking treatment.

Post-harvest study

Post-harvest study has been firstly carried out in carnation cut flower under the M.Sc. thesis at IAAS, Rampur in 2008. To determine the variation on vase life due to the effect of growing locations and cultivars, four common cultivars viz. Eskimo, Helix, Nelson and Lisa grown at four locations of Kathmandu valley were taken for the study. The results revealed that a significant variation on the vase life was obtained due to the effect of growing locations and cultivars as vase life of these cultivars grown at different locations ranged from 2.7 days to 6.9 days in control vase solution. Variation on vase life by virtue of growing locations and cultivars are attributed to pre-harvest environmental factors and genetic makeup of the cultivars that imparts physical characteristics of the crops. Similarly, physical characteristics such as flower head diameter; stem diameter and length; and chlorophyll and sugar content were found varied and correlated to vase life. The chemical vase solution treatment experimented to extend the vase life, sucrose (5%) + HQS was reported super (11.6 days) as compared to control (2.7 days) (Pun 2008). Another study on the effect of different concentrations of sucrose on the vase life behavior of gladiolus was done at IAAS, Rampur indicated that 12 % sucrose solution to be the most effective substrate in prolonging the vase life (11.3 days) and the maximum number of floret opening compared to control one (9.0 days) (Pant 2002).

Marketing and policies

In Nepalese floriculture sector, several studies have been made during last decade on marketing and policy level. These investigations have raised some important issues and made recommendations for the floriculture development in Nepal. A list of studies and key findings are presented in Table 1.

Recently, a noticeable study has been carried out with respect to “Export Development of Priority Sectors of Nepal: Sector Study on Floriculture” in 2007. The reports of the study concluded that Nepal’s floriculture sector has been making remarkable progress in recent years on the domestic front, the next step of developing the sector to become internationally competitive. Report says that Nepal possesses unique natural advantages and could compete in the international floriculture market. Accordingly, innovative growers and entrepreneurs are coming up in Nepal, but government is not creating an encouraging environment for export. Besides, at present, the sector lacks the financial instruments to invest for the export quality product that requires hi-tech cultivation and airfreight. Thus, these pose a major challenge for Nepalese floriculture business. The study also made suggestions for the following future actions: testing the most appropriate agro-technical methods to achieve high quality flower; trying and practicing the most appropriate export destinations and marketing models.

Botanical/breeding

Nepal is rich in bio-diversity with a wide variety of topographical and climatic conditions within a short distance. The country houses 2.2 percent of the world flowering plants, which consists over 5,160 species of flowering plants. It also includes 246 species of flowering plants that are endemic to Nepal (Pun 2001). These have ornamental values as well and could be utilized for breeding. Many of these can be utilized to develop new and novel varieties, but are under exploited. There is a need for selection, domestication and improvement for the development of commercial floriculture.

As many as 380 species of orchids are available in Nepal. Eastern Nepal is rich in Epiphytic species, West Nepal in Terrestrial species and Central Nepal possesses both types and these are the exportable commercial importance and these need to be further innovation, commercialization and diversification.

Also, Nepal as endowed with special appropriate micro-climate could enable seed and bulb production of several seasonal flower species.

Table 1. An overview of studies and key findings

Title of the studies	Key findings
A Study on Floriculture Development in Nepal	• Nepal has good potential of domestic demand and production is growing at a healthy rate. • Western markets for traditional cut flowers are huge; however, India, Bangladesh, and Pakistan could be potential export markets in future. • Nepal is not ready, in terms of scale and infrastructure base for flower export to a meaningful level and may not be able to penetrate overseas markets on its own. Foreign collaborators with established players in the importing countries are essential to achieve success. • Many small entrepreneurs are facing difficulties to adapt and develop export oriented production in the absence of support from stakeholder institutions and government. • The industry is entirely private sector-led and the governmental agencies have virtually played no role so far.
Symposium on Prospective of Floriculture Industry in Nepal, 2001	• There are commercial nurseries in 18 districts. They are producing mostly roses, carnations, gerbera, cymbidium, liliun, tube rose, anthurium, gladiolus, and other various seasonal flowers. • Number of constraints comprises as lack of expertise for research and development, no market promotion support, poor quality output, poor post-harvest handling infrastructure, no solid marketing partnership, etc. • Prospects of some projects for foreign joint ventures are: rose, carnation, orchids, chrysanthemum, and seasonable flower seed.
Trade Competitiveness of the Floriculture	• Altogether 550 small flower growers have invested about NRs. 375 million in 80 ha of land and had turn over of NRs. 230 million in Sub-sector in Nepal 2006. • Land under cultivation can be increased to 1000 ha within 5 years if some of the development constraints are properly addressed. But this sector is thriving ill-defined and clear government policies, strategies and incentives. • Over the five years time, export of floricultural products grew by 7 times to NRs. 32.6 million in 2005/06 as against NRs. 4.0 million in 2001/02.
Identification Mission Report: Flower, Dairy, and Seed	• The floriculture sector is relatively young and has developed in the light of growing demand in the local market. The climate of Nepal gives a relative advantage over India for summer production, and Development in Nepal allows production of high quality flowers in a wide range of crops: Gladiolus, Roses, Gerbera, Tuber Rose and Marigold. • Attempts to export carnations to Japan resulted in a high return, but were not economic due to the high airfreight. Attempts are being made to export to India in summer as carnation quality is high in June.

Challenges in floriculture development

Floriculture development has been commenced in the private sectors as well as personal initiative of the growers in Nepal virtually without research and development support. The government agencies have virtually played no role so far in the development of the industry. However, floriculture has got the maximum attention of growers and new investors since 1994. Although, research and development is an integral part of any industry in the modern world, Nepalese floriculture industry is seriously lacking of investment and support in the area of research.

Domestic production of cut flowers is generally not of high quality and is of limited varieties; productivity too is generally low. Good quality planting material and varieties is quite problem for its availability that the number of growers cannot afford importation due to lacking scientific information on

specific flower crops and varieties. Problem of high volume and standard quality as well as cost-effective production for the export in international market prevail in Nepal. Lack of marketing, post-harvest and enterprise development skills are some other challenges to floriculture research in Nepal.

Research needs for the floriculture development

Nepal possesses a good scope and possibility of floriculture business. Thus, the country must be given due priority to capture this opportunity in time. The important of floriculture business had resided to export potential and it must be targeted to international market business of fresh flowers and flower seeds and bulb in future. Therefore, research and development activities should be directed towards the following areas and issues:

1. Standard quality and quantity production
2. Cost effective technologies
3. Year round production
4. Hi-tech and green house technologies
5. Propagation and tissue culture
6. Research on promising endemic plants with a long term perspective and vision
7. Areas close to national highway for cut flowers and any potential pockets for seeds

The important aspects of floriculture development include greenhouse, plant health management and modern post-harvest technique. The private sector entrepreneurs are developing technologies knowledge and skills on their own kinds in a very limited scale. The governmental institutions like NARC, Nepal Academy of Science and Technology (NAST), Department of Plant Resource (DoPR) and Department of Agriculture (DOA) have taken sole responsible of research and extension, but at present research on this sector is seriously lacking. Basically, inadequate programs, lacking of qualified manpower and inadequate budgetary provisions are the facts. Government research-extension system is very necessary to promote floriculture as a high value crop at farmer's level.

Strategically, we should effort on off-season export that requires quite hi-tech production technique and varieties, thus the research should concentrate on this front. A small-scale green house technology needs to be introduced at the farmers' level. Also, establishment of model farms at the farmers' level with low production technology is crucial for future research. Export of flower seeds and bulbs have commercially viable, thus, it is one of the potential areas of research. Other general possible research subjects on floriculture are: plant protection problems; introduction of new flower crops and establish their agro-techniques; collection, identification, evaluation and improvement of wild ornamental plants; and establishing micro-propagation technique for wild ornamental plants.

NARC should thrust seriously for the research on this sector and it should be market driven and follow the collaborative research with the participation of individual growers. Similarly, other organization such as NAST and DoPR should begin concretizing and directing their effort to the research program on promising endemic plants with a view to support the floriculture industry in the long run. Government should encourage private sectors to invest on this sector and make consistent and clear policies to marketing and transport of flowers and develop infrastructure base.

CONCLUSION

Floriculture enterprise has good scope and flourishing speed. However, systematic development of this sector has not been commenced so far. Floriculture is entirely private sector-led. Some developmental activities have been carried out with the initiatives of private sector as well as personal initiatives of growers and entrepreneurs. Therefore, this sector is marching without research and development supports from the government. Nevertheless, few researches have been culminated in the past by NARC, IAAS,

NAST, DoPR. These researches were concentrated on cut flower like gladiolus, rose, and carnation on agro-husbandry and post-harvest aspects.

The findings of these researches, whether relevant or not, are not adopted and widen in the growers and entrepreneurs level effectively. The importance of floriculture business had resided to export potential due to climatic advantage and human resources and country must capture this opportunity. Accordingly, research and developmental activities should proceed towards building competitiveness to the international flower market.

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Effect of Corm Size and Planting Depth on Flower Quality and Corm Yield of *Gladiolus* (cv. Jester)

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ABSTRACT

Gladiolus is very popular and commercial cut flower in Nepal. An experimental study was carried out at ARS, Pakhribas (1740 masl) with the objective to find out the appropriate planting depth and corm size to produce higher quality spike and higher corm yield. Three corm sizes 2.5-3 cm, 3-3.5 cm and 3.5-4 cm and three planting depths 6 cm, 8 cm and 10 cm were studied in factorial RCBD with three replications. The corm size did not show any significant effect on plant height. However, planting depth showed positive relation with plant height resulting tallest plant (63.96 cm) with deepest planting (10 cm) similarly longest spike (89.11 cm) was recorded from deepest as well as 89.91 cm from largest corm planting. Larger (11.86 cm) flower obtained from combination of largest corm with deepest planting. Maximum florets per spike (17.96) were found from 10 cm planting depth, while effect of corm size on number of florets was not significant. Similarly larger corm diameter (8.04 cm) was obtained from 8 cm planting depth and 7.97 cm diameter obtained from 3.5-4 cm corm planting. Average corm weight (from single plant) was found highest from 8 cm and 10 cm planting depths with 138.5 gm and 138.1 gm respectively. Total corm and cormel yield was not significant due to both corm size and planting depth. Considering all of these facts large size corm (3.5-4 cm) and 8 cm planting depth was found better for flower quality.

INTRODUCTION

Gladiolus, which is commonly known as sword lily is a very popular cut flower. Among the bulbous flowers it is number one cut flower. *Gladiolus* is valued for its beautiful flowers which open in sequence and long vase life. *Gladiolus* was introduced in 1988 and perhaps the first commercially grown cut flower in Nepal. The annual production of its cut stem is estimated to one million. Besides home consumption it can be exported to India and other gulf countries (J B Tamang, personal communication). Farmers are attracted towards its cultivation due to its dual benefit, spike as well as corm production.

The corm size plays an important role for obtaining good plant growth, spike quality, corm and cormel production (Singh 2000, Singh 2001). A study at BSI Calcutta was done on corm size and planting depths. Combination of medium corm size (4-5 cm) and shallow planting (5 cm) has resulted maximum cormel production (Negi and Raghava 1986). In another experiment (Negi and Raghava 1986) observed positive relationship with plant height and corm size. According to Bhattacharjee (1981) there is positive relationship between planting depths and flower and corm quality. Bhutani (1999) reported that large size corms bloom earlier than the small ones. He also reported that planting the corms at different depths would help to obtain the good succession of blooms. Therefore with the objective to find out the appropriate planting depth and corm size formal study was carried out in *gladiolus*.

MATERIALS AND METHODS

The experiment was carried out at Samalbari (1740 m) for two consecutive years 2003/2004 and 2004/2005. There were two factor treatments and the design was RCB (2 x 2 factorial) with 3 replications.

Treatments

<u>Corm size</u>	<u>Planting depth</u>
S ₁ =2.5-3 cm	D ₁ = 6 cm
S ₂ = 3-3.5 cm	D ₂ = 8 cm
S ₃ =3.5-4 cm	D ₃ = 10 cm

Plot size was 1.5 x 0.6 m² and 20 corms of Jester variety were planted in each plot. Corm planting was done on 21st January, 2004 and 21st March, 2005. 5 kg compost and 60:30:30 NPK gm/m² were applied. All compost and full phosphorus + full potash + half nitrogen were incorporated at the time of land preparation. While half nitrogen used as top dressing 30 days after planting. The spacing used was 30 cm x 15 cm. Bavistin drenching was done after emergence for plant protection from Fusarium rot. Earthing up, staking, weeding and irrigation were done as require. Spike emergence started from May and spike harvesting was done from June while corm harvesting was done in December. Spike harvesting was done when first pair of floret open and corm harvesting was done after drying up leaves. Data were recorded on plant height, number of leaves at the spike initiation time; stem length, flower size, number of floret per spike and vase life. After corm harvesting data were collected on average corm weight per plant, size of corm, total corm and cormel yield per plot. All the compiled data were analyzed over years using Genstat software package.

RESULTS AND DISCUSSION

Plant height (cm)

Plant height was recorded at time of spike harvesting and it was found significant different only due to planting depths. Deeper planting found increased plant height (63.96 cm), which was found superior over planting at 6 cm. Planting at 8 cm and 10 cm depth were found statistically at par with each other (Table 1). Size of corms and the interaction of planting depth and corm size were not observed statistical different. According to Uddin (2001) larger corm planting at shallower depth resulted taller plant while small corm with deeper planting resulted smaller plant. Similarly Singh (2002) also reported that larger corm (5.10-6.0 cm) produced taller plant in variety 'Aarati' as well as variety 'Pink Friendship'. Singh (1998) also reported that large corm (6.0±0.15 cm) produced taller plant (46.89 cm) in variety Sylvia. In our experiment corm size was not found effective to increase plant height, which also supported by Singh (2000). He also found corm sizes 2.5-3 cm, 3.20-3.80 cm and 3.80-5.10 cm were statistically at par with each other.

Number of leaves

Number of leaves was counted at the time of spike initiation. It was found non significant due to all treatments. However 9-10 leaves were observed at spike initiation time. However, Singh (2000) reported as higher number of leaves with large size corm in variety 'Aarati'. He also reported in variety 'Pink Friendship' corm size (4.6-5 cm) produced maximum number of leaves (8.8) per plant.

Harvesting days after spike initiation

Spike harvesting days after spike initiation was recorded and found to be significant different among corm sizes. Larger corm planting harvested earlier (11.58 days) (Table 2).

Stem length (cm)

Stem length is one of the important and decisive parameter of cut flower standard fixation. Corm size, planting depth and year found significant for this parameter but not interaction. Larger corm (3.5-4 cm) increase spike length (89.91 cm), which found superior over com sizes 2.5-3 cm nad 3-3.5 cm. while

corm sizes 2.5-3 cm and 3-3.5 cm were found statistically at par with 82.76 cm and 85.09 cm respectively. According to Singh (2000) spike length increase with larger corm sizes which also supported by Sharma and Gupta (2003); Singh (1998) and Kumar and Yadav (2006).

Flower size

Flower size obtained by taking average of length and diameter. It was found highly significant due to corm size and planting depth (Table 2). Its interaction also found significant but not with year. Largest flower (11.86 cm) achieved by largest corm with deeper planting

Days for flowering

Harvesting period after spike initiation was counted. Corm size was found influencing on harvesting days. Larger corm planting were found harvesting earlier (116.71 days), while smaller corm planting harvesting in 117.92 days (Table 2).

Number of floret per spike

Floret number in spike is important criteria of spike standardize in market. More floret per spike will increase the per spike price. The relationship of corm size and floret number was not found statistical difference. But effect of planting depth and year on floret number recorded significant difference. Highest (17.96) number of floret was observed with deeper planting, while 16.93 and 17.62 floret number were recorded from 6 cm and 8 cm planting depths respectively (Table 2).

Average corm and cormel weight per plant

Average corm yield of single five plants were taken and analyzed. Corm size was not found significant but planting plant depth was found significant. middle planting increased the corm yield (Table 3). In case of cormel yield per plant non significant difference were recorded.

Average corm diameter

Average corm diameter was found significant with both corm size and planting depth, but not interaction. Largest corm size found from larger corm (7.966 cm) and middle planting (8.038 cm) (Table 3).

Corm and cormel yield (ton/ha)

Total corm and cormel per plot were taken and converted to ton/ha. It was found non significant different. However, among three corm sizes largest corm planted produced highest corm yield (19.77 t/ha). Similarly corms planted at 8 cm depth produced highest corm yield (19.47 t/ha (Table 3).

Vase life

Spikes were harvested after first two florets open and evaluated its vase life in 12% sucrose solution. Individual corm size, planting depth and year were observed significant. Interaction of these three treatments was not found significant. Largest corm planted spikes discarded only after 15.54 days. Similarly deeper planted spikes discarded in 15.51 days.

Table 1. Response of corm size and planting depths on vegetative growth of gladiolus

Corm sizes (cm)	Plant height (cm)	Number of leaves	Days for 50% corm sprouting
2.5-3	60.7	8.7	26.3
3-3.5	63.0	8.7	26.0
3.5-4	62.7	8.8	24.2
F test	NS	NS	NS
Planting depths (cm)			
6	59.9	8.7	24.2
8	62.5	8.7	25.9
10	64.0	8.8	26.4
F test	**	NS	NS

Table 2. Response of corm size and planting depths on floral parameters of gladiolus

Corm sizes (cm)	Days for spike initiation	Days for flowering	Spike length (cm)	Number of floret per spike	Flower size (cm)	Vase life (days)
2.5-3	105.4	117.9	82.7	17.3	11.1	8.2
3-3.5	105.9	117.9	85.1	17.5	11.3	11.5
3.5-4	105.1	116.7	89.9	17.7	11.5	15.5
F test	NS	NS	***	NS	**	***
Planting depths (cm)						
6	106.3	118.2	83.3	16.9	10.9	9.6
8	105.0	117.2	85.3	17.6	11.3	12.8
10	105.1	117.2	89.1	17.9	11.6	15.5
F test	**	NS	**	**	***	***

Table 3. Response of corm size and planting depths on vegetative growth of gladiolus

Corm sizes (cm)	Avg. corm weight/plant (gm)	Avg. cormel weight/plant (gm)	Corm diameter (cm)	Corm yield (t/ha)	Cormel yield (t/ha)
2.5-3	122.6	19.8	7.4	16.9	1.9
3-3.5	134.5	22.2	7.7	18.2	2.3
3.5-4	140.0	27.1	7.9	19.7	2.5
F test	**	NS	*	NS	NS
Planting depths (cm)					
6	120.5	20.0	7.4	16.5	2.0
8	138.5	30.3	8.0	19.4	2.7
10	138.1	18.8	7.6	18.9	2.1
F test	**	*	**	NS	*

CONCLUSION

The results discussed in this paper have clearly demonstrated that plant characters (plant height and number of leaves) were found highest in corms planted deepest (10 cm). Similarly floral characters (stem length, flower size, number of florets per spike and vase life after harvesting) were recorded highest with large corm (3.5-4 cm) planting deepest in the soil. While corm weight, corm diameter and total corm/cormel yield were found better in large corm planting 8 cm below the ground. Availability of more food material stored in larger corms is the reasons for highest production of flower and corm. Similarly a large size corm was reported as a superior in terms of plant growth, flowering, corm and cormels production (Pillewan et al 2004). Thus from this analysis we can conclude that largest corm and deepest planting is better for high quality and quantity of flower. But large corm with planting below 8 cm is superior in terms of corm and cormel yield.

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Development of Roller Type Hand-Operated Coffee Pulper

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ABSTRACT

In Nepal, specialty coffee is cultivated in steep, marginal and shady land at the altitude range of 800-1600 m and it is cultivated in more than 1400 ha in 22 hill districts. There has been significant increase in specialty coffee export from negligible amount in 2002 to 220 mt in 2008. To enhance the quality of coffee for international export, wet processing technology is introduced in Nepal few years back. Pulping is one of the important processes of wet processing and hence, more than 350 coffee pulping centers were established. Different types of coffee pulpers viz. wooden roller, metallic roller and drum type etc were introduced in Nepal. Major problems of wooden and metallic roller pulpers are low capacity and low pulping & cleaning efficiency; high breakage of beans & frequent maintenance requirements. Similarly the problems of Chinese drum pulpers are high cost and difficulty in repair & maintenance. To cater the needs of small scale pulping, Agriculture Engineering Division has designed fabricated and tested the Roller Type Hand Operated Coffee Pulper. Genuine Engineering Workshop and General Mechanical Works contributed in fabrication of these prototypes. After several modifications, its comparative performance was tested with the wooden roller pulper in field condition. The operating capacity of Roller Type Hand Operated Coffee Pulper was 60 kg/hr with pulping and cleaning efficiency above 99 and 96 percent respectively. Similarly the broken parchment and parchment loss was less than 0.33 and 0.44 percent respectively. The capacity of the modified roller pulper was found to be increased by 76 percent than the wooden pulper. Similarly pulping and cleaning efficiency is found to be increased by 2 and 6 percent in modified roller pulper. However the broken percentage of parchment and loss of parchment along with pulp is found to be reduced by 62 and 75 percent in this type of pulper.

Key words: Coffee processing, coffee pulper, roller type coffee pulper

INTRODUCTION

In Nepal, specialty coffee is cultivated in steep, marginal and shady land at the altitude range of 800-1600 m and it is cultivated in more than 1400 ha in 22 hill districts (AEC 2006). Since the production cost is found to be comparatively less and income per tree can range from USD 1- 6 per annum, it is considered to be an attractive cash crop for small and poor farmers of mid hills (Luke 2006). There has been significant increase in specialty coffee export from negligible amount in 2002 to 220 MT in 2008. To enhance the quality of coffee for international export, wet processing technology was introduced in Nepal few years back. Pulping is one of the important processes of wet processing and hence, more than 350 coffee pulping centers were established. Different types of coffee pulpers viz. wooden roller, metallic roller, metal disc and drum types etc were introduced in Nepal.

Wooden roller Pulper technology was introduced in Nepal (brought from Indonesian Museum) in 2003 (CoPP 2005). This pulper (Fig.1) consists of wooden roller wound helically with GI wire over the roller surface. The cost per unit of pulper ranges from Rs. 4500-Rs.5500 (with out stand). Majority of the pulping centers use wooden pulpers. The average capacity of the pulper is 34 kg of fresh cherry per hour. The major problems of this type of pulper are low capacity and low pulping & cleaning efficiency; high breakage of beans & frequent maintenance requirement.

Drum Pulper was imported from UK in 2004. It consists of stainless steel abrasive drum and fluted nylon roller to pulp the coffee. It can be operated manually as well as by using electric motor. The capacity of this pulper (electrically operated) is about 210 kg/hr. This prototype is successfully replicated by Agriculture Engineering Division (AED), NARC with the support from Coffee Promotion Project (CoPP) in Nepal with similar performance as UK prototype. Similar Chinese drum pulper was recently imported in Nepal and the cost of this pulper is about Rs. 18 thousands per unit (with out stand & electric motor). The major problem of this type of pulper is high cost and difficulty in repair & maintenance.



Fig. 1. Wooden Pulper



Fig. 2. Drum Pulper

This study was conducted in 2006-07 to address the problems related to coffee pulping of small farmers in Nepal and to modify/develop improved coffee pulping technology for the production of quality parchment.

MATERIALS AND METHODS

In this study the field assessment of existing pulpers was conducted in Kavre and Kaski district to evaluate the performance of existing pulping technology and to identify its problems. Similarly the physical parameters of commonly used coffee cherry was also assessed and key area of improvement in the design of new coffee pulper was identified. After designing the new coffee pulper, it was fabricated in local workshop and laboratory and field-testing was conducted to evaluate the coffee pulpers.

The parameters used for evaluation of coffee pulpers are pulping capacity, pulping efficiency, cleaning efficiency and broken parchment, which are defined as below:

$$\text{Pulping capacity (kg/ hr.)} = \frac{\text{Weight of fresh cherry pulped (kg)}}{\text{Time taken for Pulping (hrs.)}} \dots\dots\dots (i)$$

$$\text{Pulping efficiency (\%)} = \frac{\text{Total Weight of Pulped Parchment (kg)}}{\text{Total Wt. of Parchment in fresh cherry fed in Pulper (kg)}} \times 100 \dots\dots\dots (ii)$$

$$\text{Cleaning efficiency (\%)} = \frac{(\text{Total Weight of Pulped Parchment (kg) - weight of Pulp mixed with Parchment (kg)})}{\text{Total Wt. of Parchment in fresh cherry fed in Pulper (kg)}} \times 100 \dots\dots\dots (iii)$$

$$\text{Broken Parchment (\%)} = \frac{\text{Total Weight of broken Parchment (kg)}}{\text{Total Wt. of Parchment in fresh cherry fed in Pulper (kg)}} \times 100 \dots\dots\dots (iv)$$

$$\text{Parchment loss along with pulp (\%)} = \frac{\text{Total Weight of Parchment mixed with pulp (kg)}}{\text{Total Wt. of Parchment in fresh cherry fed in Pulper (kg)}} \times 100 \dots\dots\dots (v)$$

RESULTS AND DISCUSSION

Physical parameters of the fresh Cherry

Arabica is the only type of variety of coffee grown in Nepal. Longitudinal and lateral diameter and weight of 300 numbers of randomly selected fresh cherry of Arabica variety was measured and the result is presented in table 1. The longitudinal diameter ranged from 11 to 16 mm where as lateral diameter ranged from 9 to 14 mm. Similarly the weight of fresh cherry varied from 0.59 to 1.94 gm. The average measurement on longitudinal and lateral diameter and weight of a fresh cherry were 13.83 mm, 12.16 mm and 1.21 gm respectively. There was more variation on weight of cherry than its lateral and longitudinal diameter.

Table 1. Dimension and weight of fresh cherry (Arabica)

Statistics	Longitudinal Diameter (mm)	Lateral Diameter (mm)	Weight (gm)
Mean	13.83	12.16	1.21
Max	16.00	14.00	1.94
Min	11.00	9.00	0.59
Standard Deviation	1.01	1.00	0.26
Coeff. of Variation	0.07	0.08	0.21

Longitudinal and lateral diameter of fresh cherry and parchment of three types of coffee: Arabica, Yellow Katura and Pakamara is presented in table 2. It indicates that the pulp thickness is at the range of 1 mm in Yellow Katura and Arabica variety where as that of Pakamara variety is 1.8 mm. From the table 2, it indicates that there should be adjustment mechanism to remove the pulp of thickness 0.8 to 2.0 mm range.

Table 2. Dimension of fresh cherry and parchment of different variety

Variety	Fresh Cherry		Parchment	
	Longitudinal Diameter (mm)	Lateral Diameter (mm)	Longitudinal Diameter (mm)	Lateral Diameter (mm)
Yellow Katura	14.6	11.8	12.5	9.6
Arabica	13.83	12.16	12.1	9.7
Pakamara	19.6	13.6	16.3	9.7

Problems and issues related to wooden and metal pulpers

Wooden and metal roller pulper is the dominant coffee pulper used by the small farmers in coffee pulping in Nepal. The major problems and issue on wooden and metal pulpers were collected through field survey and field-testing is listed below.

- **Low pulping efficiency** of wooden as well as metal roller pulper, as parchment is found to be broken in case of large cherry and small coffee cherry is not found to be pulped at all. The broken parchment is found to be about 0.89 percent of total parchment.
- The **cleaning efficiency** of metal roller pulper is also found to be poor as significant amount (8.89% of pulp) is found to be mixed with parchment. Hence more labour is needed to separate pulp in the parchment. Moreover loss of parchment along with pulp is 1.78%.
- The **capacity** of the wooden pulper is found at the range of 30 kg/ hr where as that of metal roller pulper is found to be at the range of 35 kg per hour. Most of the farmers in Kaski and Kavre realised the need of increased capacity of pulper as the coffee area is increasing.
- **Loosened as well as broken wires** are major problems of wooden pulper. Similarly **swelling of wet wooden roller** and breakage of parchment is also found to be reported.
- During the field observation it was also observed that roller was not perfectly fabricated and the gap between the roller and plastic pipe covered shaft was also not uniform.

Characteristics of new developed pulper

By addressing afore mentioned problems a roller type hand operated coffee pulper was designed and fabricated with following features.

- Uniform and concentric roller is the prerequisite of metal roller pulper hence it is turned in lathe machine to have uniform and concentric roller surface.
- To avoid loosening and breakage of GI wire, the helical gear was created by welding around the roller surface in helical fashion (Fig. 3). To have uniform depth around the roller surface again the roller is turned to make the depth of helical gear uniform around the roller surface.
- To generate gradual pressure on the coffee cherry and easy separation of pulp, the helical gear surface is made round.
- To adjust and maintain the uniform gap between the parallel shaft covered with plastic pipe and metallic roller, a simple adjustment mechanism is made.
- To avoid water entering in the roller bearing an oil seal was fitted.
- For easy feeding sloppy hopper is also fitted.
- The handle and the height of the frame is ergonomically designed so that it is easy for operation.
- The parchment and pulp outlet chute is fitted for easy collection of parchment and pulp.



Fig. 3: Helical gear around the roller



Fig.4: Developed Pulper in Operation

Performance of developed pulper

The result of several test run of developed coffee pulper (roller type hand operated coffee pulper, Fig. 4) is presented in table 3. The pulping capacity of the developed pulper ranges from 56 to 67 kg/ hr with average capacity 60 kg/hr. The average pulping efficiency is of 90 percent and the cleaning efficiency is of 96 percent. Average broken parchment in modified pulper is only 0.23 percent and the parchment loss along with pulp is 0.44 percent. Test result shows that there is less variation on capacity, pulping efficiency and cleaning efficiency but more variation in broken parchment loss and loss of parchment in pulp. It is mainly due to the variation on size ripeness of fresh cherry used for pulping.

Table 3. Test results of newly developed coffee pulper

Performance parameters	Mean	Max	Min	SD	Coff. of Var.
Pulping Capacity (kg/hr.)	60.49	67.33	56.16	4.73	0.07
Pulping Efficiency (%)	99.23	99.69	98.85	0.30	0.00
Cleaning Efficiency (%)	96.59	98.77	93.85	1.73	0.02
Broken Parchment (%)	0.33	0.63	0.15	0.16	0.25
Parchment Loss along with Pulp (%)	0.44	0.77	0.15	0.24	0.31

Comparative test results of the original roller pulper and the developed pulper is presented in table 4. It shows that the capacity of the developed pulper is found to be increased by 76 percent. Similarly pulping and cleaning efficiency is found to be increased by 2 and 6 percent. However with respect to broken percentage of parchment and Loss of parchment along with the pulp it is found to be reduced by 62 and 75 percent respectively. Hence the results show that from all aspects the developed pulper is found to be superior to original metal pulper. The operators and farmers also realized the better performance and easiness in operation of the modified metal roller pulper.

After the long-term field-testing of the developed coffee pulper in Sindhipalchowk for whole season, there was good demand of this pulper from the coffee farmers. AED, NARC trained 2 manufacturers to fabricate for the commercial production of this pulper. Till date, more than 30 pulpers were brought and used by the farmers of Kavre, Lalitpur, Makwanpur, Lamjung districts

Table 4. Comparative test results of newly developed and original metal roller coffee pulper

Performance Parameter	Developed Pulper (Roller Type Hand Operated Coffee Pulper)	Original Metal Roller Pulper	Comparative Performance
Pulping Capacity (kg/hr.)	60.49	34.29	76.4
Pulping Efficiency (%)	99.23	97.33	2.0
Cleaning Efficiency (%)	96.59	91.11	6.0
Broken Parchment (%)	0.33	0.89	-62.9
Parchment Loss along with Pulp (%)	0.44	1.78	-75.3

CONCLUSIONS

A roller type hand operated coffee pulper was developed and it is found to be superior compared with existing wooden and metal roller pulper with respect to pulping capacity, pulping efficiency, cleaning efficiency, broken parchment and parchment loss. It is found to be appropriate for small pulping centres. The specification of the developed coffee pulper is found to be as following.

- Pulping capacity 60 kg/hr
- Pulping efficiency >99%
- Cleaning efficiency >96%
- Broken Parchment <.33%
- Parchment loss <0.44%)

The developed coffee pulper is already commercialized and there are manufacturers trained in manufacturing this pulper. There is need of support from department of agriculture for the promotion of this pulper and provision for subsidy for small coffee farmers.

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Dairy Animal Research in Nepal: Current Status and Future Strategies

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ABSTRACT

Introduction of productive exotic dairy cattle and buffalo breeds in the country for genetic improvement of local animals was initiated with the establishment of Livestock Improvement Section in 1952. The cattle population in the country during the last five years increased slightly (0.06%) while that of buffalo increased at the rate of 2.7 percent annually. The existing per capita milk and meat availability of 50.7 lit and 8.5 kg is below the targeted requirement level of 57 lit milk and 14 kg meat in Nepal. Complete stall feeding of dairy animals particularly crossbred animals with cut and carry system is the common practice practiced in the dairy pocket areas. During winter and dry period animals have to depend heavily on crop residues. The most prevailing buffalo production system in the major milk shed areas is to purchase lactating buffaloes from the traders and dispose them for slaughter after the milk production. The major dairy pocket areas are concentrated around the highways of the country. The government breeding policy is to upgrade the local animals up to 62.5 percent exotic blood level for the hills whereas in terai and inner terai the upgrading may be unrestricted up to higher level. Different studies have shown the possibility for the productivity improvement through the selective breeding of local buffaloes. Artificial insemination in cattle and buffalo is done through 173 government and 34 private AI centres in 44 districts of the country. Artificial insemination has covered in cattle 8.06 percent of adult female population whereas in case of buffalo it is only 1.55 percent. The average conception rate achieved by artificial insemination is 49 percent. There are around 1100 active Milk Producers Cooperative Societies within the country. The private dairies and Dairy Development Corporation collect the milk through MPC's from 29 districts in the country and the collected milk is mostly sold as pasteurized fluid milk. The major buffalo markets are located in terai area where the buffaloes from India and Nepal mix and flow into the marketing network. There is no organized market for dairy cattle in the country. Poor nutrition due to shortage of quality feeds and fodders, heavy dependence on straw and crop byproducts, poor reproductive efficiency, untapped potential of indigenous breeds and poor management conditions are the major problems that caused low productivity in dairy animals. To improve the productivity and efficiency of the dairy animal production, multidisciplinary coordinated research on dairy animal production is important. There should be long term vision with the active participation of all the stake holders in this regards. Technologies already verified and proven should be widely up-scaled and adaptable technologies developed from neighboring research institutes should be tested and verified and transferred for mass scale adoption with public private participation.

Key words: Exotic dairy animal, stall feeding, crop residue, artificial insemination, growth projection.

INTRODUCTION

Livestock is an integral component of mixed farming system in Nepal. This sector contributes around 32 percent in agricultural gross domestic products (AGDP) of the country. Agriculture Perspective Plan (APP) envisages the share of livestock in AGDP to reach at 45 percent from current level at the end of plan period (2014/15). The dairy is the most important sub sector sharing almost 2/3rd of livestock GDP. Cattle and buffalo are the principle dairy animals in the country and the yak to a certain extent. It has

been estimated that about 75 percent and 47 percent households in the country keep cattle and buffalo respectively. Beside primary milk production, their contributions in terms meat (buffalo), manure, hide, power for agricultural operation and traction are also significant. The sector is gradually transforming into semi commercial/ commercial production system particularly in peri-urban areas with good access to transportation.

The historical livestock development initiatives in Nepal can be traced back to 1917 Bikram Era in which the then Rana regimes brought some European cattle breeds in the country. The first official organization "Livestock Improvement Section" was established in 1952 for development of livestock in the country with main objectives of improving genetic potentialities of indigenous cattle through introduction of exotic cattle breeds. Thereafter Red Sindhi, Jersey and Brown Swiss cattle and Murrah buffaloes were introduced in Nepal. These animals were initially kept at Singh Durbar Livestock Farm, which later on moved to Khumaltar from Singh durbar in 1969. The other exotic cattle breeds introduced Holstein and Ayresshire. Artificial insemination of cattle with fresh semen in the beginning and with imported frozen semen started later on to speed up the genetic improvement program.

The first five-year plan of Nepal had indicated the need for development of modern dairy industry. The dairy development initiative in the country was taken by the government with experimental production of Yak cheese in 1952. The first Yak Cheese production factory was established in Langtang, Rasuwa with assistance of FAO. Later in 1954, a small-scale experimental milk processing plant was established in Tushal of Kabrepalanchowk district and by 1956, a Central Dairy Plant with processing capacity of 500 lph was established at Lainchaur in Kathmandu. In the mean time two additional cheese factories were established in alpine regions under Department of Agriculture (NDDB, 2001).

The Dairy Development Section was established within Department of Agriculture in 1954. A Dairy Development Commission was formed in 1955, which later on 1962 converted into Dairy Development Board. Again, the Dairy Development Board was converted into Dairy Development Corporation in 1969 under the Corporation Act of 1964. With this institutional set up, four major Milk Supply Schemes namely BMSS in the east, HMSS and KMSS in central and PMSS in the west were established during 1973 to 1980, which are involved both in collection and processing of milk. The involvement of private sector on dairy development started in the late 1970s. In 1992, the government established National Dairy Development Board with the major functions and responsibility of formulating and recommending policies and plans for dairy development in Nepal and strengthen the dairy sector by bringing coordination between private and public sector.

Contribution of dairy animals

The estimated annual milk production from cattle and buffalo is 1.3 million metric ton with the monetary value of 32.8 billion rupees, which corresponds to 14.5 percent of the AGDP (225.25 billion rupees) and 45.5 percent of LGDP at current price. Beside the main product milk, the economic contribution from the other products/ byproducts of dairy animals such as manure, meat, draft power and hides is also substantial. Above all the employment opportunities (full and partial) provided from the sector is quite significant.

Table 1. Contribution of dairy animals (Value at current price)

Commodity	Quantity	Rate (Rs/kg)	Amount (Million Rs.)
Milk (MT)	1312140	25.0	32803.5
Meat (MT)	142000	84.0	11928.0
Manure (MT urea equivalent)	156521	16.0	2500.0
Hides (MT)	38000		
Agricultural GDP			225246.0

* Based on manure production at 1 ton DM/Year/TLU (250kg); effective availability of nutrients at 15% from stall fed and half of that amount from grazed animals accounting for nutrient loss, Nitrogen content of manure 0.34% thus providing 8 kg N/TLU/Yr with estimated 9000000 TLU large ruminants in the country, nitrogen content in urea -46%.

The dairy is a crucial sector in terms of flow of money from urban areas to the rural producer farmers contributing significantly for livelihood improvement. It has been estimated that about 10 percent of the

national milk production comes under formal milk marketing channel, which would roughly account NRs 3280 million flow from urban consumers to rural producer farmers annually.

Dairy animal population and distribution

The current estimates of the buffalo and cattle population in the country are 4.37 million and 7.04 million respectively (2006/07). The population of pure yak in the country is dwindling with the current estimates of about 8000 heads. Jhapa, Syangja, Kaski, Dhading and Kailali are the districts with higher buffalo population whereas cattle population are higher in Jhapa, Morang, Sunsari, Ilam, Nawalparasi, Rupandehi, Kapilbastu, Dhading, Nuwakot and Kailali districts.

Present production, consumption and projected demand

The estimated proportion of milking cattle and buffaloes to respective total population are 13 and 26 percent from which the total milk production in the year 2005/06 was 1312 thousand MT. Of the total milk production, the buffalo shared 70.6 percent and rest by cattle. During last five years, the milk production increased by 3.3 percent annually, slightly at higher rate than the population growth indicating productivity improvement. Similarly of the 219 thousand MT of meat produced in the year 2005/06, the buffalo shared 64.8 percent. The per capita availability of milk and meat in Nepal is 50.7 lit and 8.5 kg respectively, however the disparity in consumption between well off and poor people as well as between city dwellers and village dwellers are very high. The per capita availability of milk in our country is quite below that of other South Asian countries (Table 2). Pakistan is well ahead from the world in terms of per capita milk availability (153 kg against 74 kg world average). The per capita meat availability in Nepal is slightly better compared to that in India. The basic per capita milk and meat requirement have been estimated to be 57 lit and 14 kg respectively in Nepal. The per capita milk requirement estimated by Indian Council of Medical Research is 102 lit/annum.

Table 2. Per capita availability of milk and meat

Country	Per capita availability		Requirement		Surplus/deficit (%)	
	Milk (kg)	Meat (kg)	Milk (kg)	Meat (kg)	Milk	Meat
Nepal	50.7	8.5	57.0	14.0	-11.1	-39.1
India	63.0	6.0	57.0	14.0	+10.53	-57.1
Pakistan	153.0	14.0	57.0	14.0	+168.0	0
World	73.9	36.4	57.0	14.0	+29.6	+160.0

The demands for livestock products increase mainly due to increase in human population and change in food habits associated with increased income level. The demands for livestock products are considered to be highly income elastic. The production has to be increased to cater increasing demand due to population growth and increased income, for increasing per capita availability to basic requirements and also for import substitution. Both during 9th and 10th five –year plan period, the targeted annual growth rate for milk and milk could not be achieved, therefore, the growth rates have to be further accelerated to achieve annual growth rate of 6.1% during end of APP plan period.

The annual growth rate in national demand for livestock products is estimated at 6.77 percent per annum as a cumulative effect of 2.25 percent annual population growth rate and 4.53 percent growth in real income. It has been estimated that during the next decade, milk demand from the urban sector will grow by 11.1 percent per annum (Milk Marketing Study NDDDB/DANIDA/ADB/2001). It has also been estimated that national meat demand will reach 453000MT in 2010 for which annual growth rate of more than 15% is required which seems simply very difficult and the increased import be anticipated.

The government of Nepal has targeted to increased per capita availability of milk and meat to 55 lit and 10 kg respectively in the 3 years Interim Plan Period (Table 3). As further growth in population is restricted by availability of resources, the challenge ahead of researchers and extensionist is to improve productivity of animals. The 6 percent annual target growth rate in milk would be sufficient to meet the basic requirement of 57 kg by next 5 years, whereas more than 10 percent annual growth rate is required

to meet meat requirement. The strategy would be to improve milk productivity through feeding and health improvement in short to medium term and genetic improvement of buffaloes in long term. Emphasis has to be given on increasing meat production by availing number of male buffalo calves for fattening by discouraging early disposals of calves and feeding improvement.

Table 3. Growth projection

	Base year	Interim period				Next Five Year Plan			
	63/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72
Population (000)	25887	26469	27051	27634	28216	28799	29394	30003	30625
GR Target (%) –Milk		4	5	6	6	6	6	6	6
Milk production	1312	1364	1430	1508	1587	1666	1744	1823	1902
Per capita availability (kg)	50.7	51.5	52.9	54.6	56.3	57.9	59.4	60.8	62.1
GR Target (%)–meat		6	7	8	9	10	10	10	10
Meat production (,000MT)	227	238	254	272	293	316	338	361	384
Per capita availability	8.8	9.0	9.4	9.9	10.4	11.0	11.5	12.0	12.5

Source: MOAC (2006/07)

Dairy animal production system

The dairy animal production system in Nepal is influenced by availability of feeding resources, prevailing environment, market and the socio economic condition of the farmers. The production system varies greatly across agro ecological zones. Farmers adjust their efforts and orient their activities in animal raising according to their productivity and income drawn from them. Better the productivity better is the care and management given to them. Subsistence and mixed production system is prevalent across the rural part of country, whereas dairy production has been gradually transforming into semi commercial/commercial production system in the peri-urban areas with good access to market and transportation. Complete stall-feeding of dairy animals particularly crossbred animals with cut and carry system is prevalent in this dairy pocket areas. Local cattle are generally raised under complete grazing in nearby forest and fallow land. Buffaloes are partially grazed and cut and carry system is common during lactating period. In mid hill regions, grazing of buffaloes in the village communal grazing land, nearby forest and fallow land is common. In high hills and mountain, some farmers even keep buffaloes under migratory management system and animals are brought upto alpine pasture for summer grazing. Yak and crossbred are raised under migratory management system. Under subsistence production system, supplementary feeding (mostly grain by-products) is limited to animals in production stage. During winter and early dry summer, animals have to heavily depend on crop residues. Specialized housing for animals is not common under subsistence system. Housing condition becomes poorer in the high hills compared to that in terai or low hills. These animals are housed in the shed either separated or attached on the side with the owners' house. The most prevailing buffalo production system in the major milk shed areas are purchasing of lactating (early stage) buffaloes from traders, keeping them throughout lactation for milk sell, disposing of buffaloes towards end of lactation for slaughter and buying new lactating buffaloes for regular supply of milk.

Major Dairy Animal Production Pocket Areas

The major dairy pockets in the country are concentrated around East West and other major highways. Farmers in Ilam, Jhapa, Morang, Sunsari, Chitwan, Nawalparasi, Rupandehi, Kaski, Dhadhing, Kavrepalanchowk, Lalitpur, Makwanpur districts are mostly adopting semi/commercial dairy production.

DAIRY ANIMAL BREEDS AND BREEDING POLICY

Buffalo breeds

Lime, Parkote and Gaddi are the three buffalo breeds identified so far in Nepal at phenotypic and chromosomal level. All three breeds identified are riverine type with $2n=50$ chromosomes. About 90 percent of the buffalo population in the hills and mountains and slightly less than 90 percent in terai are estimated to be indigenous (these three breeds and possibly others yet to be identified). However, due to indiscriminant breeding, Lime and Parkote breeds are intermixed and the breeds in pure form are declining rapidly. Murrah is the principle exotic buffalo breed introduced in the country for upgrading indigenous buffalo population. Frozen semen of Nili Ravi was also introduced from India but at limited number and comprehensive study of this breed has not been performed yet. Some Jafrabadi and Surti buffaloes were also supposed to be introduced in the country through informal route.

About 10 percent buffaloes in the hills and slightly greater than 10 percent in terai are considered to be exotic Murrah and their crossbred with indigenous buffaloes. However, the CBS (2001/02) reports gives this figures to be slightly less than 2% of the national buffalo population and highly contradicting with this report, DLS estimates that about 24.6 percent of the buffalo population are improved (exotic and crossbred). Kavre, Rupandehi, Sarlahi, Dhading, Chitwan, Nuwakot and Kaski are some of the districts having higher number of exotic/crossbred buffaloes. The households having 0.5-1ha, 1-2ha and 0.2-0.5ha of land have the highest number of exotic buffaloes.

Cattle breeds

Till date seven cattle breeds (Table 4) including yak have been phenotypically characterized. Lulu cattle have been studied at molecular (DNA) level with collaboration of Japanese University.

Jersey, Holstein, Ayreshire, Brownswiss, Sindhi and Hariyana are the exotic cattle breed introduced in Nepal, of them Jersey and Holstein and their crosses with indigenous are widely adopted breeds.

The national sample census of agriculture suggests only one percent improved breed available in the country. However, a latest review by ABTRACO figure out about eight percent of the total cattle population are exotic breed and rest are indigenous.

Table 4. Distribution of indigenous cattle breeds

SN	Cattle breeds	Distribution
1	Achhami	Far western region (Achham, Bajhang, Bajura and Doti districts)
2	Khaila	Far western region (Dadeldhura, Doti and Baitadi districts)
3	Lulu	Manang, Mustang and Dolpa districts
4	Pahadi	Across the hills
5	Pahadi	Across the hills
6	Siri	Ilam districts (probably extinct)
7	Yak/ Nak	Mountain regions

Source: Neopane (2002)

Breeding policy

The occasional importation of Murrah she buffaloes and continuous upgrading of indigenous buffaloes with frozen semen and Murrah bull distributed are basic buffalo development strategies adopted in the country. Recently, government has made a policy to unrestricted upgrading to Murrah in Terai and maintenance of upto 62.5 percent Murrah blood in the hills. However, the regulation and monitoring mechanism is very poor to implement the policy.

Crossbreeding with exotic breeds has been the cattle breeding policy to upgrade the indigenous breed for increased productivity. Jersey is the recommended exotic cattle breed for upgrading indigenous cattle with blood level restriction to 62.5 percent (50-75%) for hills and terai region. The breeding policy advocates for avoiding Holstein breed due to its better management demand, however, the commercial dairy farmers are strongly demanding the breed and reconsideration on the policy is essential.

PRODUCTION POTENTIAL

Milk production potential of buffaloes

The standard lactation performance of buffaloes in 305 days is given in Table 5. The performance of Murrah breed is under on station condition at Livestock Development Farm, Lampatan, Pokhara and rest in on farm condition of western hills.

Table 5: Standard lactation performance of buffaloes

	Lime ¹	Parkote ¹	Murrah ²	50% Murrah ³	75% Murrah ³
Milk (l/lact)	962	1022	1543	1222	1560

*Excluding milk offered to calf generally 1 teat for 4 months.

Source: 1. Shrestha *et al.* (2003); 2. Singh (2007); 3. Rasali *et al.* (1998)

A study conducted in western hill districts has depicted a greater variability in terms of lactation performance Fig 1). Some 25 percent of the recorded population have average lactation yield of around 1200 lit. Similar production trend has been reported by Amatya *et al* (2000), but lower lactation performance of indigenous buffaloes (875 lit) has also been reported (Rasali *et al* 1998).

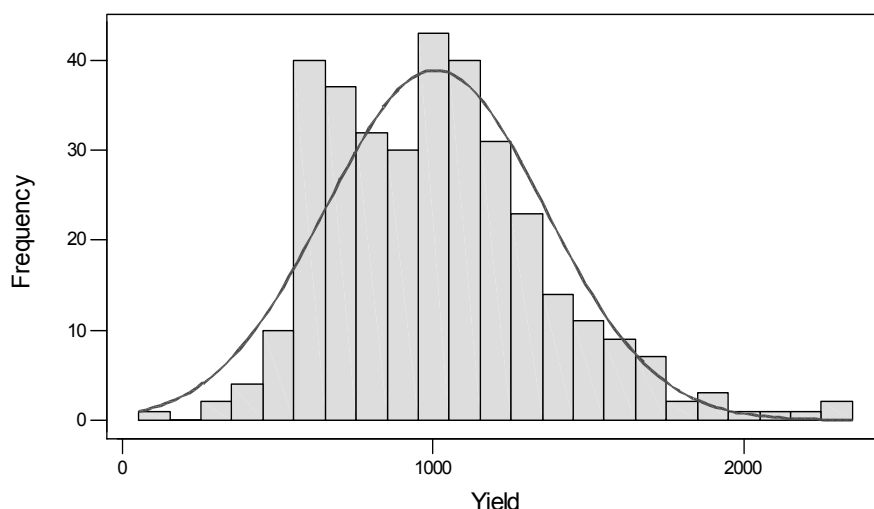


Figure 1: Graph representing variation and lactation performance of indigenous buffaloes

Among the three indigenous buffalo breeds identified, Gaddi buffaloes found in far western hill districts are comparatively better in terms of lactation performance. The average daily milk yield for the first three months was 4.69 lit from two teats and 4.62 lit in next three months with one teat for calf. The lactation length varied from 14 to 22 months (Pokharel, 2007).

The herd average of Murrah buffaloes at Livestock Development Farm, Lampatan in 1990s was 1265 lit per lactation (Singh, 1997) which has improved significantly to 1543 lit in a standard lactation of 305 days in recent years through continuous selection and culling practice (Singh, Pers communication). The average milk yield per buffalo per year in the farm has reached to 1847 lit excluding milk offered to calves, which is generally for a period of 5 months. The herd performance in different lactation is: 1st lactation – 1279±288 lit, 2nd lactation – 1556±318 lit, 3rd lactation – 1520±305 lit, 4th lactation – 1562±283 lit and 5th lactation – 1578±192 lit. in 305 days. The lactation performance of some exotic buffalo breeds in their home country has been presented as Table 6.

Table 6. Milk production potential of some Indian and Pakistani buffaloes

Breed	Lactation yield (lit)	Lactation length (days)	Age at first calving (M)	Calving interval (d)
Murrah	2000	300	44	453
Bhadavari	1100	270	50	478
Jaffarabadi	1850	300	50.7	440
Mehsana	1700	310	42.2	476
Nili Ravi (India)	1950	300	43.3	487
Surti	1400	290	56.4	535
Nili Ravi (Pak)	1800-2500			
Kundi (Pak)	1700-2200			

*Source: Institute for Buffalo Research India for Indian breeds

Production performance of cattle

The productive and reproductive performances of local and exotic/crossbred cattle have been presented in Table 7 and 8.

Table 7. Productive and reproductive performance of native cattle (Mean $\pm$ SD)

Breeds	AFC (months)	Calving interval (m)	ADMY (lit)	Lactation length (days)
Lulu	52 (46-56)	18 (12-24)	1.6 (0.5-3.5)	195 (180-210)
Achhami	60 (48-72)	17 (12-24)	1.5 (1-4)	225 (180-270)
Siri	50 (42-70)	19.6 $\pm$ 0.9	4.5 (2-6)	168 $\pm$ 2.0
Khaila	55 (50-65)	18.0	2.5 (2-3)	305.0
Yak	56.6 $\pm$ 0.75	21.3 $\pm$ 0.76	0.8 (0.5-2)	160 (180-210)
Terai	49.9 $\pm$ 0.46	16.3 $\pm$ 0.23	2.1 (2-3)	246.0
Pahadi	50.1 $\pm$ 1.1	17.6 $\pm$ 1.98	1.1 (1-1.5)	240 $\pm$ 2.1

Source: ABD (2005)

Table 8. Productive and reproductive performance of exotic cattle

Breeds	Age at 1 st service (m)	Age at 1 st calving	Calving intervals (m)	Av. Daily milk yield (l)	Lactation (d)
HF cross	19	29.9	18	5.5	325
Jersey cross	23	32	15	5.3	303
BS cross	26	35	17.8	4.6	269

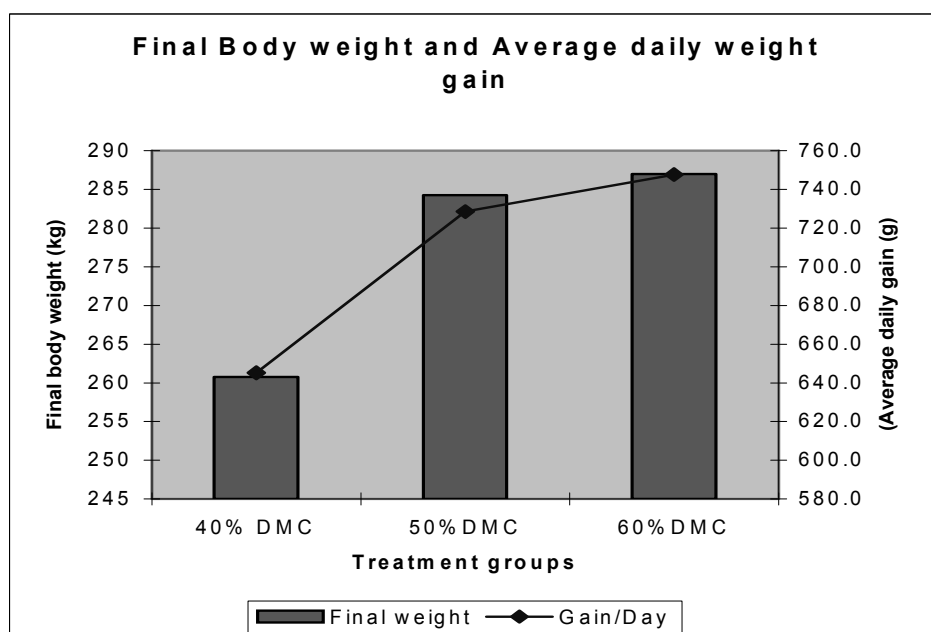
Source: ABD (2005)

Growth potential of buffaloes

The average daily growth rate of indigenous male buffalo calves from average of 8 months to 16 months age under traditional farmer's management condition was found to be around 200 g/day. Whilst the growth rate of indigenous calves reached upto 575 g/d when 40 percent of the daily DM requirement is supplied through concentrates in on farm condition. The potential growth rate of up to 747 g/day has been observed when 60 percent of DM requirement is supplied through concentrate under on station condition (Fig. 2).

Pakistani buffaloes: The average gain in live weight per day is 1.87 lb up to one year and 1.46 lb up to two years of age. It may incidentally be pointed out that this gain is under ordinary conditions of feeding and management. They were not specifically raised for beef production. If fed on balanced economical rations and properly cared for, a daily gain in wt. of 2.25 lb in healthy male calves would not be difficult to achieve.

Indian buffaloes: Feeding grain-less diets to buffalo calves can support a growth rate of about 500 g/h/d and can be used economically in growing buffalo calves. A growth rate of 500-600 gms can be sustained on wheat straw based ration with supplementation of concentrate containing sunflower cake concentrate mixture instead of costly cake like GNC.



Feeding growing buffalo calves at higher plane of nutrition (120% above ICAR standard) resulted in gain of 748 gm growth rate on urea treated wheat straw based ration with little supplementation of green. In India intensive feeding of male buffalo calves for meat production has been started for the first time in a commercial feedlot for quality meat production since last 5 years (1999-2004). In a Village Demonstration farm with HAIL, a commercial feedlot to house 5000 male calves has been established. The facilities include environmentally controlled animal houses with slatted floors where urine and dung are collected in the Keller and are regularly pumped out for spraying in the forage field. The feedlot has its own feed compounding feed mill and about 100 acre farm to cultivate green fodder. The male calves at the age of 8-10 months are purchased from the farmers and are quarantined for 15 days during which vaccinations and de - worming are provided. Thereafter, they are brought to the main farm and are fed on high protein / high-energy diet to put on an additional weight of 120 Kg in 4 months to produce quality meat. The Murrah calves grow at the rate of 900 to 1000 gm per head per day with feed conversion ratio of 5.0: 1. The cost of 1 kg live weight gain comes to around Rs. 25.00 (US\$ 0.5) per kg live weight gain (Feed cost Rs.20.00 + overhead cost Rs.5.00 per day). The dressing percentage of such animals is around 65 percent. A 250-kg live animal produces a carcass of about 150-kg fetching a price of Rs.65.00 to 90.00 (US\$ 1.5 to 2.0) per kg in the wet market internationally. The quality of the buffalo meat is excellent, as it is lean, tender and juicy. They are never fed on antibiotics, hormones and growth promoters (Ranjhan 2004).

THE DAIRY DEVELOPMENT POLICY

The government has recently approved National Dairy Development Policy (2064) with the main objectives of:

1. Increasing milk production and productivity in rural areas
2. Commercialization of dairy production with competitiveness and expansion of collection, transportation and processing industries
3. Product diversification to cater internal demand, import substitution and export promotion and
4. To make available quality milk and milk products to the consumers.

To achieve the objectives the following guiding policies have been envisaged.

- Making dairy enterprise as main basis for rural poverty alleviation by bringing milk produced in rural areas to urban markets.
- Resource centers will be developed by involving cooperatives, farmer's groups and entrepreneurs to improve productivity through breeding and conservation and selection of local breed.
- Animal health and disease prevention program will be effectively launched.
- Promotion of Animal insurance
- Provide low interest rate to buy more milch animal
- Development of nutrition package, suitable pastures technology for production improvement during dry season.
- Encourage the farmers to produce more milk in dairy production potential area
- Milk collection and chilling centers will be established to promote dairy farming in areas having road access.

Existing buffalo research and development farm and institutions

Table 9 presents the existing buffalo research and development farm and institutions.

Table 9. The existing cattle and buffalo research and development

Station/Farm/Institute	Species	Breed	Strength	Capacity
BRP, Khumaltar	Cattle	J, HF, L	100	150
RARS, Tarahara	Buffalo	M, L, Arna	80	150
RARS, Lumle	Cattle	J	15	25
	Buffalo	L	20	30
LD Farm, Pokhara	Buffalo	M	180	200
LD Farm, Jiri	Cattle	J,BS		
Syangboteche Yak	Yak	L	40	
NLBC, Pokhara	Cattle	J Bull	Semen Collection	
	Buffalo	M Bull	Semen Colection	
IAAS	Buffalo	M	70	
	Cattle	H		

The other institutions involved in dairy development in the country are

1. National Animal Science Research Institute and its Four Disciplinary Divisions - Animal Breeding Division, Animal Nutrition Division, Animal Health Division and Pasture and Fodder Research Division
2. Central Cattle and Buffalo Promotion Office, DLS, Hariharbhawan
3. Dairy Development Corporation (with 14 dairy processing industry and 10 cheese factory)
4. National Dairy Development Board
5. Community Livestock Development Programme, DLS
6. Private Dairies (with 109 processing industries and 14 cheese factories)

Central Dairy Cooperatives Association Nepal and Milk Producers Cooperatives

The Central Dairy Cooperatives Association Nepal (CDCAN) represents 1580 primary milk producer cooperative societies at local level and 36 district milk producer cooperative unions at district level from around 51 districts. The CDCAN covers around 423000 households with an estimated 10 percent annual growth rate and provide support to the member cooperatives for establishing milk and dairy product industries, provide services/technical supports, education and training services. As milk is of perishable nature and the range of skills involved in its production and marketing, dairying requires a number of services that can best be provided by cooperative action. It is not surprising therefore that the cooperative movement has featured prominently in the development of the dairy industry worldwide.

Collaboration with the following international dairy research and development institutions would be beneficial for streamlining dairy research and development efforts in our country:

1. National Dairy Research Institute (NDRI), Karnal, India.
2. Central Institute for Buffalo Research (CIRB, Hisar, India)
3. Central Institute for Cattle Research (India)
4. Pakistan Agricultural Research Council
5. Philippine Carabao Centre (PCC), Philippines

Improvement of dairy animals

National Animal Breeding Centre formally known as Animal Breeding and Artificial Insemination Section under DLS.

AI with fresh semen started in Nepal: 2017/18 BS

AI with frozen semen started in 2025/26 B.S.

AI Coverage- 207 AI centres including 34 private in 44 districts

AI Coverage- 8.06 percent in cattle and 1.55 percent in buffaloes

Frozen semen import – 283413 doses (Brown Swiss, Jersey, Holstein, Ayresshire,

Tirentase breeds of cattle and Murrah buffalo),

Average conception rate- 49 percent

Table 10. Organization and technicians engaged in insemination: 2062/2063

Region	DLSOs/AI centers	Private centers	Total centers	Total centers	Inseminators	Total AI	AI center	AI/ Inseminator
Eastern	8/51	6	57	57	115	25594	385	190
Central	16/73	12	12	85	161	36225	341	221
Western	10/35	14	14	46	104	21669	373	210
Mid-western	8/10	1	1	11	22	1982	169	90
Far-western	2/4	1	1	5	13	1971	389	81
Total	44/173	34	34	207	415	87441	1657	792

Source: Sah (2007)

Marketing and import export situation

The major portion of the milk produced in the country is home consumed or processed for ghee making, marketed informally (direct sell from producer to consumers) and only slightly more than 10 percent comes into formal milk market.

The DDC milk supply schemes collect milk from 29 districts in the country amounting around 60000 MT annually (150000 lit daily). The private dairy sector operates in the same areas where DDC operates (225000 lit/day), at half of its current processing capacity. Upto early eighties, DDC was collecting milk through its own milk collection centers located in different villages. Now the collection centres are handled by the farmers' themselves through organized MPCs. At present there are around 1100 active MPCs throughout the country. The milk collected by formal sector (both DDC and private dairies) is mostly sold as fluid processed (pasteurized) milk, and some dairy products such as butter, cheese, ghee, sweets, yoghurt and ice cream in the city centres. DDC has one powder milk plant with annual SMP production capacity of around 600 MT. Initiatives have been taken by members of MPCs and private entrepreneurs to establish another powder milk plant in Chitwan district.

Nepal is the net importer of live animals and livestock products. The statistics shows that the annual import of live buffaloes for meat from India is around 150000, which nearly reached 300000 in the year 2003/04. In the same year, 7400 buffaloes were exported from the country. The imported buffaloes are mostly spent buffaloes, which are no more useful for milk production or old male buffaloes after termination of their productive life. Most of the live animals imported are for slaughter, whereas few

buffaloes are also imported for milk production purposes. Around 2000 milch buffaloes are brought annually to Kathmandu and Kavre districts.

The major buffalo markets are located in Terai area and these are the places where Indian and Nepalese buffaloes mix and flow into the marketing system. Entry point along the border are Damak, Belbari, Dhulabari, Kunjibari (Jhapa), Dohomana (Morang), Madhuvan (Sunsari) Bangamakatti and Bodebarsain (Saptari), Jitpur (Bara), Sakhuwa and Barhathawa, Jamunia, Parasi (Nawalparasi), Ramuwapur (Banke), Thapuwabagia (Bardiya), Bahadurgunj and Shivapur (Kapilbastu).

Beside live animals, some livestock products are also imported in the country. A study by NEW ERA (2000) revealed that around 16 MT of buffalo fillet and prime cuts worth 1.3 million rupees was imported in Kathmandu valley. Nepal Dairy Association estimates imports of 1892 MT SMP, 17MT cream/butter, 124 MT of Ghee, 108 MT of cheese/Paneer, 21 MT of ice cream and 17 MT of other products worth 470 million for the year 2003/04. The major export livestock product of the country is ghee (clarified butter), which is again exported through informal sector. The volume of export in the year 2003/04 was 545 MT. In the same year, 144 MT of fresh milk was also exported to India from eastern region of the country. Yak cheese is another important export livestock commodity, though the volume is small.

Table 11: Trade of livestock products

	Products	Unit	2002/2003	2003/2004	2004/2005	2005/2006
Export	Ghee	Kg	39009	72772	23025	9371
	Milk	Lt	30260	2170658	1747785	932911
	Chhurpi	Kg	3806	7786	5064	70
	Skin	Sq.ft.	1402582	1807381	194404	86765
Import	Ghee	Kg			16500	192
	Milk	Lt	482479	326247	287865	243260
	Chhurpi	Kg	1100		93875	830
	Yak tail	No				6210

Source: ABTRACO (2007)

Investment situation

The major loan investment agency for livestock development in Nepal is Agricultural Development Bank, Nepal. During the FY 2005/06, the bank had invested NRs. 1847011 thousand in livestock sector. The major research and development investment in buffalo commodity in the country during various fiscal years is presented in the Table. 12. Investment of I/NGO sector in buffalo commodity is very poor, and are mostly seem to be interested in small animals and poultry.

Table 12. Annual investment on Bovine Research (Rs' 000)

Investment	Year				
	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Research	5930 (23)	3919 (18)	4341 (18)	4000 (17)	5290 (18)

MAJOR ISSUES

The pertaining issues that need to be addressed first for streamlining research on dairy animals for their improvement are:

- Non coordinated research program – scattered and patchy works
- Lacks continuity and coherence on research efforts
- Breeding policy emphasizes on upgrading but silent on improvement through selection
- Technology dissemination and Adoption – generally poor
- Research on socio economic aspect- virtually non existent

The core problem identified in dairy animals in the country is low production and productivity for milk and meat production causing poor economic return to the farmers. The consequences are situation of importation of milk and milk products and meat animals in the country negatively contributing towards trade balance. The core problem is attributed to:

1. Poor nutrition due to shortage of quality feeds and fodders, heavy dependence on straw and lack of appropriate feeding management and standards.
2. Inadequate number of animals for meat production due to high calf mortality and early disposal of male calves in major milk shed areas, and development and dissemination of appropriate calf rearing and fattening technologies
3. Low milk production from buffalo is due to poor reproductive efficiency, lack of appropriate high yielding breeds for different eco zones and, untapped potential of indigenous buffalo breeds,

FUTURE STRATEGIES/DIRECTIONS

1. Establishment of Dairy Research Institute: It has been strongly felt necessary to establish a Dairy Research Institute with mandate of streamlining research on dairy animal and dairy processing, training of farmers and SMS and higher education in the field of dairy science. The Dairy Research Institute has been proposed at present 18 Regional Agricultural Research Station, Tarahara. Dairy Animal Research Farms at following locations have also been suggested.

Tarahara, Sunsari (within Institute premises- representing Eastern Terai)
 Khumaltar, Lalitpur (for hills)
 Rampur, Chitwan (Inner Terai)
 Lumle (for indigenous buffaloes)
 Nepalgunj, Banke (Western Terai)
 Mustang (for Yak in mountain region)

Besides, the existing Livestock Development Farm, Lampatan, Pokhara (Buffalo), Jiri (Cattle) and Syngbotche (Yak) need to be strengthened as Elite Resource Centres and strong collaboration and linkage be maintained with research farms.

2. National Coordinated Research Programme on Cattle and Buffalo led by respective coordinators. Program planning, implementation and monitoring need to be coordinated by the National Program.

3. Focus on participatory and on farm research: Initiation should be taken for establishment of outreach research sites at appropriate location covering different agro ecological regions and different production system.

4. Researcher led to farmers' based problem research with separately focusing the need for subsistence and commercial dairy farmers. Researchers need to be accountable and responsible.

5. Multi disciplinary approach: The present scattered, patchy and non-coordinated works need to be abandoned and multidisciplinary team and consolidated approach be taken to solve multifaceted farmers problems.

6. Source center development: Efforts will be put for establishment of Nucleus herd (of cattle and buffalo) at research farms and elite herds at farmers' level to cater the need for elite genetic materials as guided by national breeding policy and farmers need.

7. Technology transfer and up scaling: Emphasis will be given for training on good practices, identification of most suitable methods for technology transfer and up scaling with broad consensus of concerned stakeholders.

8. Technology adoption from neighboring research institutes and verification/ modification at local level to optimize maximum use of limited resources and to save time constraints whenever and wherever possible.

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Overview of Bovine Paratuberculosis in Nepal

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ABSTRACT

An attempt was made to know the status of Paratuberculosis (Johne's disease) a chronic granulomatous infectious disease of ruminants in Nepal. In past years intradermal skin test (Johnin test) had been conducted to identify the prevalence of the disease. Intradermal skin test carried out during 1982- 1988 in cattle of organized farms of Kathmandu and Pokhara valley showed an over all prevalence of 3.22 percent (0.9-10.13%). In 1999, 115 serum samples from buffaloes and 98 serum samples from cattle of different districts of Western Nepal revealed 39 samples (33.9%) and 27(27.5%) samples positive to antibodies against paratuberculosis by absorbed ELISA. During 2003/2004 rectal scrapings were collected from 28 buffaloes and 26 cows and 4 scrapping and 3 cultures were positive for acid fast organisms. In recent years (2006-2008) studies on paratuberculosis were conducted by using different diagnostic tests and over all prevalence of 7.10 percent (3.5-9.09%) were detected in DTH(Johnin test), 4.55 percent (4.25-4.85%) in faecal smear, 0.70 percent in faecal culture and 5.34 percent (4.54-5.82%) in Agar Gel Immunodiffusion Test AGID) in cattle of Kathmandu valley and Chitawan district.

Key words: Agar gel immunodiffusion test, ELISA, infectious disease, Paratuberculosis, prevalence of the disease

INTRODUCTION

Paratuberculosis (Johne's disease) is a chronic granulomatous infectious disease of domestic ruminants which has been reported in wild ruminants including rabbits and camelids. This disease was reported for the first time by John and Frothingham 1985. It is caused by *Mycobacterium avium* sub sp. *paratuberculosis*, a acid fast organism. The animals are infected at early age but disease appears later after one year of age. The disease is characterized by progressive weight loss and diarrhoea and emaciation. Diarrhoea occurs in later stages. It is characterized by chronic granulomatous enterocolitis, Lymphangitis, Lymphadenitis(Chiodini et al 1984). Economic loss in the herd is mainly due to decrease in production, feed efficiency, culling of infected animals cost of diagnosis and control measures. There are very scanty information regarding Johne's disease in Nepalese context and mostly intradermal skin test has been carried out in past years. Hence, in his study attempt has been made to carry out additional diagnostic tests eg faecal culture and AGID. This study was conducted to help in carrying out future studies on bovine paratuberculosis, to find out the occurrence of paratuberculosis and develop future strategies on this disease.

MATERIALS AND METHODS

Review of past works

Annual reports of Central Animal Disease Investigation and Research Laboratory from 1982/83 to 1987/88 were reviewed for the incidence of Johne's disease in cattle.

Selection of animals

The cattle which were more than one year of age and which were showing symptoms of paratuberculosis like emaciation and intermittent diarrhea were selected.

Intradermal skin test (Johnin test)

The test was carried out by single intradermal inoculation of 0.1 ml of Johnin purified protein derivative (1 mg/ml, BP Division, IVRI, Izatnagar) at a shaven site on one side of the neck. The thickness of skin was measured before inoculation and at 24, 48 and 72 hours after injection with the help of Vernier callipers. Animals showing an increase of 3 mm in thickness of skin were considered positive (OIE Manual 2000, Sharon 1992)

Laboratory examination

Faecal smear examination: Faecal samples were collected directly from the rectum of each goat. Two gram of faecal sample was mixed well in 20 ml of distilled water and kept for 30 min for settling. One ml of supernatant was centrifuged at 1000 g for 20 min and smears were prepared from the sediment. After heat fixation smears were stained by Ziehl Neelsen's (ZN) method and examined under microscope using oil-immersion objective. The presence of 2-3, strongly acid-fast bacilli in clumps were considered as positive (OIE Manual 2000).

Culture of faecal samples: Faecal processing: About 2 g of faeces was transferred to a 50 ml test tube containing about 20 ml of sterile distilled water mixed thoroughly for 30 min at room temperature and was allowed to settle for 30 min. Following decontamination of faecal sample with Hexadecyl pyridinium chloride (final concentration of 0.75%) samples were centrifuged and the sediment was used for culture into three slants of Herrold's egg yolk medium (HEYM) two each with Mycobactin-J (Allied Monitor Inc. Missouri, USA) and one tube without Mycobactin-J. The tubes were observed for any growth at 4 week intervals (Tripathi et al 2000).

Serological tests – AGID: Agar gel immunodiffusion test: Agarose gel (1%) prepared in sterile PBS (pH 7.4) was poured into the petridishes and allowed to solidify at 4°C. Wells of 3 mm diameter were punched in a hexagonal pattern of 6 peripheral wells for sera and a central well for the antigen with a distance of 5 mm in-between. The optimum concentration of sonicated antigen (1.0 mg/ml) was kept in the central well after addition of test sera in the peripheral wells. The test sera were charged in duplicate wells. On each plate one set of positive sera in duplicate was always included as control. After incubation at 4°C the gels were examined at 24 and 48 hours for development of precipitation lines. The appearance of single clear precipitation line was recorded as positive.

RESULTS AND DISCUSSION

Results of reviews

Intradermal skin test carried out in cattle of organized farms of Kathmandu and Pokhara valley showed an overall prevalence of 3.22 percent (0.9-10.13%) (Table 1) (Annual Reports of Central Animal Disease Investigation and Research Laboratory, Kathmandu (1982-1988)).

Absorbed ELISA was conducted in 115 serum samples from buffaloes and 98 serum samples from cattle of different districts of Western Nepal which revealed 39 samples (33.9%) and 27 (27.5%) samples positive to antibodies against paratuberculosis. In the same study, 11 (34%) out of 32 goats were found to be positive for paratuberculosis (Joshi and Joshi 1999). Similarly, rectal scrapings were collected from 28 buffaloes and 26 cows and 4 scraping smears and 3 cultures were positive for acid fast organisms (Jha 2003/2004)

Results of recent studies

In recent years (2006-2008), studies on paratuberculosis were conducted by using different diagnostic tests conducted at Animal Health Research Division, NARC, Khumaltar and over all prevalence of 7.10 percent (3.5-9.09%) were detected in DTH, 4.55 percent (4.25-4.85%) in faecal smear, 0.70 percent in faecal culture and 5.34 percent (4.54-5.82%) in AGID. in cattle of Kathmandu valley and Chitawan district (Table 2). There were minimal positive cases in faecal culture due to the hardy growth of the organism. It also depends upon the stage of infection and bacterial load in the faeces. Although faecal culture takes long time for development of bacterial colonies it is considered as gold standard test and AGID is a test with more specificity. A combination of tests should be carried out to diagnose the disease in animals.

Table 1. Result of Johnin test conducted in cattle (1988-98)

Fiscal Year	Total number	Johnin +ve	% +ve
1982/83	305	13	4.2
1983/84	183	6	3.2
1984/85	148	15	10.13
1985/86	660	6	0.9
1987/88	433	14	3.2
	1729	54	3.12 (0.9-10.13)

Table 2. Year wise findings of diagnostic tests

Year	Place	Total no. of animals	Animals suspected	DTH (%)	Faecal smear (%)	Faecal culture (%)	AGID (%)
2008	Kathmandu valley	141	20	5 (3.5)	6 (4.25)	1 (0.70)	8 (5.67)
2007	IAAS, Rampur	44	20	4 (9.09)	-	-	2 (4.54)
2006	Khumaltar BRP	103	12	9 (8.73)	5 (4.85)	-	6 (5.82)

Livestock farm of Khumaltar and IAAS long history of farming and regular testing of the farm animals have never been practiced in those farms. Regular culling of diseased animals should be carried out in order to reduce the occurrence of this disease as clinically affected animals act as shedders and source of infection to healthy animals. The laboratory tests have detected occurrence of this disease in bovines. More detail study covering more number of animals should be carried out. Studies should be carried out at molecular level.

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Food Security Contribution and Vision of Sustainable Goat Production in Nepal

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ABSTRACT

Goats are important livestock commodities in Nepalese farming communities. Majority of rural population depends on goats for meat, milk, manure, Chyangra Pashmina, and pack use in the high mountain. They are popular for income generation and known as "Living Bank of Poor" in rural areas of Nepal. Species is popular as PEWA among the women. Every rural household keeps 2-5 goats while this number increases to 8-10 heads in potential pocket area. Goat production in the country is not adequate to fulfill the demand of meat and subsequently every year large number of goats, more than 400000 heads, is imported from the neighboring countries such as from India and China. Therefore there is huge potential to increase the goat population for food security in the country itself. A sustainable goat production, goat research and development program should aim with the vision to enhance the production and productivity of goats sector in particular with the integrated effort on client oriented problem based, participatory and systemic research and development, maintain the dynamism in goat production system for food security. Research and developmental vision with the issue hindering on food security contribution by goats has been explained in this strategy paper.

Key words: Chevon, chyangra pashmina, food security, living bank of poor, research and development strategies, vision

INTRODUCTION

Goats are one of the most important livestock species in Nepalese farming system. Majority of rural population depends on goats for meat, milk, manure, Chyangra Pashmina, and pack use in the high mountain. Every rural household keeps 2-5 goats while this number increases to 8-10 heads in potential pocket area. They are known as "Poor Man's Cow" and "Living Bank of Poor" in rural areas of Nepal. Goats are usually known as cash generating animal during emergency. Goat enterprise suits with the landless marginal and small farmers.

Goat production in the country is not adequate to fulfill the demand of meat and subsequently every year large number of goats, more than 400000 heads, is imported from the neighboring countries such as from India and China. Therefore there is huge potential to increase the goat population for food security. The price of chevon "goat meat" has increased tremendously over last 20 years and the trend increment has been quite high in goats as compared to other species suggesting high demand of goat meat in the country (Neopane 2003).

This paper discusses the contribution of goats to food security and the vision of sustainable goat production in Nepal. Further, the paper also provides suggestions on development strategies for sustainable goat production in Nepal.

GOAT GENETIC RESOURCES

The goat population in Nepal is shown in Table 1. There are four indigenous goat breed in Nepal. They are Chyangra, Sinhal, Khari and Terai goats.

Table 1. Indigenous goat breeds and population

Breeds	Altitude (m asl)	Rearing zone	Percent	Population (number)
Chyangra	> 2500	High hills and mountain	4	338923
Sinhal	1500-2500	High hills and mountain	35	2965579
Khari	300 - 1500	Across the hilly region	53	4490733
Terai	<300	Across the Terai region	8	677847
		Total	100	8473082

Source: MoAC, 2009

High numbers of goats are concentrated in hills and mountain and hence more contribution on food security in this agro zone. About 5-10 percent of goats are improved in Nepal. Exotic goats breeds are Jamunapari, Barbari, Beetal and Saanan. Jamunapari and Barbari are used to upgrade the Khari and Terai breeds in Nepal.

PRODUCTION POTENTIALS

Goats are mainly reared for meat, fiber, milk and pack use. In Nepal goats share about 12 percent of the livestock gross domestic products (LGDP).

Reproductive and productive performance of goats

Over the period of time, NARC has done considerable work on quantification on the reproductive and productive performance of indigenous goat breed. The updated information is shown in Table 2.

Table 2. Production performance of indigenous breed of goats (Value are mean $\pm$ standard errors)

Parameters	Breeds			
	Terai	Khari	Sinhal	Chyangra
Age at first service (days)	348 $\pm$ 10.7	311 $\pm$ 5.6	363 $\pm$ 12.4	405 $\pm$ 9.9
Weight at first service (kg)	17.3 $\pm$ 0.49	15.4 $\pm$ 0.22	17.0 $\pm$ 0.35	18.5 $\pm$ 0.40
Age at first kidding (day)	491 $\pm$ 5.1	453 $\pm$ 6.2	576 $\pm$ 9.8	555 $\pm$ 9.6
Weight at first kidding (kg)	19.5 $\pm$ 0.56	17.8 $\pm$ 0.23	20.5 $\pm$ 0.42	18.8 $\pm$ 0.35
Kidding interval (days)	336 $\pm$ 4.2	302 $\pm$ 3.7	287 $\pm$ 5.4	354 $\pm$ 8.7
Litter size at birth (number)	1.4 $\pm$ 0.21	1.6 $\pm$ 0.02	1.1	1.0
Litter weight at birth (kg)	2.5 $\pm$ 0.33	3.38 $\pm$ 0.06	2.0	1.9
Litter size at weaning (number)	1.3 $\pm$ 0.26	1.42 $\pm$ 0.03	0.8	0.7
Litter weight at weaning (kg)	11.1 $\pm$ 1.0	11.9 $\pm$ 0.36	10.0	9 - 11
Gestation length (days)	149.9 $\pm$ 0.30	144.8 $\pm$ 0.15	145 - 150	145 - 150
Body weight (12 months) (kg)	20.1 $\pm$ 0.97	16.3 $\pm$ 0.33	22.4	20.0

Source: Neopane (2004)

Goat Products and Food Security

Meat Production situation in Nepal: A comparative meat production situation of different livestock and poultry in Nepal is shown in Table 3. The data has indicated that central region has highest meat production (70568) followed by eastern development (56054 mt) (Table 3). Annual meat production is lowest in far western Nepal (23349 mt). This has indicated that priority should be given to the far western region on goat production if government wants to use the goats for feed security.

Meat production potentials and contribution on the food security: The existing national meat production level is 60 gram from the indigenous goats (Upreti and Shakya 2008) but the potential is

average of 100 g/day if the developed technology is used to improve on the different goat husbandry system (Figure 3).

Table 3. Comparative meat production situation in Nepal

Development Region	Meat production of animal species (mt)						Total Meat (mt)
	Buffalo	Sheep	Goat	Swine	Poultry	Duck	
Eastern	33538	383	11592	7261	3193	87	56054
Central	47083	352	11283	3524	8263	63	70568
Mid western	31211	601	8194	2189	2396	64	44655
Western	17760	1078	9557	2362	1708	14	32479
Far western	17439	333	4307	699	566	5	23349
Total	147031	2747	44933	16035	16126	223	227105
Percent	64.74	1.21	19.78	7.06	7.10	0.10	100

Source: MoAC 2007.

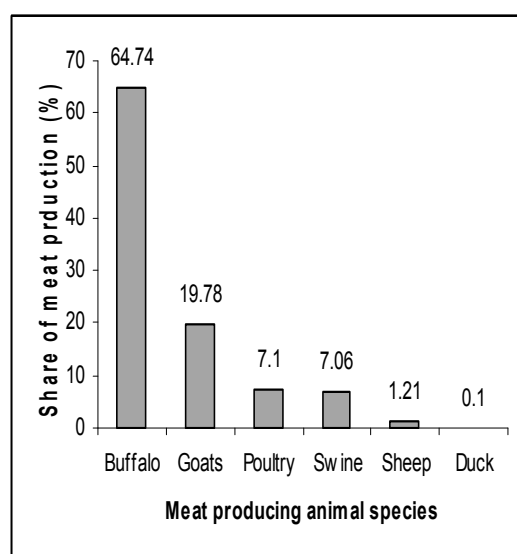


Figure 1. Species wise share of meat production situation in Nepal

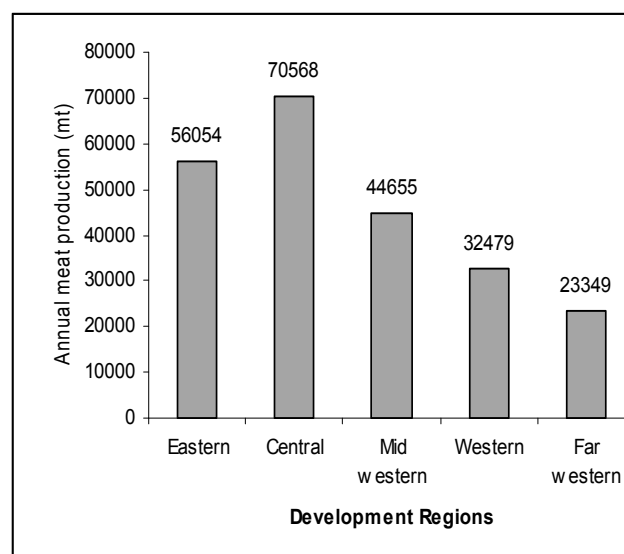


Figure 2. Annual meat production by development regions of Nepal

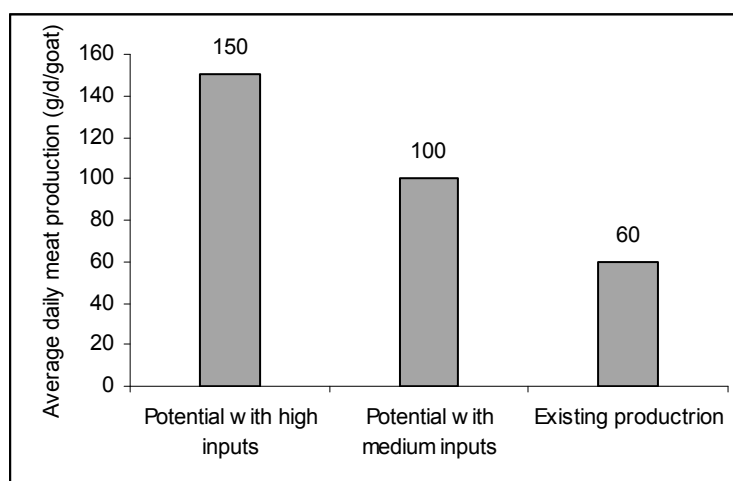


Figure 3. Existing meat production situation and potential

RESEARCH AND OTHER ISSUES

Despite of its economic value to the small farmers, the species is neglected for the research and development authorities. But in the recent years, government has set a priority for goat development to secure food in the rural area.

National issue

Huge number of goats imported especially during the festival (from India and China)

Public and planner issue

1. Goats are major cause of deforestation, range land destruction.
2. Goats are responsible for soil erosion.

Research and development issues

Goat Breeding

- Low productivity of native goats.
- Lack of breed improvement program and policy
- Undue emphasis to introduce exotic blood without proper investigation.
- Lack of nucleus/elite herds of different breeds of goats.
- Development/establishment of fast growing meat type goats for commercial meat production.
- Disease resistance breed development in indigenous stock (Molecular study)

Production (Fodder and pasture)

- Inadequate feed/forage
- Agro-forestry management technologies inadequate.
- Limited suitable high altitude pasture and fodder species.
- Horti-pastoral system technologies inadequate.
- Declining in communal grazing land.
- Lack of forage seeds
- Inadequate forage preservation and conservation technologies.

Feed utilization (Animal nutrition)

- Lack of technology package on use of crop and insutrial agro-byproducts for feeding goats.
- Lack of technology suitable for stall feeding management.
- Lack of technology for non-conventional feed stuff for goat feeding

Goats health

- Inadequate information on epidemiology, pathogenesis, treatment and control strategies of infectious and non-infectious diseases of goats.
- External and internal parasites problem.
- Inadequate studies on economically important diseases (PPR, Liver fluke, coccidiosis, gastro-enteritis, posterior paralysis, diarrhea, mange, gid pneumonia, FMD).

Production and management

- Lack of scientific goats husbandry practices suitable for different agro ecological zone of the country
- Lack of technology for feedlot production system on goats.
- Lack of economic related study.

Multidisciplinary

- High mortality both pre and post natal stage
- High cost of meat production.
- Problem of poisonous plants in hills and mountain.
- Repeat breeding problem.

Others

- Inadequate efforts to consolidate available information/technology in the form of package and practices.
- Lack of adequate training and technical support.
- Lack of short, medium and long term strategies for research and development.
- Inadequate and restricted market outlets.

VISION AND STRATEGIES

Vision

Goat research and development program should aim to enhance the production and productivity of goats sector in particular with the integrated effort on client oriented problem based, participatory and systemic research and development, maintain the dynamism in goat production system for food security.

Strategies

Following suggestion can be made for goat development which ultimately helps to secure the food in rural areas of Nepal.

- As the rural people are largely dependent on goats, a clear-cut research and development strategies suitable to the different agro-ecological zone of the country is urgently needed.
- Goats farming needs to be promoted to subsistence to semi-commercial and commercial farming
- A marketing net work for live animal collection needs to be developed.

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Boer Goat (*Capra hircus*): an Alternative Breed to Increase Meat Production in Nepal: A Review

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ABSTRACT

There are about 8.47 million goats in Nepal (MoAC 2009). Most of these goats are local and very adaptive to the different ecological zones of Nepal (Subtropical (Terai goats), mid hills (Khari Goats), Mountains (Sinhali) and Temperate (Changra). There may be about 18 percent crosses between these locals and exotic breeds such as Jamunapari, Barbari, and Kiko. Although the number of the goat population is big, their performances in terms of daily live weight gains were very low (40 to 66 g) as compared with the daily live weight gains of Boer Goats (136 to 250 g) and daily live weight gains of Boer goat crossbreds (100 to 200 g). The Boer goats had faster growth rates and were heavier than the local/indigenous breeds of goats from Nepal. The feed conversion ratios of the Boer goat crosses were 1: 3.18-3.60) whereas local Khari goats had 1 : 7.43-13.04. The Boer goats and its crossbreds had higher average litter size (1.63 to 2.2) than those of the indigenous breeds and its crossbred goats (1.0 to 1.8). The feeding behavior of the Boer goats (preference to browsing than grazing) was found to be similar with that of the local/indigenous goat breeds of Nepal. The Boer goat has already been introduced in Nepal by a private farmer in 1999. The spread of the Boer Goat Population in developed countries like Australia, New Zealand, and USA has been found to be faster because of the quality of meat (low Cholesterol content) and high level of average daily growth rates. The main objective of this review paper is to compare the some of the important performances of the indigenous breeds of Nepalese goats with the Boer goats and its crosses in order to utilize the Boer Goat breed as an alternate breed to increase meat production in Nepal.

Key words: Boer goat, breeds, crossbreds, kidding rate, live weight gains

INTRODUCTION

Goat meat (Chevon) is one of the most popular meat in Nepal. The present goat population (8.47 million goats in Nepal (MoAC 2009)) is meeting about 72-78 percent of the total goat meat availability in Nepal (36055t/yr). The rest 22-28 percent goat meat is imported in the form of live animals mostly from India and Tibet (4, 00,000 to 5, 00,000, Upreti and Shakya 2008). The goats in Nepal are well adapted to all the ecological zones, Terai goats in the subtropics terai, Khari goats in the mid-hills, Sinhali goats in the high mountains and changra goats in the temperate (Neopane 2003). Terai and Khari goats representing about 20 and 56 percent of the total goat population in Nepal (Kharel and Neopane 1998) and Terai and Khari goats have 40 and 60 percent twinning, respectively, (Neopane, 2004). These indigenous goats have significantly lower daily live weight gains (50g, Upreti et al 2007) than Boer (186 to 291/g, Van Niekerk and Casey 1988) and its crossbred goats (100-200 g, Farmer communication 2008).

The reason for the import of such a number of goats from India or Tibet is mainly because of the significantly lower meat producing ability of the indigenous goats as compared to the exotic meat producing goats e.g. Boer or its crossbreds. The Boer goats which are now getting rapid popularity in the developed (USA, New Zealand, Australia, Japan) and Developing (Sir Lanka, India) countries have fastest growth rate pre- and post-weaning with an excellent feed conversion ratio (1:3.18-3.60, US Grain

Council, 1997-98 cited in Nimbkar 2002) and low cholesterol content (Keblinger 2002) are already introduced in Nepal by a private farmer Mahesh Basnet in 1999 (Personal Communication 2008).

In this review, there has been an attempt to compare the some of the important performances of the Indigenous, Boer and its Crossbred goats in order to priorities the South African Boer goat breed as one of the most potential breeds to upgrade or crossbreed the local/indigenous breeds for increasing meat production in Nepal.

BREEDING (KIDDING) AND OTHER PERFORMANCES

Boer goat

The Boer Goat of South Africa has been selected for the meat in that country using performance testing (Stephen 2000). Boer goat is a large double muscled animal famous for meat and hardiness. The most important characteristic of this breed is that the meat production capability is passed on to their kids. As the meat production is the main objective of the goat farming in Nepal, good Boer goat stock should be used for crossbreeding and breeding up schemes to produce superior meat type goats in Nepal. Boer goat produces very good crossbreds having hybrid vigor with local breeds (Nimbkar 2002).

The Boer goat does have high fertility from multiple births including triplets and quadruplets and they are non-seasonal breeder (R. Edward and A. Warkneh, www.ziegen-caprine.ch/boer.html, Lu.D. Christopher 2001). A study on Boer and Nguni goats carried out by Lehloeny, Greyling and Schwalback in South Africa in 2003 reported that the average litter size of the Boer goats was 2.2 ± 2 . Similar study carried out in India by Nimbkar (2002) indicated that Boer goats have high prolificacy with close to 100 percent twinning.

The breeding age of the Boer goat is about 6 months. The litter size under normal management is found between 1.63 and 1.93 kids per parturition and under good management up to 2.25 kids per parturition (Grenling 2000, DAGRIS 2005). The economic productive age of a Boer goat is approximately 10 years (SASBA 2001).

Female Boer goats produce around 2kg of milk per day for about 120 days. This much milk yield is adequate to feed twins and to provide the household with rich milk after the kids are weaned (Nimbkar 2002).

The boer goat is known to be very resistant to diseases like bluetongue and enterotoxaemia and to poisons like prussic acid. This breed is more resistant to diseases than most of the native breeds and its crosses also carry this resistance (Nimbkar 2002).

Goat breeds in Nepal

Broadly Nepalese goats are classified into four breeds. 1. Terai, 2. Khari/Hill, 3. Sinhal and 4. Chyangra. Their breeding performances or the kidding rates reported by Kharel and Neupane (1998) were 140 percent for Terai, 160 percent for Khari, 110 percent for Sinhal and 100 percent for the Chyangra. There are also some exotic breeds such as (Jamunapari and Barberi and their crossbreds with indigenous breeds).

The range of the kidding rate of different indigenous, exotic and crossbred goats in Nepal are given in Table 1. According to the Table 1, the ranges of the kidding rate for Terai, Khari, Sinhal, Chyangra, Jamunapari, Barberi, Barberi x Khari, Khari x Sinhal and Jamunapari x Khari are between 140 and 180 percent, 122 and 165 percent, 110 and 146 percent, 100, 116, 135 and 191, 129 percent and 161, 122 percent, and 120 and 160 percent, respectively.

The range of the kidding rate reported by the different authors for the Boer goats was between 163 and 225 percent. From the review of the kidding rates between the Boer goats and the goat breeds in Nepal, the kidding rates of the Boer goat breed are higher than the kidding rates of the goat breeds in Nepal.

Table 1. The kidding rate of the different indigenous, exotic and crossbred goats in Nepal (%)

References	Breeds						Crossbreds		
	Terai	Khari	Sinhala	Chyan gra	Jamun apari	Barberi	Barberi x Khari	Khari x Sinhala	Jamunanpari x Khari
Kharel and Neupane, 1998.	140	160	110	100	-	-	-	-	-
Tamrakar et al 2000	180	-	-	-	-	191	-	-	-
ARS (Goat) Annual Report 2002/3	-	165	146	-	-	164	161	-	160
Dhangadhi Goat Dev. Farm, Annual Report 1996/97	-	133	-	-	-	-	-	-	-
LAC, Annual Report 1996/97	-	-	-	-	-	-	-	122	-
NARC, Annual Report 1997/98	-	158	127	-	116	142	158	-	146
NARC, Annual Report 1998/99	160	127-156	-	-	-	-	-	-	-
NARC, Annual Report 1999/2000	-	158	127	-	116	142	158	-	146
NARC, Annual Report 2000/01	-	148	-	-	-	152	1470	-	-
ARS (Goat) Annual Report 2004/05	-	122	132	-	-	175	129	-	140
ARS (Goat) Annual Report 2005/06	-	146	146	-	-	135	156	-	120
Range	140-180	122-165	110-146	100	116	135-191	129-161	122	120-160

LIVE WEIGHT GAINS

Boer goats

The South African Boer goats are best known for meat-producing ability. These animals have the fastest growth rate pre-and post-weaning with an excellent feed conversion ratio (1:3.18 – 3.60, U.S. Grains Council 1997-98). Boer and its crosses with indigenous goats have been found to be adaptable to all types of climates. A report on the trials conducted by U.S. Grains Council (1997-98) revealed that average daily liveweight gains of Boer cross (male) and Boer cross (female) were 164 and 119, respectively.

Boer goats are known to have fast growing rate compared to other goat breeds. Under good pastoral conditions, the growth rate of the first 12 months can be 200 g/day (Christopher 2001). Two scientist Van Niekerk and Casey in 1988 in their study with the Boer goats recorded the average growth rates 291, 272, 245 and 250 g/day from birth to 100, 150, 210 and 270 day of age in male Boer goats, respectively. The corresponding growth rates were 272, 240, 204 and 186 g/day from birth to 100, 150, 210 and 270 day of age in female Boer goats.

Phaltan, 2002 reported that daily live weight gains of well fed pure and crossbred Boer kids can be between 150 and 300 g. Martin Farris in 2002 in her article in Goat Rancher reported in the USA that

Boer buck kids from fast growing blood lines will average over 320 g of daily live weight gain (average weaning weight of over 32 kg), if provided with good diet. In the same article she reported that Boer buck kids from average sires and worst sires will average about 260 g of daily live weight gain (average weaning weight over 27 kg) and 160 g of daily live weight gain (average weaning weight over 18 kg), respectively.

Panday et al (2008) noted that the daily live weight gains of the Boer goat crossbreds were between 100 and 200 g. Farmers at Sunderbajar, in 2008, expressed that the Boer goat introduced in Nepal in 1999 was the main source of the Boer goat crossbred production (about 25 to 50% blood of Boer goat).

Terai, Khari and Sinhal goats

The average daily live weight gains of Terai, Khari and Sinhal breeds of goats are presented in the Table 2. From the table it can be seen that there are variations in the growth rates within the breeds and between the breeds. For example the daily growth rates of Terai goats (63-96 g) were higher than the daily growth rates of khari (50.1-67.8g) and Sinhal goats (43.3 g). There were also differences in the daily growth rates between and within three breeds at their different ages. For example, the daily growth rates of Terai goats (65-92 g) at the age of 180 days had still higher daily growth rates than the daily growth rates of Khari (50.1-67.8 g) and Sinhal goats (56.9-63.4 g) at the same age.

Local and crossbred goats at Dhangadhi Goat Development Farm, Budhitola, Kailali

The average daily live weight gains of the local and crossbred goats maintained at Dhangadhi Goat Development Farm, Budhitola, Kailali are given in Table 2.1. This table has clearly indicated some differences in the ADLGs between the locals (80.66 g at 0-120 days age and 39.92g at 120-180 days age) and crossbreds (84.48g at 0-120 days age and 42.72 g at 120-180 days age). Differences in ADLGs were apparent between male and females in both local and crossbred animals. Similarly, there were differences in the ADLGs between the single and twin born kids in both the categories of the breeds in both the sexes.

Table2. The average daily liveweight gains (ADLGs) of Terai, Khari and Sinhal breeds of goats in Nepal (g)

References	Breeds											
	Terai				Khari				Sinhal			
	General	0-180d	0-270d	0-365d	General	0-180d	0-270d	0-365d	General	0-180d	0-270d	0-365d
Panday et al 2007	-	-	-	-	50-70	-	-	-	-	-	-	-
Upreti et al 2007	-	-	-	-	53-66	-	-	-	-	-	-	-
Kunwar et al 2001	-	-	-	-	11-20 (straw based diet)	-	-	-	-	-	-	-
Pandey & Sainju 1996/97	-	-	-	-	40-47	-	-	-	-	-	-	-
Tamrakar et al 2000	63-96 (0-120d)	65-92 (120-180d)	-	-	-	-	-	-	-	-	-	-
ARS (Goat) 2005/06	-	-	-	-	-	54.3	43.8	38.9	-	62.7	48.5	40.8
ARS (Goat) 2004/05	-	-	-	-	-	50.1	42.6	40.3	-	63.4	51.9	46.6
ARS(Goat) 2002/03	-	-	-	-	-	50.7	44.3	38.7	-	56.9	47.3	44.5
NARC 2001/02	-	-	-	-	-	67.8	67.3					
NARC 1999/2000	-	65.1	-	-	40.5	-	-	-	43.3	-	-	-
NARC 1999/2000	-	-	-	-	19.8-23.0 (straw based diet)	-	-	-	-	-	-	-
NARC 1998/09	96.3	-	-	-	42.7	-	-	-	-	-	-	-
NARC 1988/89	-	-	-	-	68.3 (0 – 120d, on-farm) 80.0 (0 – 120d, on station)	-	-	-	-	-	-	-

Table 2.1. The average daily liveweight gains (ADLGs) of the local and crossbred goats maintained at Dhangadhi Goat Development Farm, Budhitola, Kailali, Nepal

Breeds	ADLGs (g)	
	0 – 120 days	120 – 180 days
A. Local	80.66	39.92
Male	84.76	42.34
Single	99.33±54.75 (18)	48.00±17.42 (17)
Twin	70.19±19.0 (6)	36.67±36.5 (5)
Female		
Single	78.13±48.83 (8)	41.67±21.83 (5)
Twin	75.0±33.25 (8)	33.33 ± 18.83 (7)
B. Cross Breeds	84.48	42.72
Male	87.84	51.04
Single	103.25 ± 84.58 (14)	58.33 ± 32.17 (10)
Twin	72.42 ± 30.42 (18)	43.75 ± 20.0 (12)
Female		
Single	88.58 ± 42.0 (15)	26.12 ± 4.33 (15)
Twin	73.67 ± 33.25 (16)	42.67 ± 21.0 (16)

Data in the parenthesis are the number of observations. **Source:** S.L. Shakya (1988/89), Annual Report, Dhangadhi Goat Development Farm, Budhitola, Kailali, Nepal.

Jamunapari and Barbari

The average daily live weight gains (ADLWG) of Jamunapari and Barbari breeds of goats are presented in Table 2.2. According to the table ADLWG of Jamunapari and Barbari goats are 62.0 g and 39.3-82.8 g, respectively. The growth rate at 0-365 days of age was higher in the Jamunapari (58.4 g) than those of the Barbari goats (40.8 g-48.4 g) of the same age.

Table 2.2. Average daily live weight gains (ADLGs) of Jamunapari and Barbari Breeds in Nepal.

References	Breeds							
	Jamunapari			Barbari				
	General	0-365d	General	0-120d	120-180d	0-180d	0-270d	0-365d
Tamrakar et al 2000	-	-	-	64.0-83.0	63.0-76.0	-	-	-
ARS (Goat), 2005/06	-	-	-	-	-	61.1	-	-
ARS (Goat), 2004/05	-	-	-	-	-	58.7	45.7	-
ARS (Goat), 2002/03	-	-	-	-	-	57.2	47.1	40.8
NARC, 2001/02	-	-	-	-	-	58.2	57.3	-
NARC, 1999/2000	62.0	-	39.3	-	-	62.9	-	-
NARC, 1998/99	-	-	82.8	-	-	-	-	-
NARC, 1997/98	-	58.4	-	-	-	-	-	48.4
Range	62.0	58.4	39.3-82.8	64.0-83.0	63.0-76.0	57.2-62.9	45.7-57.3	40.8-48.4

Crossbred goats

The average daily live weight gains (ADLWG) of 50 percent crossbred goats in Nepal are given in Table 2.3. According to the table, ADLWG of Barbari, Jamunapari, and Kiko crosses with Khari were 43.5 g, 49.9-52.0 g and 46.8 g, respectively. As was the case with local breeds (Table2), there were also differences in the ADLWSs between and within crossbreds at different ages. For example, the ADLWG of Barbari x Khari, Jamunapari x Khari and Kiko x Khari at the age of 0-180 days had 46.5-75.0 g, 52.7-60.9 g and 51.1-59.6 g, respectively.

Table2.3. The average daily live weight gains (ADLGs) of 50% crossbred goats in Nepal (g).

References	Breeds											
	Barberi x Khari				Jamunapari x Khari				Kiko x Khari			
	General	0-180d	0-270d	0-365d	General	0-180d	0-270d	0-365d	General	0-180d	0-270d	0-365d
ARS (Goat), 2005/06	-	54.6	38.0	34.3	-	59.1	44.3	40.5	-	54.4	43.3	40.1
ARS (Goat), 2004/05	-	52.3	47.1	-	-	60.9	45.4	-	-	59.6	49.1	-
ARS (Goat), 2002/03	-	46.5	40.4	37.3	-	52.7	44.5	38.9	-	51.1	42.7	37.6
NARC, 2001/02	-	70.0	62.0	-	-	-	-	-	-	-	-	-
NARC, 1999/2000	43.5	-	-	-	52.0	-	-	-	46.8	-	-	-
NARC, 1998/99	-	-	-	-	49.9	-	-	-	-	-	-	-
NARC, 1997/98	-	-	-	44.9	-	-	-	42.7	-	-	-	53.7
Range	43.5	46.5-75.0	38.0-62.0	34.3-44.9	49.9-52.0	52.7-60.9	44.3-45.4	38.9-42.7	46.0	51.1-59.6	2.7-49.1	37.6-53.7

From the review of the daily live weight gains between Boer and its crossbred goats, and local (Indigenous) and its crossbred goats, it is quite apparent that Boer and its crosses have higher daily growth rates and are heavier than the Nepalese local/indigenous or its crossbred goats.

FEEDS AND FEEDING BEHAVIOR

Boer goats

Boer goats prefer small trees and shrubs as their basic diets. These animals have exceptional ability to utilize certain plants which are less appetizing to other livestock and are also good in biological control of weeds (Lu 1988). Experiments conducted at Omtgenna Experimental farm in Namibia have reported that Boer goat consumes 74 percent leaves and 26 percent grass (SASBA 2001) (<http://studbook.co.za/boergoat/value.html>). Boer goats are also found spending more time grazing than other breeds of goats. Boer goats are found to prefer browsing than grazing. Boer goats are heavy eaters. However, the feed conversion ratios of the crossbreds as well as purebred Boers are very high (2.5 to 3.5 kg dry matter per kg weight gain, Nimbkar 2002).

According to the review of the Boer goats by Casey and van Niekerk in 1988, Boer goats are drought resistance, tolerance of tannins, efficient for fiber digestion, tolerant to different ambient temperature and lower water turn over rate.

Indigenous/local goats

Most of the Nepalese indigenous /local goats are kept under sedentary system where they are left to graze during the daytime and penned during the night (AND 1997/98). Goats are mostly maintained on the forages from the forest, fodder trees and grazing land (Panday et al 2003/04). Concentrates either rice bran, ground maize, maize flour, millet flour, broken rice (kanika) or kitchen waste in the form of "Khole" are given to some of the needy animals. Common salts are given at regular intervals (15-30 days) (Panday 1996/97). Goats in the hills and mountains mainly browse on shrubs and thorny bushes which are hardly used by any other ruminants. These animals are the most efficient converters of unwanted vegetation to quality animal protein (Tiwari 1994). Local goats are very slow in gaining live weight. For example, a study carried out at Khatteldada, Gorkha revealed that the feed conversion ratios of these animals were found to be 1 : 7.43-13.04 (Panday et al 2007, Upreti et al 2007).

The feeding habits of the goats in Nepal have been found to vary with the ecology and the season of the year in the same locality. Stall feeding, intensive or extensive, and migratory and transhumance systems of goat raising are popular in the terai, mid-hills and high mountains, respectively (Bastola et al 2006).

CONCLUSION

The findings from this review of Boer goat and its crosses, indigenous and its crosses with Jamunapari, Barberi and Kiko goats indicate that Boer goats have outstanding characteristics for hardiness, adaptability, fertility and growth potential. The Boer goat has also the ability to transmit its superior phenotypic characteristics to other breeds when used for crossbreeding. Although, local breeds of goats in Nepal have lower live weight gains than the Boer goats, they have very good ability for the adaptability and tolerance to diseases. With the exception of the Chyangra, all other three local breeds are prolific. Almost all the indigenous breeds of goats prefer browsing than grazing. Therefore, it is concluded that Boer goat may be a very good alternative breed for crossbreeding with indigenous breeds in order to increase meat production from the goats farming in Nepal

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Effect of Stylo on Dry Matter Intake and Growth Performance in Goat

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ABSTRACT

A wide range of fodder species are available in the mid-hills of Nepal. Most of them do not meet the nutrient, mainly protein, requirements of livestock. Stylo (*Stylosanthes guianensis*) is a legume herb with high crude protein content and which can be grown in the mid-hills of Nepal. This study, conducted in the mid-hills of Nepal, examined the effects of stylo dry matter intake (DMI) and body weight gain in goats. To examine the effects of stylo on DMI and growth in goats, twelve 6-7 month-old castrated male goats were assigned to three dietary treatment groups (n = 4/group). Ad libitum tree foliages were used as basal diets in each treatment, with the addition of maize flour in the first treatment (D₁), concentrate in the second (D₂) and concentrate plus 200 g Stylo in the third (D₃). Diet 3 that included stylo reduced (P<0.01) concentrate intake (16.3 g kg^{-0.75} d⁻¹), followed by Diet 2 (17.6) and Diet 1 (17.7). In addition, goats offered Diet 3 tended to gain more body weight (17.1 kg) in the 255 days than in Diet 1 (14.7) and Diet 2 (13.2) and also tended to have a higher daily weight gain (67.2 g d⁻¹) than in Diet 1 (57.5) and Diet 2 (49.6). Therefore, it can be concluded that stylo supplementation in the basal diet of fodder leaves (Diet 3) was beneficial in reducing the cost of production for sustainable goat production in the hills of Nepal.

Key words: Dry matter intake, goat, growth performance, stylo, tree foliage

INTRODUCTION

Goats are very important in Nepal, especially for poor, rural people who live in the hill regions. As ruminants, goats are dependent mainly on roughage feed obtained from forest and community pasture land. However, most of the fodder available in the hill regions may not meet the protein and mineral requirement for goats, so the farmers supplement with either legume forage or concentrate feed. There is a large shortage of concentrate feed in Nepal (Upreti and Sheresth 2006); the deficit is mainly due to the use of this feed by other consumers such as non-ruminant, including people.

Introduction of forage legumes into the farming system has been suggested as one of the strategies for ensuring the sustainability of livestock and crop yields. Forage legumes not only provide better quality feed for livestock but also contribute to sustaining soil fertility. Legumes have much higher protein levels than leaves and grasses and also provide essential minerals and vitamins (Horne and Sturr 2000).

Stylo (*Stylosanthes guianensis*), a perennial fodder legume of Latin American and Central American origin and introduced into other areas throughout the world, has been given much attention. It is a sub-shrub, semi-erect or erect, with a strong tap root and small round root nodules. Phengsavanh (1997) reported that stylo 184 grows quickly and is well-adapted to a wide range of environmental conditions. It was initially used mainly for ruminants. However, now, stylo 184 is fed more commonly to pigs than ruminants. It was reported that the most economic way to improve energy intake and performance of animals fed on crop residues is to supplement them with good quality forages, such as stylo (Horne and Stur 1999). In addition, Bamikole (2003) reported that macro-mineral bioavailability in grass planted

with Verano-stylo legume or treated with nitrogen fertilizer can improve the utilization of Ca in goats. Therefore, in areas with a shortage of concentrate and/or it is expensive, stylo can be an alternative protein source for livestock. This study examined the effects of stylo on dry matter intake and growth in goats.

MATERIALS AND METHODS

Farmer selection and cage fabrication

This trial was carried out in Katteldanda, Gorkha, at farmers' field for 257 days, from December 2005 to October 2006. This area is similar to the agro- eco-zone of Bandipur where the cafeteria trial was carried out. To conduct the study, twelve participating farmers were selected to construct a metabolic cage (length = 1 m, width = 0.5 m, height = 1 m) using locally produced wood and bamboo. The cages were built on 1 m stilts and roofed with corrugated sheeting.

Experimental animals

Twelve castrated goats of similar age (6 - 8 months) and weight (12.2 - 12.9 kg) were selected and divided randomly into 3 groups of 4 goats each. Before starting the experiment, each goat was drenched against internal parasites and dipped against external parasites. Animals were penned individually in a metabolic cage and provided with fresh drinking water *ad libitum*.

Experimental diet

The nutrient requirements of goats were calculated according to NRC recommendation. The dry matter requirements of goats were calculated on the basis of 3.5 percent of their body weight. Nitrogen (crude protein) and other nutrient requirements were met as per NRC (1984) requirements. The farmers were assigned one of three feeding diets for their goats:

Diet1: Maize flour (150 – 200 g) + fodder leaves (*ad libitum*)

Diet2: Compound feed (150 – 200 g) + fodder leaves (*ad libitum*)

Diet3: Compound feed (150 – 200 g) + fodder leaves (*ad libitum*) + stylo (200 g)

Different locally available fodder species collected from community forests and farmlands were used as the basal diet.

Compound feed preparation: The following ingredients were used in concentrate feed preparation.

Ingredient	Percentage
Maize (whole)	60
Rice bran	23
Mustard cake	15
Salt	1
Mineral mixture	1

The feeding procedures of the different diets were as follows:

Diet 1: A mixture of maize flour and salt (152 g) were hand fed in a basin early in the morning. This was followed by hanging a weighed amount of tree foliage by a rope over a trough in front of the cage. More weighed foliage was added as needed. Usually, the diet was given in late afternoon for evening consumption. The orts were collected and weighed the following morning prior to feeding the next days.

Diet 2: Maize flour and salt (152 g) were hand fed in a basin early in the morning. Tree foliage was then offered in the same manner as in Diet 1.

Diet 3: Maize flour and salt (152 g) were hand fed in a basin early in the morning. Tree foliage was then offered in the same manner as in Diet 1 and Diet 2. In addition, a weighed amount of stylo was hung by a separate rope. Orts were collected as in Diet 1 and Diet 2.

In all treatments, samples of each type of feed offered and their Orts (if any) were collected, air-dried and stored for future chemical analyses. The duration of the experiment was approximately 180 days and the animals were weighed every 15 days in the morning before feeding. The treatment assigned to each group of farmers was changed every six months so that each goat would be subjected to each of the treatments for six months in a cross-over design.

Data Recording and analysis: Daily feed intake was recorded by a dial balance for the experimental period of 270 days. Offered feed samples were collected and analyzed according to Goering and Van Soest (1970). Data were analyzed by one way ANOVA using Statistica version 8.

RESULTS AND DISCUSSION

Feed intake

Total dry matter intakes (DMI; g d⁻¹) of goats differed (P<0.01) among treatments but total DMI per kg w^{0.75} per day, as % body mass, and as % body mass per kg w^{0.75} were not different (Table 1). Similarly, fodder DMI in g d⁻¹ differed among treatments, but per kg w^{0.75} did not. There was a highly significant difference (P<0.01) in DMI (g kgw^{0.75} d⁻¹) of concentrate among treatments, where inclusion of stylo in Diet 3 reduced concentrate intake.

Table 1. The feed intake of goats in different dietary treatment

	Diet 1	Diet 2	Diet 3	P
Concentrate Feed				
DMI g d ⁻¹	167.7±2.80 ^a	155.3±2.96 ^b	160.9±2.80 ^{ab}	0.01
DMI g kgw ^{0.75} d ⁻¹	17.7 ± 0.32 ^a	17.6 ± 0.34 ^a	16.3 ± 0.32 ^b	0.00
Stylo				
DMI g d ⁻¹)	0	0	37.9 ± 0.83	0.00
DMI g kg w ^{-0.75} d ⁻¹	0	0	3.3±0.16	0.00
Fodder				
DMI g d ⁻¹	579.9±12.43 ^{ab}	550.0±12.3 ^a	617.2±12.43 ^b	0.00
DMI g kg ^{-0.75} d ⁻¹	60.6 ± 1.03	62.2±1.09	62.3±1.03	0.47
Total DMI				
DMI g d ⁻¹	736.4±14.7 ^a	704.2±14.32 ^a	793.8±14.7 ^b	0.00
DMI g kg ^{-0.75} d ⁻¹	77.1±1.31	79.7±1.39	80.4±1.31	0.17
DMI % body mass	3.66 ± 0.08	3.88 ± 0.9	3.77 ± 0.08	0.20
DMI % body mass kg ^{0.75}	7.7±0.13	7.9±0.14	8.0±0.13	0.17
N	68	61	68	

Different superscripts within rows indicate significant difference (Tukey's HSD, P<0.01) among means Means are with ± SE. n is number of Sample size.

Growth

There was no significant difference in growth of goats on the different diets (Fig. 1). Goats in Diet 3 (stylo included) tended to be heavier than the other two diets (without stylo diets); Diet 2 had lowest body weight from beginning to end of the trial. Growth of goats in Diet 1 was similar to Diet 3 until 165 days of feeding, but, thereafter, Diet 3 showed the fastest growth rate.

Goats in Diet 3 tended to gain more body weight (17.1 kg) in the 255 days than under Diet 1 (14.7 kg) and Diet 2 (13.2 kg) and tended to have a higher daily weight gain ($67.2 \pm 6.35 \text{ g d}^{-1}$) than in Diet 1 ($57.5 \pm 6.35 \text{ g d}^{-1}$) and Diet 2 ($49.6 \pm 6.7 \text{ g d}^{-1}$) (Table 9). The daily metabolic body mass gain ($\text{g kg}^{-0.75} \text{ d}^{-1}$) in Diet 3 (6.74) was marginally higher than in Diet 1 (6.14) and Diet 2 (5.5).

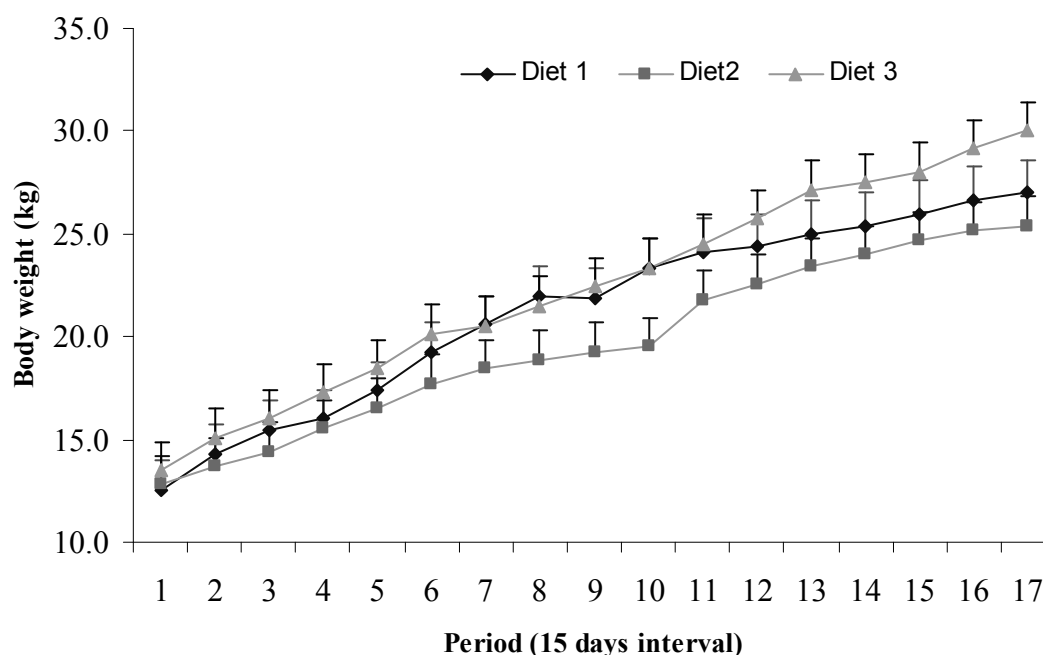


Figure 1. The effect of different dietary treatments on body weight change pattern of goats.

Table 2. Effect of different dietary treatments on weight change of goats. Means are with $\pm$ SE

	Diet 1	Diet 2	Diet 3	P
Body mass (kg)				
Initial	12.4 $\pm$ 0.92	12.1 $\pm$ 1.06	12.9 $\pm$ 0.92	0.85
Final	27.0 $\pm$ 1.90	25.4 $\pm$ 2.10	30 $\pm$ 1.90	0.31
Total gain	14.7 $\pm$ 1.52	13.3 $\pm$ 1.75	17.1 $\pm$ 1.52	0.29
N	4	3	4	
Daily weight gain(g d^{-1})	57.5 $\pm$ 6.35	49.6 $\pm$ 6.71	67.2 $\pm$ 6.35	0.16
Daily metabolic body mass gain ($\text{g kg w}^{0.75} \text{ d}^{-1}$)	6.14 $\pm$ 0.67	5.50 $\pm$ 0.70	6.74 $\pm$ 0.70	0.098
N	68	61	68	

The inclusion of stylo in the goat's diet did not affect total and fodder DMI ($\text{g kg w}^{0.75} \text{ d}^{-1}$). In contrast, Phengsavanh and Ladin (2003) reported that providing stylo 184 as a supplement to a medium quality grass diet resulted in significant increase in feed intake. This may have been due to the higher CP intake from stylo which would create a better rumen environment for digestion of feed. In this study, concentrate feed was provided in all dietary treatments, which had a high CP content.

Total DMI in Diet 1, Diet 2, and Diet 3 were 77.1, 79.7 and 80.4 $\text{g kg}^{-0.75} \text{ d}^{-1}$, respectively, which were higher than the annual mean DMI ($58.0 \text{ DMI g kg}^{-0.75} \text{ d}^{-1}$) of 3 - 4 years old goats in Nepal (Shinde et al 2000). The higher DMI in this study may be due to the younger age of goats, as requirements of young are greater than adults within a species (Thonney et al 1976). Similarly, DMI, as percent body weight and metabolic body

size, both were not significantly different among dietary groups. It was 3.7, 3.9 and 3.8 by body weight (BW), and 7.7, 7.9 and 8.0 by metabolic body size ($W^{0.75}$) in Diet 1, Diet 2 and Diet 3, respectively. In Omani goats of various breeds, Mahgoub et al (2005) reported that DMI as percent BW was 2.8 to 3.2 and DMI, as percent of $BW^{0.75}$ was 5.8 to 6.5 which were quite lower than results in this study.

There was, however, a significant difference in compound feed/maize flour intake. Goats consumed less concentrate feed when stylo was included as supplemental feed in the diet than diets without stylo. Legumes have much higher levels of protein in their leaves than grasses and also provide essential minerals and vitamins (Horne and Stür 2000). In addition, Bamikole (2003) reported that Verano-stylo in the diet can improve the utilization of Ca. Consequently, some of the concentrate could be replaced by stylo without reducing total DMI and weight gain of goats, which could be an important factor for reducing feed costs. In support, Richard et al (1994) suggested that the legume tree *Gliricidia sepium* can replace some of the concentrate used in a diet based on kinggrass (*pennisetum purpureum*) for growing goats. Njwe and Kona (1994) reported that in the absence of concentrate, smallholder farmers can provide 200 g d⁻¹ of stylo hay supplement to yearling lambs to obtain significant increases in feed intake, utilization and weight gain.

The growth of the goats fed with different diets did not differ significantly, however, the daily metabolic body mass gain ($g\ kg^{-0.75}\ d^{-1}$) in Diet 3 was higher (6.74) than in Diet 1 (6.14) and Diet 2 (5.50). Goats on Diet 3 were heavier than on the other two diets, especially after 150 days of feeding, and that may have been due to stylo. The average daily gain (ADG) on Diet 3 was 67.2 g d⁻¹ which tended to be higher than that on Diet 2 (49.6 g d⁻¹) and on Diet 1 (57.5 g d⁻¹). The ADG obtained in the experiment was also higher than the 50 g d⁻¹ of an average goat herd of Nepal (Anonymous 2004) and the 44 g d⁻¹ at the Agriculture Research Station (Goat), Bandipur (Kuwar et al 2001). The growth rate of the present study is supported by results of Phengsavanh and Ledin (2003) who reported an ADG in goats of 27.1, 41.0, 63.9 and 70.5 g d⁻¹ on 0, 20, 30 and 40 percent stylo mixed diets, respectively.

CONCLUSION

In this experiment, stylo inclusion to the goat diet reduced concentrate intake significantly, although the total DMI was not reduced. The reduction in concentrate intake could be a major factor for reducing costs in goat production. Therefore, it can be concluded that stylo supplementation in the basal diet of fodder leaves (Diet 3) was beneficial in sustainable goat production.

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Production, Feeding Value and Toxic Elements of Nimaro (*Ficus roxburghii*) in the Hills of Nepal

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ABSTRACT

Production level, feeding value, polyphenolics and toxic elements of Nimaro were monitored and reviewed during 2006 to 2007. Seasonal effect on nutrient content was also studied. Old leaves shed in December to January and new leaves appeared in Feb to March. One vigorous tree yielded 45 ± 5.0 - 73.33 ± 15.28 kg fresh leaves every year. Leaves were bigger in size ($24.58 \pm 5.79 \times 17.08 \pm 5.79$) and were even used as plate or tray during festival. Average 15.67 ± 2.08 to 19.33 ± 3.06 kg firewood was produced per lopping per tree. Edible fodder leaves and small twigs were moderate in CP content (11.95 to 13.35%). Fiber content was moderate in quality where NDF and ADF was recorded 44.0 and 37.98% respectively. Macro mineral recorded were 2.79 and 0.24 percent calcium and phosphorus, respectively. A complete set of information on macro-mineral, micro mineral; polyphenolics (lignin and tannin) were completed and presented. Information on toxic elements, as median value, such as aluminum (median 195 mg/kg feed, arsenic (60 µg/kg) lead (560 µg/kg Feed/, mercurus (66 µg/kg feed). and nitrated 27.1 m mo/kg was recorded. Reported level of toxic element was not harmful to the ruminant animals.

Key words: feeding value, minerals, polyphenolic, production, toxic elements.

INTRODUCTION

Nimaro is one of the important fodder tree species in Nepal. It is versatile and can be used as fodder, fuel wood, and green leaf plate during ceremonial parties. The tree is easily established on a wide rang of soil type at a variety of altitude (800-5,000 masl) and in a range of rainfall zones. Most favorable altitude to grow Nimaro is 1650 masl (Wood et al 1994). There is clearly a need for a more systematic study of fodder production and quality to make best use for ruminant feeding. Information on the feed composition will help to formulate the ration. Similarly, information on the toxic elements will help for safe feeding to ruminant animals. Therefore, this study was designed to find out on the production potential, feeding value and toxic elements of Nimaro as a fodder tree in the hills of Nepal.

MATERIALS AND METHODS

Three sites in the hills of Nepal such as ARS Pakhribas, ARS Bandipur and RARS Lumle were selected during 2006/07 to conduct the study. Tree morphology, production level, feed composition (proximate principles) and major mineral (Ca and P) were recorded. Information on toxic elements content in Nimaro was compiled and reviewed to include in the report.

Production performance

Tree foliage was determined in these sites using three mature trees. Trees were lopped during December one month before leaf shedding. Fresh matter (FM) was estimated to determine fresh yield per tree. Firewood was estimated after feeding the plants to the goats ie remaining twigs is considered as firewood.

Feeding value and anti-nutrient factors

Three samples were obtained from mature Nimaro trees from each site. Mature trees were tagged and monitored for its chemical composition. A total of 1 kg of sample of fresh leaves was received from the branches. Two separate samples of fresh leaves were taken from the lopped branches. Each sample was bulked, mixed thoroughly, and 100 g removed for drying. The leaves were dried to a constant weight in an oven at 60°C and grounded in electric-operated sample grinding mill to pass approximately 1-mm particles. Weight loss on drying was used to estimate the dry matter content of the fresh leaves sampled.

Samples were analyzed for dry matter, total ash, CP, NDF, ADF, minerals (complete set of minerals, both macro and micro) and polyphenolic, anti nutrient factors, such as tannin and lignin were also estimated.

Toxic elements

Toxic elements of Nimaro were reviewed to show the potential toxic status of Nimaro. This analytical work was done at International Plant Analytical Exchange Program (IPE) of the Netherlands in collaboration with Pakhribas Agriculture Center (PAC) during 1995.

RESULTS AND DISCUSSION

Production characteristics

Production characteristics of fodder tree is shown in table 1. Nimaro was medium sized fodder trees with mean height of 5.0 ± 1 to 6.33 ± 1.53 meter and canopy was measured of 5.83 ± 0.76 to 7.0 ± 1.0 meter. Vigorous matured tree yielded 45 ± 5.0 to 73.33 ± 15.28 kg fresh leaves every year. But Shaky (1990) reported annual production of 60-80 kg green foliage per tree. The lower yield may be due to records from comparative younger trees. Leaf shedding recorded from December to January and new leaf emerged during Feb to March.

Leaves were bigger in size ($24.58 \pm 5.79 \times 17.08 \pm 5.79$) and were even used as plate or tray during festival. Average 15.67 ± 2.08 to 19.33 ± 3.06 kg fire wood was produced per lopping per tree. These woods are left over of looped branch after eaten by ruminants.

Table 1. Morphology and production characteristics of Nimaro in different sites

Sites	Plant morphology		Production character			Leaf character		
	Height (m)	Canopy (m)	Leaf shedding	New leaf occurring	Yield (FM /kg/tree)	Fuel wood*	Long (cm)	Breadth (cm)
ARS, Pakhribas	6 ± 1.0 (3)	7 ± 1.0 (3)	Dec	Feb	73.33 ± 15.28 (3)	16.67 ± 2.89 (3)	-	-
ARS, Bandipur	6.33 ± 1.53 (3)	6.67 ± 0.58 (3)	Jan	Mar	71.67 ± 10.4 (3)	19.33 ± 3.06 (3)	24.58 ± 5.79 (6)	17.08 ± 5.79 (6)
RARS, Lumle	5 ± 1.0 (3)	5.83 ± 0.76 (3)	Dec	Feb	45 ± 5.0 (3)	15.67 ± 2.08 (3)	-	-

Note: FM = fresh matter, Figures in parenthesis are number of observation, * Once ruminants eat the leaves and twigs, the left over branches were used as firewood.

Nutrient contents

Crude protein content is the most important criterion for feeding feeds & fodder. Nimaro is important fodder tree as a protein source. Crude protein level measured (13.2%) in this study was similar to other reporters. Edible fodder twigs were moderate in CP content that ranged from 11.95 to 13.35 percent. Crude protein level of 13.2 ± 1.2 was reported by wood *et al* 1994 in ARS Lumle. Shaky (1990)

reported a similar level of CP (12.28 to 13.35). Further, Upreti and Shrestha (2006) reported CP of 11.95 ± 2.39 percent in vigorously matured leaves. This information showed that Nimaro contained moderate level of crude protein. Crude protein in fodder tree ranges for 10.01 to 19.99 percent are considered as moderate and more than 20 percent are high in CP content (Upreti and Shrestha 2006).

Table 2. Seasonal effect on proximate principle of Nimaro

Seasons	Description	Proximate principles					
		DM(%)	CP(%)	EE(%)	CF(%)	TA(%)	NFE(%)
Spring	Mean	33.3	12.9	2.4	12.6	12.8	59.3
	std	5.0	2.6	0.6	0.6	2.6	4.0
Pre-monsoon	Mean	25.2	13.0	1.8	14.6	9.8	60.9
	std	1.5	1.7	0.3	1.2	1.4	1.3
Monsoon	Mean	24.2	13.5	1.7	17.2	9.2	58.5
	std	4.6	1.3	0.2	1.2	2.5	3.7
Winter	Mean	36.3	11.8	1.9	12.9	11.0	62.4
	std	6.5	2.5	0.5	0.7	2.7	5.2

Minerals

A complete chemical status of Nimaro leaves has been illustrated in table 2 where 7 major minerals and 15 trace minerals are presented with their median values.

Ash content in Nimaro was 11.3 percent, which is lower, as quoted by wood et al (1994) of 13.1 percent and higher as quoted by Mahato and Subba (1988) where they recorded 7.9 percent. There may be variations due to the newly sprouted leaves when the leaves were obtained (Feb to March) (Table 1).

Tannin

Nimaro recorded lower level of extractable tannin of 2.89 percent and apparent total 3.85 tannin of 2.6 percent (Table 2), which is safe to feed animals. Fodder tree containing tannin more than 5% is considered low in feed quality (Barry and Manley 1984). Tannin content in tree foliage is fluctuating. It is mainly due to the altitude and climates condition such as rainfall, temperature and sunlight. Under certain weather conditions, tannin levels may rise sharply in some species and reduce the nutritional value of the fodder. These may be potential for selecting times or condition where tannins are less active and thus improve the nutritive value of the feed. There is also may be potential to manipulate tree metabolism by simple means such as watering or shading to improve feed quality (Wood et al 1994).

Lignin

Nimaro recorded moderate level of lignin containing 14.2 percent. Fodder tree containing more than 20 percent ADL is considered as low in quality as more ADL containing fodder are lignified and difficult to digest by the ruminant (Upreti and Shrestha 2006).

Crude lignins are collective aggregation of non-carbohydrate components of the cell wall that are insoluble in 12 M sulphuric acid.

Toxic elements

Nimaro was evaluated for its toxic level in leaves. Major toxic substances were aluminous, arsenic, lead, mercury and nitrate (Table 2). Some of them are disused as follows:

Arsenic: Nimaro recorded median 60 µg arsenic/kg leaves. Goats require this element and in deficiency the growth rate is affected. Animal exhibits rough skin. But if fed in excess, it causes vomiting, diarrhea and sever abdominal pain. In normal feeding of this fodder species to ruminant species, the chance of toxicity is low.

Aluminum: This element appears in milk co-incidentally and is required by the suckling young. But it is critical if fed in excess amount (McDonald, 1995). Nimaro recorded a median value of 195 mg/kg. If co-incidentally excess amount appeared in milk, toxicity may affect the neonate.

Nitrate: Nimaro recorded a median 27.1 mg/kg leaves on DM basis. Nitrate itself may not be toxic to animals, it is converted to nitrite in the rumen under favorable conditions, which is toxic. Green oat contains a large amount of nitrate. Oat hay poisoning is an example of nitrite poisoning (McDonald, et al 1995). Nitrite, as sodium nitrite, should not be more than 60 mg/kg DM (12% moisture content) in animal diets which is equivalent to 14 mg nitrite nitrogen/kg DM (McDonald, 1995).

CONCLUSION

Nimaro is a good source of green foliage yielding 45 ± 5.0 - 73.33 ± 15.28 kg fresh leaves every year during the winter season. It can be used as feed supplements to the crop residue based diet of the ruminant animal as the foliage can be lopped during dry winter season. Season greatly affects feed composition. Crop as such is moderate in status of nutrient level. Nimaro is moderate in tannin and lignin content and therefore the crop is safe to feed ruminant animals.

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Table 3. Nutrient contents polyphenolics and toxic element content in Nimaro leaves

Major Nutrient Contents and Toxic Element Content in Mikko Leaves									
1. Nutrient contents & other parameters			2. Minerals			3. Polyphenolics		4. Toxic Elements	
Parameter	Nutritive value %	2.1 Macro mineral Minerals	Content (median)	2.2 Micro minerals Minerals	Content (median)	Polyphenolics	Content % (median)	Elements	Content (median)
DM	26.61	1. Calcium (mmol/kg)	664	1. Boron (mg/kg)	21.4	3.1 Lignin	14.2	1. Aluminum (mg)	195
CP	11.98	2. Chlorine (mmol/kg)	40.8	2. Chromium (µg/kg)	1201	3.2 Tannin	2.6	2. Arsenic (µg/kg)	60
TA	11.3	3. Magnecium (mmol/kg)	179	3. Cobalt (µg/kg)	223			3. Lead (µg/kg)	560
EE	2.7	4. Phosphorus (mmol/kg)	58.8	4. Cupper (mg/kg)	12			4. Mercury (µg/kg)	66
CF	15.38	5. Potasium (mmol/kg)	390	5. Flourine (mg/kg)	5.7			5. Nitrate (mmol/kg)	27.1
NDF	44.0	6. Sodium (mmol/kg)	4.5	6. Iodine (mg/kg)	610				
ADF	37.98	7. Sulphur (mmol/kg)	38.0	7. Iron (mg/kg)	16				
				8. Manganese (mg/kg)	234				
				9. Molybdenum (µg/kg)	251				
				10. Nickel (µg/kg)	1940				
				11. Selenium (µg/kg)	138				
				12. Stontium (mg/kg)	302				
				13. Sulphate (mmol/kg)	16.8				
				14. Vanadium (µg/kg)	361				
				15. Zinc (mg/kg)	22.5				

Effect of Herbal Liver Stimulant (Livoliv) on the Feed Consumption, Feed Conversion Ratio, Weight Gain and Economics of Commercial Broilers

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ABSTRACT

A study was undertaken to assess the effects of Livoliv on the performance of commercial broilers. One hundred and twenty day-old broiler chicks were allotted into two groups with three replications in each treatment. The control group was fed with the basal diet while the experimental group received the basal diet + Livoliv 250@ 0.25 g/kg of feed. The trial was conducted for 49 days at Swine and Avian Research program, Khumaltar, Nepal. Data on feed intake, body weight, feed conversion and mortality were collected weekly and subjected to statistic analysis. It was shown that 49-day body weight change of broiler was significantly ($P<0.01$) higher in the experimental diet (1461 g) compared to the control diet (1346 g). Feed Conversion Rate was found to be lower in Livoliv added diet (2.57) as compared to control (2.63) but remained statistically non-significant throughout the entire period. Similarly, significantly ($P<0.05$) higher cumulative feed intake (3.642 kg vs 3.426 kg) and dressing percentage ($75.14\pm0.82\%$ vs $72.75\pm0.66\%$) was observed in experimental diet. An additional profit of Rs 5.90 per bird over the control was recorded. It may be concluded from the present study that supplementation of Livoliv @ 0.25 g/kg in broiler feed can improve on body weight, feed consumption, FCR, dressing percentage as well as income of commercial broilers. However, further experiments are needed to elucidate the optimum supplementation concentration of Livoliv to ensure sustainable profitability of broiler production under Nepalese condition.

Key words: Broiler chicks, economic return, feed conversion rate, herbal liver stimulant, mortality.

INTRODUCTION

Poultry keeping is a common feature in Nepalese farming system from ancient times till today. Chicken is one of the most important poultry species, Chicken contributes not only as a nutritional source of food, but also for its economic, cultural and religious significance. The total population of chicken in Nepal is 23.02 million, contributing 15605 mt. chicken meats annually (Bhattarai 2005).

Though Broiler production is growing rapidly with an annual growth rate of 13 percent in the country, most of the farms are found to be small and scattered (Dhaubhadel et al 2007). Bhurtel and Shaha (2000) reported a very low net profit per broiler (Rs. 8.6) under small farm; mainly due to high cost of input, poor FCR and low market price of bird. It is observed that small farm generally depends on feed produced by feed industry; quality of feed in most case is of low standard. Some early studies showed that continuous feeding of antibiotics as growth stimulants to chicken resulted in a decreased growth response (Guo et al 2004). Importantly, some countries have already bans on use of antibiotics in chicken production due to growing concern of antibiotics residues in the meat and eggs and on possibly increasing bacterial resistant and their potential transfer from birds to man via the food chain (Casewell et al 2003, Cunha 2007). Therefore, in addition to problem of low profitability, the next important challenge of small broiler farm is growing tendency of consumers against excessive use of antibiotics. So it is important to search for alternatives that could ensure sustainable productivity and profitability of small broiler farm in the country.

Herbal products have been reported to be effective growth promoters in chicken production (Sarma et al 2001, Guo et al 2004, Islam et al 2005). Work carried out in others countries have shown positive effect of herbal liver stimulant on performance of chicken (Singh and Chauhan 2000, Chatterjee and Agrawala 2002, Singh et al 2002, Mishra et al 2004). Chatterjee and Agrawala (2002) further reported that supplementation of herbal liver stimulant (Livoliv) improve gastro-intestinal microenvironment of the birds and thereby enhance utilization of nutrients and ultimately increased in productivity. However, the effect of herbal liver stimulant (Livoliv) on performance in broilers is not yet fully investigated in Nepal. Therefore, this trial was designed to assess the effects of Livoliv on feed consumption, FCR, weight gain and economics of broilers under Nepalese conditions.

MATERIALS AND METHODS

Experimental birds

One hundred and twenty-day-old Vencob 100 broiler chicks were procured from Avinash Hatchery, Kathmandu. They were allotted into two groups with three replications of each treatment. The chicks were weighed individually and divided randomly in to two groups with three replications of 20 chicks each. The chicks were reared in deep litter system for 7 weeks under standard practice of management. The chicks were vaccinated against Mareks disease on 1st day, Ranikhet diseases on 4th day and for Gumboro disease on 14th day. Prior to housing the chicks the floors were cleaned and disinfected properly. One 100 watt bulb was provided for each replication for lighting and maintaining the tempreture. The temperature in the trial room were maintained at 95 degree F with the help of electric heaters for first week ,then it was reduce by 5 degree per week up to 4 weeks of age of the birds. Thereafter, the temperature in the trial room was maintained at 80 degree till the end of experiment.

Experimental diet

The commercially available broiler starter/finisher diet was used as basal diet. The experimental diet was prepared by addition of Livoliv 250 @ 0.25 g/kg in the basal diet. The chicks were provided broiler starter ration for the 1st four weeks, and than the broiler finisher ration till 7th weeks of age. Fresh and clean water was provided to the birds through out the trial period. Weighed quantity of feed was offered thrice in a day. Daily records of feed offered and weekly records of total feed consumption were maintained through out the study period. Feed wastage was control as much as possible and accurate feed consumption was calculated by subtracting the feed residues in the feeders and wastage from the total feed offered in the week.

Composition of experimental diets

Diet groups	Treatments
D1	Basal diet (Control)
D2	Basal diet +Livoliv 250 @ 0.25 g/kg feed

Experimental procedure

The feeding trial of 49 days was conducted at Swine and Avian Research Program, Khumaltar, Nepal. Weekly body weight, feed intake, and mortality were recorded and feed efficiency and relative growth rate percentage were calculated. Besides of growth parameters, economics in terms of income over chicks and feed cost were calculated including the extra supplemented charge. At the ends of the trial three birds form each groups were randomly selected and kept on fast for one day. After the fast, the birds weighed, and slaughtered by Koshers method and scalded at a temperature of 123 to 128 degree F for 1-2 minutes in hot water. The carcass was than defeathered and the carcass characteristics and organs weights were recorded.

Statistical analysis

All the data collected from the experiment were analyzed using MINITAB statistical package. The cost of chicks, basal diet, livoliv supplemented diet and selling price were considered to be Rs 26 per chicks, Rs 18 per kg, Rs 18.042 per kg and Rs 90 per kg live weight of bird, respectively.

RESULTS AND DISCUSSION

Body weight

The mean weekly body weight of broiler is presented in Table 1. Body weight of broilers was found higher with herbal liver stimulant supplemented group as compared to control. However, significant ($P<0.05$) effect was observed only after 4th week. At 7th week of age, a significantly ($P<0.05$) higher body weight of broiler was recorded in the experimental diet (1460.9 g) compared to the control diet (1345.6 g). This result was in agreements with the findings of Islam et al (2005) who observed significantly higher body weight in herbal supplemented broiler (1613 g) compared to the non-supplemented (1530 g). Mishra et al (2004) also found positive effect of herbal liver (Livoliv) supplementation (600 g/ton) on body weight of broilers up to 8 weeks of age. Similarly, higher body weight gain for probiotic (Lacto Sacc @ 0.025%) supplementation was also noticed by Mahajan et al (2004).

The Figure 1 clearly revealed that relative growth rate (RGR) percentage was highest in the early period and declined progressively in the subsequent periods of rearing. The RGR percent was calculated as 163.4 and 172.3 at 1st week that was slump down to 26.9 and 28.3 percent at 7th week for control diet and supplemented diet, respectively. This indicated that RGR percentage remained in declining trends with subsequent period of rearing. Irrespective of treatment, weekly weight gain found to be in increasing trends up to 6th week of age and then declined with rearing period. This illustrated the fact that in terms of body weight, 6th week of rearing is the appropriate marketing age of broiler for fetching higher profit.

Table 1. Effect of Livoliv on body weight, FCR and saving of broilers

Age	Body weight (g)		FCR		*Saving per bird (Rs)	
	Control	C+ Livoliv	Control	C+ Livoliv	Control	C+ Livoliv
1 day	42.02 $\pm$ 0.43	43.27 $\pm$ 1.18	-	-	-	-
1 week	110.7 $\pm$ 1.12	117.8 $\pm$ 2.74	1.92 $\pm$ 0.07	1.90 $\pm$ 0.05	-18.42 $\pm$ 0.16	-17.95 $\pm$ 0.23
2 week	216.7 $\pm$ 1.61	232.2 $\pm$ 5.54	2.30 $\pm$ 0.04	2.26 $\pm$ 0.05	-13.74 $\pm$ 0.17	-12.79 $\pm$ 0.54
3 week	330.1 $\pm$ 7.15	365.9 $\pm$ 10.5	2.67 $\pm$ 0.03	2.60 $\pm$ 0.07	-10.12 $\pm$ 0.49	-8.20 $\pm$ 0.93
4 week	504.0 $\pm$ 19.8 ^b	564.6 $\pm$ 13.8 ^a	2.58 $\pm$ 0.07	2.55 $\pm$ 0.04	-2.05 $\pm$ 1.38	0.87 $\pm$ 0.98
5 week	715.6 $\pm$ 23.6 ^b	783.8 $\pm$ 30.8 ^a	2.57 $\pm$ 0.03	2.54 $\pm$ 0.06	7.26 $\pm$ 1.19	10.63 $\pm$ 2.23
6 week	1061.0 $\pm$ 29 ^b	1138.0 $\pm$ 27 ^a	2.46 $\pm$ 0.02	2.42 $\pm$ 0.03	24.35 $\pm$ 1.28 ^b	28.68 $\pm$ 0.96 ^a
7 week	1345.6 $\pm$ 25 ^b	1460.9 $\pm$ 35 ^a	2.63 $\pm$ 0.04	2.57 $\pm$ 0.04	33.43 $\pm$ 2.27 ^b	39.77 $\pm$ 2.02 ^a

Means bearing different superscript in a row of same parameter differ significantly ($P<0.05$), *Calculated as income over chick and feed cost per bird

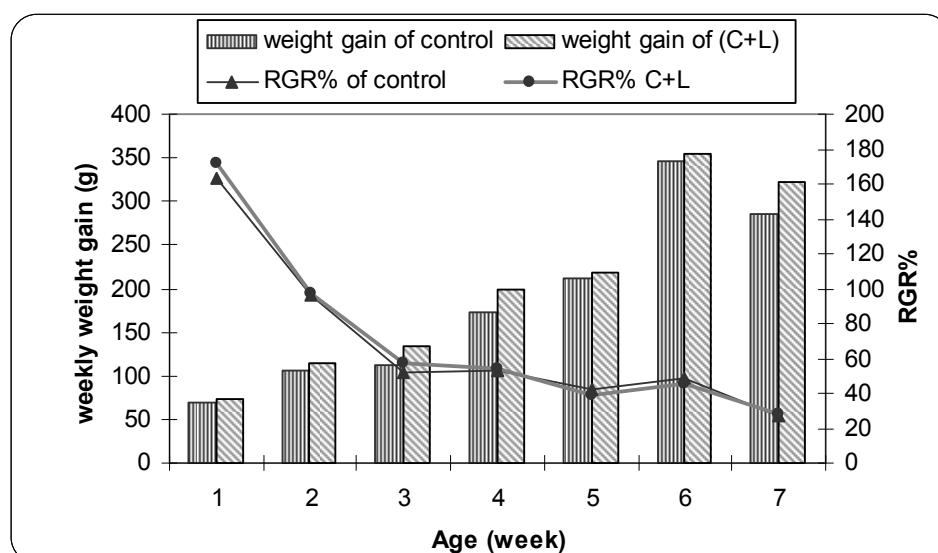


Fig. 1. Weekly body weight gain and relative growth rate percentage of broilers

A significant ($P<0.05$) effect of Livoliv on daily feed intake was observed only for the period of 3rd and 4th week, though mean daily feed intake was found numerically higher in supplemented group than that of the control in all age. In overall, daily feed intake was found to be increased with subsequent period of rearing. Similarly, supplementation of Livoliv had significant ($P<0.05$) effect on cumulative feed consumption in broilers from 3rd to 7th week of age with showing higher consumption for supplemented group compared to the control ones. Significantly higher feed consumption ($P<0.05$) for probiotic (Lacto-Sacc) fed broiler as compared to control ones was also observed by Mahajan et al (1999). However in other experiment, no significant difference on feed consumption between Chinese herbal medicine supplemented birds and non-supplemented birds was reported (Guo et al 2004).

Feed conversion ratio

The data as shown in Table 1 indicated that the effect of herbal liver stimulant was positive to improve FCR but remained non-significant throughout the study period. But significantly lower cumulative feed conversion ratio (1.91) with supplementation of Livoliv 500 g/ton in basal feed compared to the control (2.09), was reported by Singh et al (2002). Similarly, Mishra et al (2004) suggested mixing of 600 g/ton of Livoliv as a growth promoter in broiler feed to improve feed conversion efficiency. Chatterjee and Agrawala (2002) reported that Livoliv have capacity of improving nutrients utilization by improving synthesis of digestive enzymes and improving FCR through optimum digestion, absorption and mobilization. The average FCR found in this study is slightly poor (2.57) than the observation (2.3-2.5) of Bhurtel and Shaha (2000) under Nepalese condition. As no extra feed supplements and vitamins were given in this study beside of using most commonly used commercial broiler feed as basal feed; the overall poor FCR in this study might be due to the low quality of the basal feed used in this experiment. This reflected b the supplementation of Livoliv had positive effect on improving FCR in Broiler, however significant contribution could be visualized with using higher concentration of Livoliv than the dose used in this experiment.

Mortality

In the present study, overall cumulative mortality of 1.66 percent was recorded in supplemented group as compared to 3.33 percent in the control group. This was in agreement with the finding of Singh et al. (2002) who observed mortality of 3.75 percent with Livoliv-supplemented (500 g/ton) group than that of 6.67 percent in the control group. Lower mortality in broiler fed with Livoliv supplementation (600 g/ton) was also reported by Mishra et al (2004). Similarly, Chatterjee and Agrawala (2002) reported lower mortality (0.83%) in Livoliv-supplemented broiler than that of controls (3.25%). Various studies have also shown that Livoliv counteracts the damaging effects of mycotoxin on the liver and also improved immune status of the chicks, which might be the reason behind of lower mortality. The overall mortality recorded in this experiment was lower than reports of Bhurtel and Shaha (2000) who mentioned mean mortality of 9.6 and 10.8 percent for medium and large broiler farm in Nepal. Thus, the use of Livoliv as a feed supplement appeared to be helpful in reducing the mortality losses in broilers so as to enhance profitability of Nepalese Broilers farm.

Dressing percentage

Effect of Livoliv on dressing percentage of broiler was found significantly higher ($P<0.05$) with supplemented group ($75.14\pm0.82\%$) as compared to the control ($72.75\pm0.66\%$). Similar finding was reported by Singh et al (2002). Increased in average dress weight (+5.1%) and edible weight (+7.84%) along with significantly ($P<0.05$) better appearance, flavors, juiciness, tenderness and acceptability of meat for the livoliv supplemented broilers as compared to control was reported by Chatterjee and Agrawala (2002). Mahajan et al. (1999) also found significantly higher ($P<0.05$) percent yield of meat cut-up parts viz. leg, breast and a significantly lower ($P<0.05$) yield of wings, neck and cutting loss in the probiotics (Lacto Sacc) fed birds than that of control.

Economics of herbal liver stimulant (Livoliv) supplementation

The economics of broilers rearing in terms of income over chicks and feed cost is given in table 1. Significantly higher saving ($P < 0.05$) per broiler was observed for supplemented group at 6th and 7th week of age. In this study, an additional profit of Rs 5.90 per broiler was obtained for Livoliv supplemented group. This finding was in agreement with the report of Islam et al (2005). Similarly, net extra income of Rs 9.41 per dressed broiler with Livoliv supplementation was also reported by Singh et al. (2002). As medium broiler farm in Nepal are facing with challenge of low profitability, supplementation of Livoliv could be alternative option to ensure extra profit to be competitive in business along with minimizing excessive use of antibiotics to some extent.

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Scavenging Poultry Production for Uplifting Economic Status of Rural Women in Dumarwana of Bara

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ABSTRACT

This study was conducted in outreach site in collaboration with DLGSP Bara. Dumarwana VDC of Bara district was selected for the study. Twenty poor female farmers were selected and 20 chicks for each farmer, where 10 New Hampshire and 10 Giriraja bird were distributed. The main aim of the study was to uplift rural women through micro economic activities as scavenging poultry farming. Farmers were divided into 2 groups. Group 1 consisted landless laborers and Group 2 consisted small farmers (land holding 5 kattha). Data were recorded on egg production, mortality, average body weight and cost of production. Economic analysis was done. Average weight (kg) of Giriraja and New Hampshire chicken were 4 of male and 2.75 of female and 2.5 of male and 1.5 kg of female of in one year. Egg production was more in small farmers compare to landless laborers (140 vs 90 eggs). Calculated profit was Rs. 6400 and Rs. 4000 for Giriraja and New Hampshire, respectively. After the completion of this project the women came to know about marketing of local agricultural product.

Key words: Average weight, average eggs production, economic, scavenging, women,

INTRODUCTION

The present per capita average meat consumption in Nepal is very low (9.0 kg) whereas in Asia it is 25 kg (Upreti 2008). The basic requirement of meat is 14.4 kg per person per year. The situation seems even worse if per capita availability of poultry meat in Nepal is considered which is very low (0.6 kg/person/year) compared to world average (10.5 kg/person/year). There are many constraints that affect on the development of smallholder poultry production. Lower production is related to disease, feeds and feeding, breeds and breeding, marketing, trainings and management, access to production inputs, infrastructure and capital, farmer organization and government policies (Permin et al 2000.)

The Giriraja and New Hampshire chicken can be possible income generation for village farmers in central Terai. The use of these types of chicken can elevate poverty. Farmers have been raising native chicken on scavenging system since long back. Their production performance is low. Giriraja chicken is dual purpose breed (PAC 1997). This breed is popular for crossing native chicken. This breed is heat tolerance, disease resistance, laid more egg, and higher growth rate. The breed is potential to use in backyard farming under low feeding system.

A world poultry study (Gueye 2001) indicated the importance of family-level poultry rearing for food security, poverty alleviation, environment health and genetic diversity. The objectives of this project is uplifting rural women by income generation, gender equity and nutritional fulfillment.

MATERIALS AND METHODS

There were 20 female farmers in the study. Group A consisted 10 female small farmers, and Group B of 10 landless laborers from Tharu community. Training was provided to the participatory farmers and laborers about poultry farming, shed preparation, feed formulation, disease management and marketing

of poultry birds. Twenty chicks, 10 New Hampshire and 10 Giriraja chicks were distributed to each farmer. Data were recorded on average body weight of chicken, egg production, meat production. Cost benefits analysis was performed to estimate economic return from the poultry farming.

RESULTS AND DISCUSSION

Average family size, size of land holding, educational status of the farmer is shown in table 1. Looking at the family size, landless laborers recorded higher family number compared to the small farmer group. Small holders hold of average of 5 kattha land. Small farmers were more educated (45%) compared to the landless laborers (30%) (Table 1). Small farmer were engaged in agriculture sector and land less laborers in factories.

Table1. Land holding and family characteristics

Characteristics	Small Farmer	Landless Laborer
Family Size (No.)	6	7
Land Holding Size (Kaththa)	5	0.0
Education (%)	45	30
Occupation	Agricultural Labor	Agricultural labor and factory worker

Comparative production performance of New Hampshire and Giriraja chicken is shown in table 2. The average body weight gain in male and female was higher in Giriraja chicken of 4 and 2.5 kg, respectively compared to the New Hampshire. Average bodyweight gain for New Hampshire male and female recorded 2.5 and 1.5 kg, respectively which was lower in both farmers group (Table 2). Total Egg production in small farmer group was 1400 whereas in landless group it was only 810 eggs. Total meat production was 37.5 kg in small farmer and 29 kg in land less labor (Table 2).

Table 2. Comparative production performance of Giriraja and New Hampshire chickens in farmer field

Particulars	Small farmers	Landless labor
Eggs Number	1400 @140/hen	810@90/hen
Chicken meat (kg) of 10 chicks	37.5	29.0
Average body weight (kg)		
Giriraja		
Male	4.0	3.0
Female	2.5	2.0
Newhampshire		
Male	2.5	2.0
Female	1.5	1.0

Total cost of production is presented in table 3. Total expenditure included shed construction, feed cost, and medicine and miscellaneous. The cost incurred was Rs 8000.0 in small farmer and 5500.0 in land less labor group. Investment ratio was high in small farmer compare to land less laborers.

Table 3. Cost of production

Particulars	Small Farmer (Rs)	Land less labor (Rs)
Shed making	1500.0	1500.0
Feed cost	5000.0	3000.0
Medicine and Miscellaneous	1500.0	1000.0
Total (Rs)	8000.0	5500.0

Total income from chicken is presented in table 4. The total income, including sell of eggs and sell of chicken was Rs.14,400 and Rs. 9,500 in small farmers and land less laborers, respectively.

Cost benefit analysis of chicken products in two groups of farmers is shown in Table 5 and figure 1. Small farmers group were able to earn more money (Rs 6400) compared to the land less laborers (Rs 4000).

Table 4. Income from the chicken products

Particulars	Small farmer (Rs)	Land less labor (Rs)
Sell of Eggs	8400	4860
Sell of Chicken	6000	4640
Total (Rs)	14400	9500

Eggs @ 6 / piece, meat @160/kg live weight

Table 5. Cost benefit analysis

Particulars	Small farmer (Rs)	Land less labor (Rs)
Expenditure(A)	8000.0	5500.0
Income(B)	14400.0	9500.0
Profit(A-B)	6400.0	4000.0

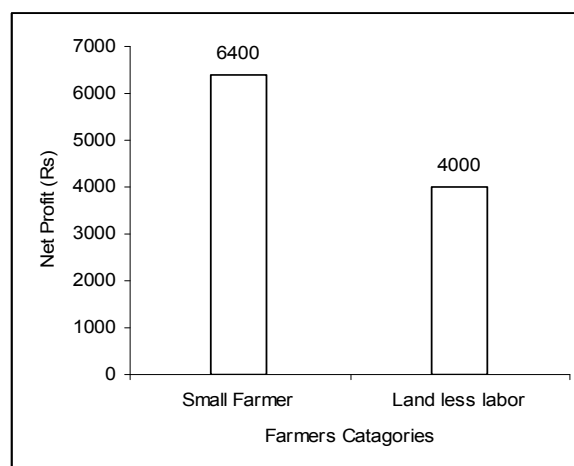


Figure 1. Profit of small farmers and landless labor from poultry raising

CONCLUSION

Poultry farming provide employment and fulfill the protein requirement of the growing population through eggs and poultry meat production. It requires low investment and return starts early. In backyard poultry farming system, birds are reared in small land holding and capital, can be managed by even the poorest social communities in rural areas. This study has indicated that the poultry rising can contribute to generate the empowerment of women by improving their financial status. Poor female farmer became aware to increase economic conditions of their households by keeping poultry. This study encourage to other women for income generation adopting the rural poultry farming. Institutions evolved in rural poultry research and development needs to consider giving emphasis on the poor, pro-poor and women.

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Study on Importance of Mozzarella Cheese and It's Use in Different Food Items

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ABSTRACT

Mozzarella is a mild, white fresh cheese. This is because it never aged.. It has semi soft, elastic texture and not as delicately flavored as its fresher counterpart. Today its main use is in the fast food industries because of its unique functional properties like meltability, stretchability and shreddability. Its production in Nepal has been boosted due to the emergence of successful business enterprise, the pizza parlor, restaurant and hotels. Especially mozzarella cheese is used in pizza, pasta, vegetable, macaroni, different types of soup, crostini (roasted bread), and green salad but in our study area mozzarella cheese was mostly used in pizza. Mozzarella cheese preparation is easy in hot summer season, which is an additional benefit to the farmers, because the protection of milk in summer is very difficult which can be solved by mozzarella cheese preparation. Furthermore, mozzarella cheese can also be prepared from the acidic milk which can't be used for fluid milk, curd etc. The study was conducted on different parameters like buffalo and cow milk, different levels of fat and amount of the coagulating agent to meet the objective of the project. Study reveled that buffalo milk is best for mozzarella cheese preparation although there is no significant difference between cow milk mozzarella and buffalo milk mozzarella. With increasing level of fat in the milk (both cattle and buffalo milk), the sensory attributes like flavor, texture, appearance and stretchbility of cheese were also found to be better Study also reveled that 0.75gm of rennet is the appropriate dose in 100 liters of milk for the coagulation process, which is one of the expensive chemical.

Key words: Acidic milk rennet, fast food industries, hot summer season, mozzarella cheese

INTRODUCTION

Livestock sector contributes about a third to agriculture GDP. Dairy sector contributes about two third in livestock sub-sector. Dairy development activities were started since 1952 with an experimental production of cheese. It leads to the establishment of a yak cheese factory in Langtang of Rasuwa district under FAO assistance in 1953. Although diversification was started earlier but the acceleration of this sector seems to be very slow. At present the demand of diversified milk products are increasing day by day.. Mozzarella is a mild, white fresh cheese. This is because it never aged. It has semi soft, elastic texture and not as delicately flavored as its fresher counterpart. Today its main use is in the fast food industries because of its unique functional properties like meltability, stretchability and shreddability. Its production in Nepal has been boosted due to the emergence of successful business enterprise, the pizza parlor, restaurant and hotels. Especially mozzarella cheese is used in pizza, pasta, vegetable, macaroni, different types of soup, crostini (roasted bread), and green salad. Mozzarella cheese preparation is easy in hot summer season, which is an additional benefit to the farmers, because the protection of milk in summer is very difficult which can be solved by mozzarella cheese preparation. Furthermore, mozzarella cheese can also be prepared from the acidic milk which can't be used for fluid milk, curd etc. In this context this study was undertaken with the following objectives:

- To understand the status and demand for Mozzarella cheese in the country to help rural farmers for increased income with product diversification.
- Establishment of mozzarella cheese production technology in peri-urban and rural areas

METHODOLOGY

In this study, structured questionnaires were prepared. Survey was conducted on different dairies, hotels and restaurants at Kathmandu, Lalitpur and Kavre districts. The main focus was on demand, supply and quality of mozzarella cheese on the survey areas. At the same time mozzarella cheese was prepared from cow and buffalo milk with three level of fat (3,4 and 5%) by adopting the standard procedure with direct renneting method (coagulating agents at 1.0, 0.75 and 0.5 g/100 lit milk) at Khumaltar laboratory. The yield and sensory attributes (appearance, stretch ability, flavor and texture) were taken. Lastly farmers' training on mozzarella cheese preparation for rural farmers was organized.

Method of mozzarella cheese preparation

Following steps was adopted while preparing mozzarella cheese

1. Standardize the milk.
2. Pasteurise milk.
3. Heat the milk at 40°C
4. Add starter culture (*Streptococcus thermophilus* plus *Lactobacillus bulgaricus* 1:1 @ 2%)
5. Ripening for 80 to 90 min
6. Renneting for 40 min
7. Cutting
8. Cooking (41°C for 40 min)
9. Drain the whey (1/3)
10. Hold curd whey for acid development
11. Drain full whey
12. Curd acidification (stretch test +ve, whey acidity 0.75% LA)
13. Curd kneading, stretching and moulding (hot water 80-83°C, 2-3 min)
14. Cheese balls/blocks (dipped in chilled water, 5-8°C for an hour)
15. Drain free water (5-8°C)
16. Brine salting of cheese (salt conc. 20%, 8-10°C for 4 hours)
17. Draining and packaging

RESULTS AND DISCUSSION

Marketing status of mozzarella cheese

Mozzarella cheese is used as a topping on pizza pie owing to its inherent stretching quality. Its production in Nepal has been boosted due to the emergence of successful business enterprise, the pizza parlor, restaurant and hotels.

The finished cheese lightly salted is white soft with a very lively surface and has a unique property called stretchability, ability to form fibres or strings when hot. But in our survey, only a few dairy industries meet this type of quality. According to the restaurant respondents, the overall quality of pizza solely depends upon the quality of mozzarella cheese. Especially mozzarella cheese is used in pizza, pasta, vegetable, macaroni, different types of soup, crostini (roasted bread), and green salad but in our survey area mozzarella cheese was mostly used in pizza and only a few restaurant used mozzarella cheese in pasta, soup and spring roll. In Kavre district, some of the restaurant used to prepare pizza by importing mozzarella cheese from Italy in the past, but these days they are not importing mozzarella cheese rather they are preparing pizza by using Kanchan and Yak cheese. However, they realized that pizza prepared from mozzarella cheese is of high quality and the problem is that mozzarella cheese is not easily available.

At present, there are 11 dairies (7 in Kathmandu, 3 in Lalitpur and 1 in Kavre) producing Mozzarella cheese. Mozzarella cheese is demanded all round the year but highest is during winter season. The survey revealed that about 500kg/day mozzarella cheese is being sold in Kathmandu valley.

The survey of restaurants in the valley and Kavre also revealed that the highest proportion of mozzarella cheese is used in Pizza (Table 1) followed by in spring role making. Some proportions are also used for Pasta and Soup preparation. In survey area 78.4% of mozzarella cheese is used in pizza preparation and only 21.6 percent used on other food items.

Table 1. Percentage of Mozzarella cheese used in making different food items in the restaurants in survey area

Locations	Pizza	Pasta	Soup	Spring roll
Kathmandu	65	10	5	20
Lalitpur	95	0	1	4
Kabre	75	5	5	15

Recently, Kanchan cheese and Yak cheese were also being found to be used in Pizza making. A significant number of restaurants in Lalitpur (70%) and Kavre (75%) were using Kanchan cheese for Pizza preparation, while few restaurants (10%) in Kavre were also found to be using Yak cheese (Table 2).

Table 2. Restaurants (%) using different types of cheese in pizza preparation

Locations	Mozzarella cheese	Kanchhan cheese	Yak cheese
Kathmandu	60	40	0
Lalitpur	30	70	0
Kabre	15	75	10

Effect of milk fat level on sensory and yield attributes of mozzarellas cheese

The effect of fat level in milk on sensory attributes of mozzarella cheese is given in Table 3 and 4. With increasing level of fat in the milk (both cattle and buffalo milk), the sensory attributes like flavor, texture, appearance and stretchability of cheese were also found to be better. The sensory attributes of cheese made from cow and buffalo milks were more or less similar.

Table 3. Effect on level of fat percentage on sensory quality scores of mozzarella cheese made from cow milk (10 scales)

Fat percentage	Flavor	Texture	Appearance	Stretchability
3	5.0	3.5	3.8	3.5
4	6.3	4.9	5.6	5.8
5	6.8	5.0	5.6	5.7

Table 4. Effect on level of fat percentage on sensory quality scores of mozzarella cheese made from buffalo milk

Fat percentage	Flavor	Texture	Appearance	Stretchability
3	5.6	3.4	3.9	3.8
4	6.4	4.7	5.8	5.9
5	7.0	4.9	5.9	5.9

The yield and chemical constituents of mozzarella cheese made from cattle and buffalo milk is presented as Figure 1. The yield was slightly greater with buffalo milk (14.2%) compared to cow milk (12%), whereas moisture content was less in cheese made from buffalo milk (45.8%). Similarly protein and ash percentage found increased in buffalo milk as compared to cow milk mozzarella cheese.

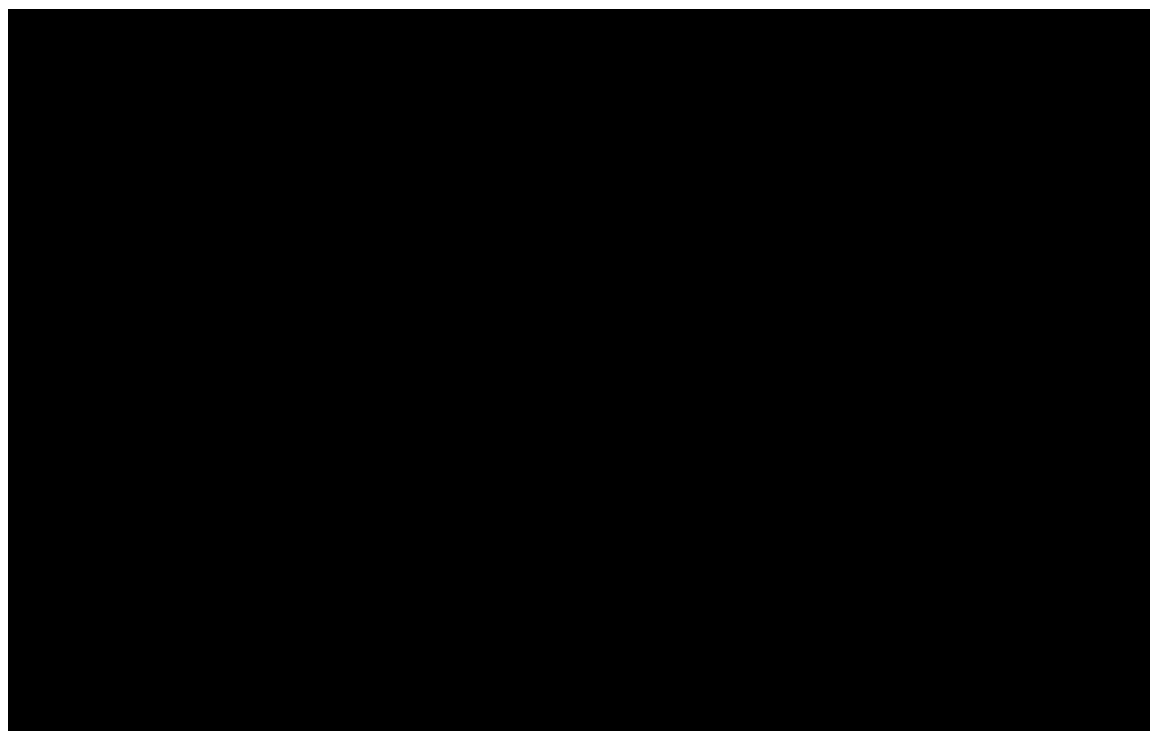


Figure 1. Diagrammatic representation of Differences in Mozzarella cheese made from cow and buffalo milk

Effect of quantity of coagulant on sensory and yield attributes of Mozzarella cheese

Rennet converts the colloidal casein micelle system into semi-solid and amorphous precipitates. Reducing the amount of enzyme (rennet) will take the longer time for coagulation to achieve the same degree of firmness. On the other hand the excessive amount of rennet addition caused bitterness in cheese. The level of rennet used on sensory attributes of cheese is given in Table 5. Higher the level rennet, the better was the flavor and appearance of the cheese.

Table 5. Effect of level of coagulating enzymes on the scores of mozzarella cheese

Levels of gram per 100 liters of milk	Flavor	Texture	Appearance	Yield	Time taken in hours
1.00	5.6	3.5	3.8	14.2	6
0.75	5.6	3.7	3.9	14.3	7
0.5	5.0	3.6	3.7	14.0	15

The organoleptic properties of cheese made from cow and buffalo milk was not found to be significantly different. However the body and texture was slightly superior incase of cow milk cheese than buffalo milk cheese whereas the reverse in case of flavor. The cow milk cheese was slightly softer as compared to buffalo milk. Cow milk cheese is typically dark yellow in color. Higher moisture and fat content were recorded in cow milk cheese where as protein and ash content were higher in buffalo milk cheese. It was also observed that cow and buffalo milk had significant difference on melting and fat leakage relatively more in cheese made from cow milk than that made from buffalo milk, which was noticed during pizza preparation. The pizza prepared with the same quantity of mozzarella cheese from the cow and buffalo were baked at about 230-240°C for about 15 minutes. The cow milk mozzarella cheese melted at a faster rate than buffalo milk cheese. Its fat linkage was considerably higher. In contrast the linkage in buffalo milk mozzarella cheese appeared to be just right.

CONCLUSION

It is concluded that the demand of mozzarella cheese is high. So farmers can increase their income, which has comparatively longer self-life than fluid milk. It is also concluded that 0.75 g of coagulating agent (rennet) is the best dose for the preparation of mozzarella cheese and buffalo milk is superior to cow milk for mozzarella cheese preparation. With increasing level of fat in the milk (both cattle and buffalo milk), the sensory attributes like flavor, texture, appearance and stretchability of cheese were also found to be better.

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Restoration of Small Lakes through Cooperative Management: A Suitable Strategy for Poverty-Laden Areas in Developing Countries

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ABSTRACT

Lake Rupa is a small, subtropical, shallow lake with a surface area of 100 ha situated 600 masl in Central Himalaya, Nepal. This degraded lake was studied between 2000 and 2006, with the goal of determining whether or not it could be restored by a community-based cooperative of local people living in its catchment. Main threats to the lake, its aquatic life and its very existence include encroachment by excessive aquatic vegetation, sedimentation, and low in-lake concentrations of dissolved oxygen (DO). Small lakes (≤ 500 ha) are relatively prone to the process of 'succession and climax', although they also can be of social, environmental and ecological importance. Thus, their disappearance could spark social chaos and disorder in areas already having to cope with other rapid environmental changes. This means that credible mechanisms for revitalizing or protecting small lakes are an important goal. Accordingly, a lake cooperative of 329 households living in close vicinity to Lake Rupa was formed in 2002, by prioritizing traditional fishers, women and other deprived community members with the goals of respecting the citizenry and equity. Following the cooperative's campaigns directed at weed removal and fish stocking, encroachment of vegetation on the lake margins was halted, its aquatic weeds became under control, and its fisheries improved. In addition to the cooperative's restoration activities, several water quality parameters, including water transparency and DO and chlorophyll-*a* concentrations, were monitored on a monthly basis. The measured water transparency was inconsistent, exhibiting large variations between 2000 and 2003. Relatively low, but consistent, values, however, were measured after 2004. The results imply that the removal of weeds, and sufficient nutrients and solar radiation are subsequently available to the lake's phytoplankton communities. Supporting this notion is that the chlorophyll-*a* concentration spiked to $205 \mu\text{g L}^{-1}$ in November 2006, the water transparency became consistent, and the DO concentration increased to $>3.8 \text{ mg L}^{-1}$ during the critical months (March–May) after 2004. These water quality indicators indicated improvement in the degraded Lake Rupa, suggesting that the establishment of cooperatives such as that highlighted in this study could be a powerful and sustainable mechanism for restoring degraded lakes in similar socioeconomic settings by maintaining equity, by connecting communities with their resources, and by facilitating integrity, equity, citizenry and social justice.

Key words: chlorophyll-*a*, cooperative, dissolve oxygen, equity, small lake, win win

INTRODUCTION

Human social dynamics, and their involvement in understanding environmental degradation and restoration, are central to studies of sustainability (Janssen and Carpenter 1999, Cairn 2003, Leigh 2005). Restoration is defined as the act of bringing back to a former state or position (Bradshaw 1996). The restoration of any degraded landscape, especially lakes, can be an expensive, time-consuming and labour-intensive process. Thus, several modalities of lake restoration have been applied in the past, focusing primarily on habitat, water quality, improvement of biodiversity and other related aspects (Richter 1986, Shapiro 1990, Perrow et al 1997).

Small lakes (≤ 500 ha) are commonly perceived to disappear over time as a result of 'succession and climax' (Niering 1987). Smaller lakes in Asia, however, are used intensively for multiple purposes (Gopal 2005), suggesting that they represent a multitude of social and ecological benefits (Bhandari 1998). Thus, the disappearance of such lakes could create social chaos and financial deprivation for the inhabitants of communities that depend on them (Gurung and Bista 2003, Gurung et al 2005). This factor could be critically important to communities with low literacy and economic activities as many deprived poor communities subsist on natural lakes for food, fishing and boating (IUCN 2004, Bhandari 2006). In contrast, affluent people mostly use such water systems for irrigation and other corporate needs (Costa-Pierce 1998), providing the potential for conflicts where the water resource is limited.

Nepal is a small mountainous country well known for its biodiversity, culture, ethnicity and community-based forestry activities (Gautam and Shivakoti 2002, Bhandari 2006). Community-based natural resource management, however, can cause social conflicts (Leal 1996), notably where social discrimination exists in a heterogeneous society, with people belonging to different ethnic castes (Chakraborty 1998), and with an economy of inequitable sharing (Upreti and Upreti 2002).

Any community desiring social justice might be able to reduce social tension emerging from a skewed distribution of wealth generated from common resources, even if less income is generated (McConney 1998). This implies that extensive fisheries could be encouraged for small lakes, as this activity is compatible with the traditional practice of sharing the wealth and resources of nature among many individuals. Consistent with this perspective, fisheries in Lake Rupa had a flourishing, plankton food-based cage fish culture, which begun ca 1975 (Pillai and Swallows 1980), as well as an open-water fishery. The fish production peaked at nearly 50 mt per annum in 1990, involving >150 families in the surrounding communities. Gradual deposition of silt in the lake, resulting from land slides, floods, and nutrient run-off, has caused a low water level in the lake, eutrophication and heavy infestation with aquatic plants (IUCN 1996, Rai 2000a,b). A seasonally based decomposition of aquatic plants, and resulting oxygen depletion caused the collapse of the cage fishery, and destroyed the livelihoods of fishers dependent on this industry.

The possibility of lake restoration in such instances often is viewed from a biophysical perspective. More crucial and central to a balance aimed at sustainability, however, are social values, which are often neglected in such activities (Klessig 2001, Klessig et al 2004). Prior to this study, a number of obstacles to this goal existed, including inadequate finances, as well as lack of mutual trust and respect among villagers. Thus, the present study examines an approach to restoration of a degraded lake that involves the cooperation of local households. The cooperative (International Cooperative Alliance, ICA) is an autonomous association of villagers who united voluntarily to meet their common economic, social and cultural aspirations through a democratically controlled enterprise (Kimberly and Robert 2004).

To implement this cooperative approach, a central theme of the lake restoration effort, it was assumed that establishment of a win-win situation was essential in attempting to manage a common resource in a heterogeneous society without causing social conflict, and in which the outcome can benefit all the stakeholders. This approach was possible because of the ability to develop criteria that judiciously prioritize citizenry, traditional knowledge, occupations, skills and the economic status of the cooperative members. This understanding and perseverance was the real strength behind this approach for sustainable management of this common resource in a society comprised of differing ethnicity and financial status. It also is pointed out here that the concept of sustainable development has been defined as a process that stimulates a sustainable co-evolution of human activities and environmental changes (Janssen and Carpenter 1999).

A recent seminal work by Leigh (2005) described community-based restoration as the best instrument for curing ecological crisis. This approach also should be helpful in the peaceful and rapid co-evolution of human activities and environmental changes in societies characterized by weak economic support

systems. Moreover, it delineates a bottom-up social mechanism for restoration of natural resources management for sustainable development. As there are limited studies on the restoration of small lakes through the participation of local community-based cooperatives, this report attempts to describe how equity and social justice-based cooperation in a heterogeneous society can play a major role in restoration of small lake ecosystems in a sustainable manner. The main objective of the present study therefore was to examine whether or not a degraded lake could be restored by stimulating and involving local communities.

MATERIALS AND METHODS

The Lake Rupa watershed is located between 28°08'N to 28°10'N and 84°06'E to 84°07'E, at 600 m a.s.l. in Central Nepal. The lake has an estimated surface area of ~100 ha (Fig. 1). The lake's total catchments area is ~30 km². The lake is narrow and elongated in shape, extending in a north-to-south direction, being surrounded by hills on the north, east and west sides. Rice fields are located in the watershed between the hills and lake in the north, with the lake's inlet stream originating from hilly terrain. The outlet drains into rice fields at the southern end of the lake. The main threat to the lake is its dangerously low water level, and its heavy aquatic vegetation, suggesting a transitional stage from a lake to formation of a swamp (Table 1).

There are 15000 individuals, representing different ethnic communities, in the human settlements in the catchment area of the lake. These communities can be categorized broadly as: (i) those dependent entirely on fishing for their livelihood, as per their tradition (*pode*); (ii) those financially weaker, and generally involved in fishing for their livelihoods (*damai*, *kami*, *sarki*, *gurung*, *magar*; and (iii) those generally with a sound financial status, although the daily income of some might not exceed \$US2 (*brahmin*, *chhetri*, *newar*).

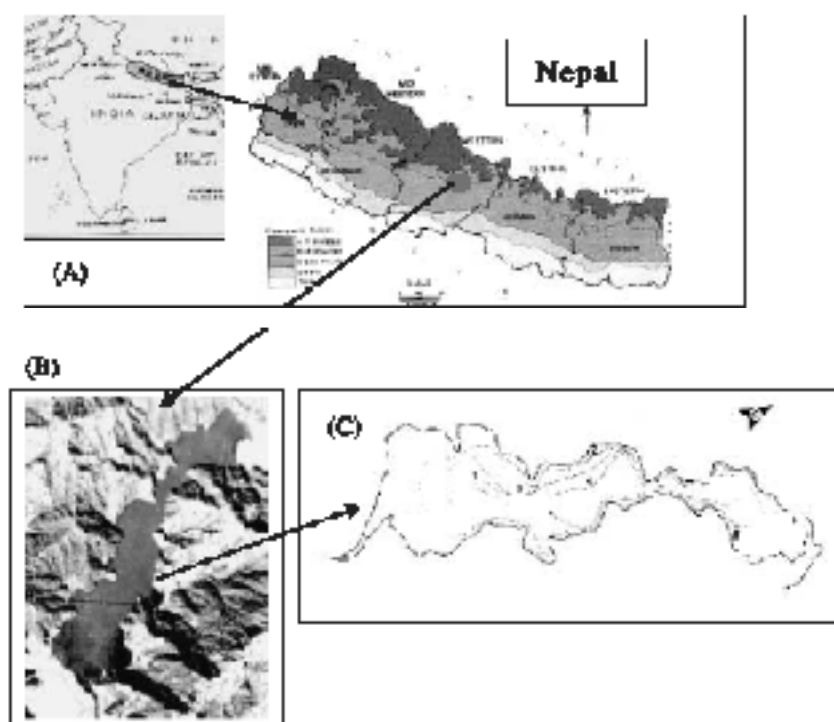


Figure 1. (a) Location of Nepal; (b) aerial photograph of Lake Rupa taken ca 1978; and (c) bathymetric map of Lake Rupa, taken from Rai et al. (1995).

To resolve the impasse of establishing a cooperative, a number of draft regulations were discussed, with active participation of people living both upstream and downstream of the lake. Several workshops and public meetings, involving fishers, village chiefs and government officials, were convened. The result of these activities was establishment of a cooperative that incorporated 329 local households located within the vicinity of the lake. The establishment of the cooperative is in the line with National Wetland Policy 2059 of the Government of Nepal (Ministry of Forest and Soil Conservation, 2003). Its major goal was lake conservation through the enhancement of lake fisheries management, to facilitate continuing benefits to society and the environment. The immediate objectives of the cooperative were: (i) to prevent human encroachment in the dry and shallow parts of the lake; (ii) to increase the financial income derived from the lake through the management of re-capture fisheries; and (iii) to implement lake restoration measures from funds generated by fish production activities. For initial establishment of the cooperative, each cooperative member invested ~5000 NRs (~\$US 71), for lake restoration, purchase of fish nets, and other activities. Poor fishers and other members who could not afford the investment cost contributed through engaging in activities such as weed removal, mending of nets, and transportation of fish seed for the cooperative.

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Table 1. Changes in some Lake Rupa parameters over the past four decades

Parameter	Characteristics		
	Ferr and Swain (1978)	Rai et al (1995)	Present study
Surface area (ha)	117	135	~100
Maximum depth (m)	6.5 m	6 m	4.7 m
Mean depth (m)	2.3	3	2.7
Vegetation coverage (%)	Nearly 5%	Nearly 65%	Nearly 30%
Volume ($\times 10^3$ m ³)	-	32.1	-
Length (m)	-	2820	2720
Breadth (m)	-	400	-
Surface water temperature (°C)	-	14-30	14.5-25
pH	-	5.6-7.8	6.9-8.5
Number of fisher families	5	6	8
Dissolved oxygen (mg L ⁻¹)	-	5.0-8.5	1.6-11.3
Fish catch (kg year ⁻¹)	3.0	-	18.5

For initial establishment of the cooperative, each cooperative member invested NRs. 5000 (USD 71), for lake restoration, purchase of fish nets, and other activities. Poor fishers and other members who could not afford the investment cost contributed through engaging in activities such as weed removal, mending of nets, and transportation of fish seed for the cooperative.

A mesh net of about 530 m long and 7 m wide was placed across the outlet of the lake to control its stocked fish. Fish seeds of 0.5-2.0 g (average individual body weight), which were available from the nearby Fisheries Research Station, were stocked beginning in 2002 (Table 2). Grass carp (*Ctenopharyngodon idella*) were expected to control submerged vegetation by their grazing activities, while common carp (*Cyprinus carpio*) uprooted submerged plants via their browsing food-searching habits. Silver (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*) were stocked to control plankton blooms. The cooperative employed 10 fisher and financially deprived members as the permanent staff since 2002 for fishing, marketing, data collection and financial book-keeping activities. Fish yield data collected during 2001 are presented for comparison.

Table 2. Stocking of fry (1–2 g individual body weight) in Lake Rupa after cooperative formation

Species	Year				
	2002/03	2003/04	2004/05	2005/06	2006/07
Exotic fish					
<i>Aristichthys nobilis</i>	71,000	20,000	57,000	3,000	31,940
<i>Hypophthalmichthys molitrix</i>	27,000	113,100	25,130	141,000	34,200
<i>Ctenopharyngodon idella</i>	205,200	37,200	22,300	22,000	65,000
<i>Cyprinus carpio</i>	196,500	177,290	164,000	3700	-
Indigenous					
<i>Labeo rohita</i>	110,100	94,200	54,200	52,700	34,000
<i>Catla catla</i>	78,400	41,700	26,500	4,000	10,000
<i>Cirrhinus mrigala</i>	47,200	36,850	15,200	30,900	51,180
Total	689,400	520,440	446,780	287,300	276,320
% stocking rate (per ha ²)	78.94	52.04	44.67	29.73	27.73

To monitor water quality changes, water samples from a fixed site in the middle of the lake were collected on monthly basis at 0, 1, and 2.5 m depths in 2000–2006. A plastic 2-L van Dorn sampler was used where the depth fluctuated between 3 and 4 m during the study period. The measured parameters were water temperature, water transparency, and chlorophyll-*a* and dissolved oxygen (DO) concentrations. The water transparency was measured with a 20-cm diameter Secchi disk with alternative white and black bands. Chlorophyll-*a* samples were obtained by filtering lake water through Whatman GF/C glass fibre filters (Whatman International Limited, Maidstone, USA) (<1.2 µm pore size). After extraction from the filter paper, the chlorophyll-*a* concentrations were determined spectrophotometrically, based on the methods of Lorenzen (1967) and UNESCO (1969). The DO concentration was measured, using the Winkler method.

RESULTS

Formation of the cooperatives

An Executive Committee of 11 members was formed to resolve local lake issues and everyday problems. The term of each Executive Committee member was fixed at 2 years, with the first Committee being formed in 2002. It was designed to maintain harmony, equal opportunities, and respect for the watershed citizenry. The Chairperson was to be elected according to democratic norms. Two vice-president posts were reserved for women and traditional fishers, which were to be nominated among the cooperative members. The posts of General Secretary and Treasurer were to be elected. Of four members, two were to be selected via election, while the remaining two were to be nominated by traditional fisher and women members, respectively.

Awareness and fisheries-based employment of cooperative members

The total fish production was 18.5 mt in the year 2004, with indigenous fish comprising 70 percent of the total yield. The contribution of indigenous fish to the total yield, including rohu (*Labeo rohita*), mrigala (*Cirrhinus mrigala*) and bhakur (*Catla catla*) and other native species were higher than the exotic, bighead (*Aristichthys nobilis*), silver (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) (Fig. 3). The income of capture fisheries provided jobs and employment to 80 percent of the cooperative member fishers; after establishment of the cooperative, the number of direct beneficiaries has increased from a few to 329 households (Fig. 4). Although only a few fishers initially had jobs related to the lake, substantial people are now involved in weed removal, fish harvest, value addition and marketing activities, etc.

Limnological parameters for monitoring water quality changes

Water temperature: The lake water temperature varied from 14.5°C in the winter, to 28.5°C in the summer months during the study period (Fig. 5a). Between the spring and summer, the surface water temperature increased, being highest mostly in June or July. The lowest lake temperature was reached in January 2002. The surface water temperature began warming from March, with an increasing length of solar radiation. The lake water begins gradually cooling generally after the monsoon season begins in August each year.

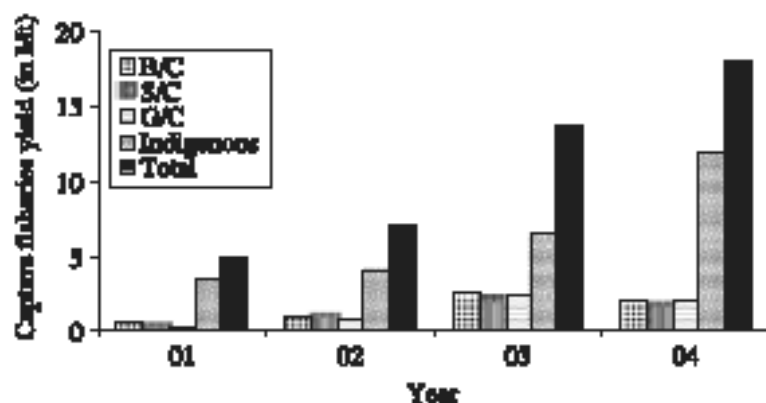


Figure 3. Fish catch in Lake Rupa (B/C, S/C and G/C represent bighead, silver and grass carp, respectively).

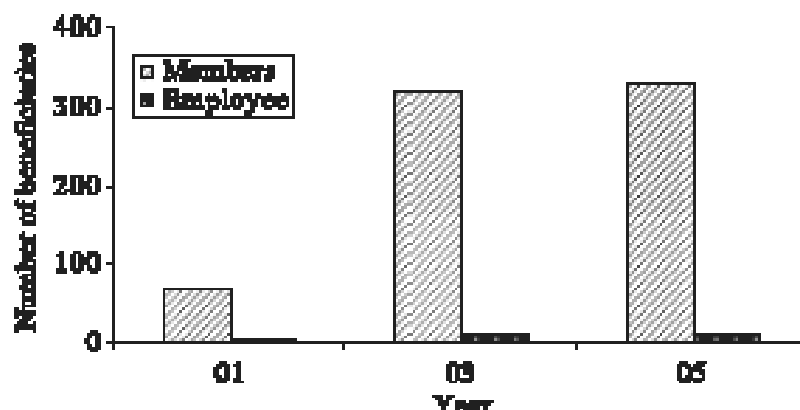


Figure 4. Number of direct local beneficiaries from Lake Rupa restoration

Water transparency: The Secchi disk transparency ranged between 0.10 and 2.8 m throughout the study period (Fig. 5b). The monthly variation in transparency was inconsistent, with sharp variations during 2000–2003. The water transparency became more consistent, however, exhibiting a comparatively smooth variation after 2003. The Secchi disk transparency generally decreased in the water column during the sampling period.

Chlorophyll-a concentration: The chlorophyll-*a* concentration ranged between 1.5 and 205 $\mu\text{g L}^{-1}$ during the study period. The concentration did not change substantially in the vertical water column. On a temporal basis, November of 2003, 2004 and 2005 exhibited small peaks of higher chlorophyll-*a* concentrations. The chlorophyll-*a* concentration increased between August and October 2006, reaching a highest level of 205 $\mu\text{g L}^{-1}$ in November in the surface water. The chlorophyll-*a* concentration gradually declined from December 2006 (Fig. 5c).

Dissolved oxygen (DO): The DO concentration was low from March to May 2002, ranging between 0.6 and 3.3 mg L^{-1} . This pattern improved after 2003 in March, April and May, when the DO ranged between 3.8 and 9.7 mg L^{-1} . The DO concentration fluctuated between 4.2 and 11.3 mg L^{-1} during the remainder of the study period (Fig. 5d). The duration of the period of low DO concentrations in the lake water between March and May decreased after 2003 (Fig. 5d).

Aquatic macrophytes: The presence of excessive aquatic macrophytes that severely hindered navigation and daily activities on the lake was a primary reason for rating Lake Rupa as being degraded. Aquatic vegetation covered almost 80–90 percent of the lake in 1999. The predominant aquatic plants were *Chara*, water chestnut, *Hydrilla*, *Vallisneria*, and water hyacinth. These macrophytes, however, have since been substantially cleared from the lake by fisheries activities, mainly because of campaigning by the cooperative. It is estimated, however, that only 10 percent of the lake surface area was covered by aquatic vegetation along the lake shoreline in 2007.

DISCUSSION

The major causes of the degradation of Lake Rupa were identified as (i) sedimentation, (ii) excessive growth of rooted aquatic vegetation, and (iii) the absence of authoritative local institutions. As a result of the decomposition of dead aquatic weeds, for example, Rai (2000a,b) reported drastic depletion of DO in the lake in April and May. The present findings, however, illustrate that establishment of the cooperative as an authoritative institution of local households not only resulted in curtailment of the encroachment of aquatic vegetation, but also in the clearing of excessive macrophyte growths. Moreover, the drastic DO deficiency, especially during March to May, has gradually improved since 2003, being largely overcome since 2004. This decreasing anoxia in the lake (Fig. 5d) is a significant indicator of environmental improvement, particularly in regard to the sustainability of aquatic organisms in the lake.

Similarly, the measured water transparency was inconsistent during 2000–2003, with the lake exhibiting large seasonal increases and decreases. After fish stocking and the manual removal of aquatic weeds from the lake, the water transparency became relatively consistent after 2004 (Fig. 5b). Earlier trends in water transparency could be the result of abundant aquatic macrophytes in the lake, which dominated the in-lake phytoplankton populations, as macrophytes can uptake nutrient from the lake bottom sediments (Takamura et al 2003, Mironga 2005). Several studies illustrated the occurrence of low water low transparency after fish stocking in lakes (Jeppesen et al 1997, Rowe 2007). However, the lowest transparency in Lake Rupa in July 2002 and 2003 was caused by heavy silt-containing run-off from the lake catchment during the monsoon season. The increased chlorophyll-*a* concentration at the end of 2006 also might be related to similar factors. The high concentrations AU: of chlorophyll-*a* suggest, for example, that the aquatic vegetation was removed, thereby facilitating the establishment of phytoplankton in the lake (Fig. 5c).

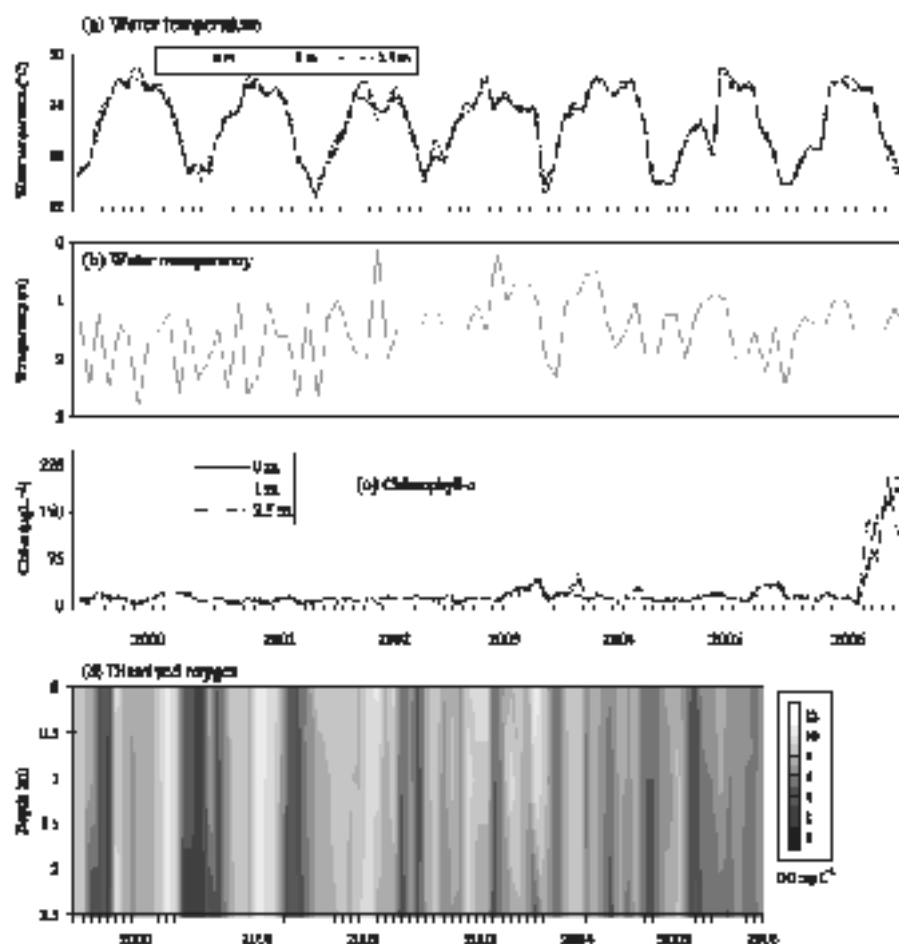


Figure 5. Annual changes in Lake Rupa water quality: (a) water temperature; (b) water transparency; (c) chlorophyll-*a* concentration; (d) dissolved oxygen concentration.

Although one of the nuisance weeds in the lake was water hyacinth (*Eichornia* sp.), members of the cooperative effectively cleared them. As part of the relevant campaign, the cooperative announced a reward of NRs 75 (nearly USD 1.05) for every kilogram of water hyacinth collected from the lake. This strong incentive also could help prevent further recolonization of the lake by water hyacinth.

Removal of fish stock was suggested in some studies as a means of attempting to control eutrophication (Shapiro 1990, Jeppesen et al 1997, Heerdts and Hootsmans 2007). Thus, a strategy of fish stocking was applied to Lake Rupa, which exhibited extensive growths of aquatic vegetation, to the extent that the lake was beginning to be transformed into swampy land. It was expected that the fish stocking (Table 2) could control the excessive aquatic weeds in the lake to some extent, as several earlier studies demonstrated that grass carp (*Ctenopharyngodon idella*) could effectively control submerged and floating macrophytes (Mitchell 1980). *Cyprinus carpio*, a bottom browsing fish, could have been effective in uprooting aquatic plants and causing the release of nutrients from the lake bottom sediments. At the present time, only 10 percent of Lake Rupa is estimated to be occupied by aquatic vegetation.

The annual fish yield tripled in 2004 to 18.5 mt more than that in 2002 after restocking (Fig. 3). The present fish yield from the lake is low (185 kg ha⁻¹), compared to other managed lakes for which the yield can be expected to be nearly 540 kg ha⁻¹ (Liu 1984). The lake's fish yield might increase in the future, if more efficient lake management efforts were undertaken. Activities such as establishment of tree plantations, river training, improving catchments, removing silt from the lake bottom, and planning

for damming, have been planned by the cooperative, utilizing financial resources generated through captured fisheries.

Combining fish species that exhibit diverse feeding habits in lakes can cause complex ecological interactions (Shapiro 1990, Padisák 2002). The indiscriminate stocking of fish species into Lake Rupa, for example, might cause interspecific food competition. In order to avoid adverse impacts therefore major attention should be given to enhancing the native fishery (Swar and Gurung 1988). Although it is known that restocked exotic fish have not yet been established in Lake Rupa, the cooperative should take measures to protect the lake's endangered and vulnerable fish species. It also is important to educate fishers that utilize gill nets, as these nets could not be environmentally friendly in regard to birds, amphibians and reptiles. This implies that, with the current restoration model for Lake Rupa, care should be taken to recognize and consider the needs of the specific aquatic communities in the lake.

Inclusion of traditional poor fishers, low-income people, and women in the Cooperative's Executive Committee reflects the respect due to the citizenry, indigenous knowledge and gender base development. As the cooperative was designed to offer a win-win situation to all its members, their link to the cooperative can be expected to enhance its harmony and stability (Fig. 2a,b). Based on the success of the present Lake Rupa restoration approach, it is expected that communities living next to or near other lakes, wetlands and swamps also will be encouraged to undertake such restoration efforts. In offering this conclusion, it also is noted that it is not necessary to establish a fishery-based cooperative for all degraded lakes. Instead, this activity can be based on the consensus of local community and the specific biodiversity conservation needs of individual lakes.

Another item meriting mention is that Lake Rupa's catchment area previously experienced indiscriminate killing of birds, fish and wild animals. Such activities in the lake and its surrounding catchments, however, have since been regulated by the cooperative, implying this approach also can be helpful in restoring the biodiversity of a lake and its catchment.

LESSONS LEARNED

The most significant problem facing most small lakes in Nepal is sedimentation associated with heavy monsoon rainfall, traditional agricultural practices and deforestation in the catchments, landslides, floods, eutrophication, water abstractions, and encroachment by aquatic plants. In fact, many Asian lakes must cope with the impacts of human activities in their catchment areas (Groombridge and Jenkins 1998). As a result of recent increases in population and poverty, the sustainability of small lakes situated near human settlements might be questioned. The growing trend of converting these lakes and their catchments in intensive aquaculture or agriculture systems should be approached cautiously because of their potential environmental impacts, and the socioeconomic problems they can create. Intensive aquaculture in such settings might be essentially a capital-intensive activity undertaken by corporations aiming to make a quick profit that is often shared by only a very small portion of the watershed population (Costa-Pierce 1992). Based on the experiences highlighted in this study, it is recognized, however, that community-run fisheries can avoid the 'tragedy of the commons' syndrome, whereby a common resource is everyone's resource to exploit, but no one's responsibility to sustain (Leal 1996, Buyali 2001).

Fish and wildlife resources associated with Lake Rupa correspond to a mosaic of interconnected aquatic and terrestrial habitats that have important roles as the main intersection for migratory birds between the Himalayan Mountains and the southern plains of Nepal during the spring and fall. Many other birds and waterfowl also use the lake and its surrounding forests as feeding and breeding habitats. In recognition of these environmental realities, one of the main objectives of the cooperative was the enhancement of fisheries and wildlife by restoring Lake Rupa. Thus, the answer to the question posed in the title to this manuscript is 'Yes'. It is believed this approach can save hundreds of small lakes around the world from

disappearing – especially in developing countries, for which the paucity of financial and other resources can have dire consequences. This approach of establishing legally constituted cooperatives to manage small lakes and their resources illustrate that it is possible to create an equity-based, win-win perspective for poverty reduction, even in conflict-prone societies, by utilizing human social dynamics.

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Stocking Effectiveness, Yield variation of Captured Fish in Reference to Natural Stock, Restocking, and Self-recruiting Populations in Lake Begnas, Pokhara

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ABSTRACT

Stocking effectiveness, annual variation and growth rate in yield per species from Begnas Lake, Pokhara, Nepal was analyzed by using long-term (1994 to 2005) landing data. The potential relationship of the numbers of stocked fish to yields was evaluated using time-lapse analysis. Species-wise annual variations were defined in terms of absolute and relative variation around the mean yield and long term trends in catch levels. The most important fishing gear used in Begnas Lake was gill net by which about 95% of the total fish landings were caught. The captured fish based on the annual stocking of advanced fry (0.5 to 5.0-g) of bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), rahu (*Labeo rohita*) and bhakur (*Catla catla*), and self-recruiting indigenous species like bhitte (*Puntius spp.*), rewa (*Cirrhinus rewa*) and several minor species. On an average, the regularly stocked species contributed 74% of the total yield, which was around 33.2 - 44.1 kg.ha⁻¹ in the last few years. A monthly peak catches of stocked fish occurred during the winter from November to January. A significant relationship ($P < 0.05$) between stocking density (SD, n kg⁻¹) and the yield of all stocked species in combination in year $n+2, 3$ (Y , kg. ha⁻¹) exist was:

$$Y (n+2,3..) = -0.001 SD^2 + 0.276 SD + 37.54 (r^2 = 0.62, P = 0.049)$$

Annual variations of stocked fish were directly related to yield, indicating higher absolute variation (37%) than the relative variation (19.7%). Self-recruiting species like rewa (*Cirrhinus rewa*) showed large variation in annual yield, possibly due to variation in annual recruitment. Trends in yield rate of recaptured fish in 12 - year periods revealed a sharp decline in the catch of self-recruiting species. This might be due to several reasons such as overexploitation, ignorance because of their smaller size, habitat loss, inter and intra species competition etc

Key words: Capture fishery, fingerlings, fishing gear, stocking structure

INTRODUCTION

In Nepal, lakes and reservoir constitute the prime inland fisheries resource, amenable for culture-based fisheries and various other forms of enhancements. Capture fishery is considered to be an important fishery resource in Nepal and contributes approximately 56.4 percent of the total fish production (36,692 mt) in the country (DoFD 2003). Begnas lake, one of the largest mid hill lake in Nepal, is situated at the northeastern edge of Pokhara valley (28° 1' N, 82° 5' E, alt 650 m), covers a surface area of 320 ha at full supply level (Rai et al 1995). It is a significant component of inland water resources occupying 5.7 percent of the total lakes and reservoirs area of Nepal, and offers potential for fisheries development and enhancement of fish production. At present Begnas lake supports small-scale fisheries and rich in fish species diversity, contributed approximately 33.7 mt freshwater fish from capture and cage fish during 2005 (Wagle et al 2007).

Fishery enhancement suitable for mid hill lakes of Pokhara valley are introduction and stocking (Swar and Gurung 1988, Wagle and Bista 1999). A fishery developed in the lake Begnas with the introduction of cage fish culture in 1972 to support the livelihood of wetland dependent aboriginal community known as Pode of Jalari. Fishing by using local traps and gill nets, is the traditional occupation of Jarari community. With the introduction of gill net during 1960s (Swar and Gurung 1988), initially fish catch increased and a few years later fish catches begun to decline due to over exploitation of the native fish resources. In order to diminish pressure on native species and enhancing lake productivity, the restocking program in the lake was initiated during 1980s with a number of exotic and native species. Exotic species silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), common carp (*Cyprinus carpio*) and native species rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*), bhakur (*Catla catla*) which do not self recruit are continued to stock. Other self recruiting native species that form the basis of Begnas lake fishery are *Puntius* spp., *Cirrhinus rewa* and *Barilius* spp. (Gurung et al 2005).

Although stocking of fish is used throughout the world (Cowx 1994, Welcome 1996), but the extent, efficiency and utilization are poorly recorded for inland waters (Lorenzen et al 2001). Some workers have studied the relationship between stocking density and yield for lakes and reservoirs (Sugunan and Katiha 2004, Phan and De Silva 2000, Welcome and Bartley 1998). Despite the overwhelming relevance of culture-based fisheries in the lakes of Pokhara valley of Nepal, no analytical study has examined whether stocking density influence stocking effectiveness.

Variability of annual landings for each species with one or more peaks are common in Begnas Lake. For intensively exploited fish stocks, annual variation in fish yield is mainly caused by variation in recruitment for established populations (Hennemuth et al 1980) and stocking of non-established population in the lake. Successful exploitation of a fishery depends not only on the quantity of fish caught, but also on the stability of fish supply (Silvert 1982, Buijse et al 1994). The variable yield of a fishery has direct consequences on the economic status of the fishers, ie increasing catches stimulate investments which in turn lead to increased fishing efforts.

The lake Begnas provides an opportunity to evaluate not only the impact of stocking practices, but also any interaction between stocked and self recruiting native species. In this study, catch data from a long-time series (12-year period: 1994-2005) are used to investigate interactions between and to analyze the variability in annual yield of a number of stocked and self recruiting fish species. The usefulness of the findings for possible improvements in the management which could result in an increase in fish yield is discussed.

MATERIALS AND METHODS

Information on stocking and species wise daily catch data was collected from the Fisheries Research Centre, Pokhara for a period of 1994 to 2005. In addition, the study had access to historical information and data on fish landing trend from the local community of Jalaris managing the lake fisheries. The fishery of the lake is operated by Jalari community organized into a society. The society and Fisheries Research Centre determines what species are stocked and when on orbitory basis. Two main types of gear used in lake Begnas: gill net and, rod and line. Local trap (paso) is also used seasonally in feeding stream of the lake. However, the later gears are estimated to contribute less than 5 percent of the total yield. Hence, catch data and yield presented in this paper based on gill net fishery. Yield data were grouped into the total catch and the contribution of major species to the local and minor species landed.

Apart from considering annual and seasonal changes in fish yield, the potential relationship of the numbers of stocked fish to yields was evaluated using time-lapse analysis (i.e. weight of stocked fish in year n to yield of stocked fish in year n+1, n+2 and so on) based on appropriate time taken to reach harvested weight for a species. In the time series analysis, statistically significant relationships between yield and stocking density were evaluated using SPSS version 10.0 software package. The regression

relationships tested were linear, curvilinear, exponential and polynomial (first and second order) and those which gives best correlation are presented.

An analysis of the coefficient of variation (CV) is carried out for annual catches of stocked species and other important fish to determine the extent of variation in yield. The long term variation in catches experienced by the fisher is expressed by the CV in annual yield. In the short-term, fishers relate their catches (y_i) in a given year to that in the previous year (y_{i-1}). In a long term data series, the mean of the absolute differences in the annual catch between successive year can be related to the mean catch according to the model developed by Buijse et al (1991):

$$U_a = \frac{[dy]}{y} = 100 * \frac{\text{mean}[y_i - y_{i-1}]}{y} (\%)$$

Where, U_a = index of absolute variation; y = mean of long-term catch; y_i = catches in the given year; y_{i-1} = catches in the previous year.

Because the fisherman generally experience short-term variation in their catch as a percentile change, the relative variation (U_r) was calculated from the mean of the absolute difference of log transformed catches (r) as:

$$r = \sum_{i=2}^n [\log_{10}(y_i / y_{i-1})] / (n-1)$$

where n = length of the time series (1-12 years) and:

$$U_r = 100 * 2(1 - 1/10^r) / (1 + 1/10^r) (\%)$$

if $U_r > U_a$, variation is inversely related to yield, but if $U_r < U_a$, relative variation is directly related to yield.

Trends in annual fish landing of Begnas Lake were estimated by using a standard semilog trend function within exponential growth rate. The model is given by (Ahmed et al 2001):

$$\ln Y = \alpha + \beta t$$

where, Y = annual fish catch (kg); t = time series (t =one for 1995-96, two for 1996-97, ...12 for 2004-05), α and β are parameters to be estimated where β is the exponential growth rate and $\ln$ = the natural log.

RESULTS

Fishery and production

The fishery of the lake is based on four regularly stocked species (ie *H. molitrix*, *A. nobilis*, *L. rohita* and *C. catla*). The most important indigenous contributing substantially in total yield are *Puntius* spp, *Cirrhina rewa* and *Barilius* spp. In addition, a number of other indigenous species are caught (Table 1), but these collectively account for less than 5 percent of the total estimated yield. About 95 percent of the total fish landed are caught by gill nets.

The mean weight of landing of the stocked species for different period is given in table 2. The mean landing size of *A. nobilis* and *C. catla* (11.3-11.8 kg) are significantly higher ($P < 0.05$) than the harvest weight for those of the *L. rohita* and *H. molitrix* (4.5-6.8 kg). Given the growth potential of these species in extensive pond aquaculture, the former group is likely to be four years old while the later group is two years old.

Fish production in Begnas lake is largely dependent on the annual stocing of four major species: *H. molitrix*, *A. nobilis*, *L. rohita* and *C. catla*. All four species are stocked as advanced fry/early fingerling, ranging in weight from 1 to 5 g. Stocking takes place in two distinct period: before rainy season (April-May) for *H. molitrix* and *A. nobilis*, and after rainy season (October-November) for *L. rohita* and *C. catla*. All seed is procured from hatchery of Fisheries Research Centre, Pokhara.

Table 1. Fish species and their contribution in capture fishery of Begnas Lake

Scientific name	Local name	Capture statistics of lake Begnas (1994-2005)	
		Yield range (kg/ha)	% contribution $\pm$ SD
<i>Hypophthalmichthys molitrix</i>	Silver carp	5.9-27.9	26.2 $\pm$ 17.7
<i>Aristichthys nobilis</i>	Bighead carp	4.6-26.8	16.5 $\pm$ 7.4
<i>Ctenopharyngodon idella</i>	Grass carp	0.4-2.1	0.3 $\pm$ 0.1
<i>Cyprinus carpio</i>	Common carp	0.1- 0.3	0.3 $\pm$ 0.1
<i>Cirrhinus mrigala</i>	Naini	0.3-11.8	3.1 $\pm$ 4.8
<i>Catla catla</i>	Bhakur	7.0-21.3	17.5 $\pm$ 3.8
<i>Labeo rohita</i>	Rohu	1.2-21.8	10.1 $\pm$ 6.7
<i>Tor putitora</i>	Sahar	0.6-3.3	2.1 $\pm$ 0.8
<i>Cirrihinus rewa</i>	Rewa	0.1-24.1	12.2 $\pm$ 10.5
<i>Puntius sophore</i>	Bhitta	0.0-5.1	4.8 $\pm$ 4.0
<i>Puntius titus</i>	Bhuruk		
<i>Xenentodon cancila</i>	Dhunge Bham	0.0-0.9	0.4 $\pm$ 0.4
<i>Mastacembelus armatus</i>	Chuche bam		
<i>Barilius barna</i>	Bagh fageta	2.1-12.0	4.9 $\pm$ 5.0
<i>B. bola</i>	Fageta		
<i>B. vagra</i>	Lam fageta		
<i>B. bendelisis</i>	Chiple fageta		

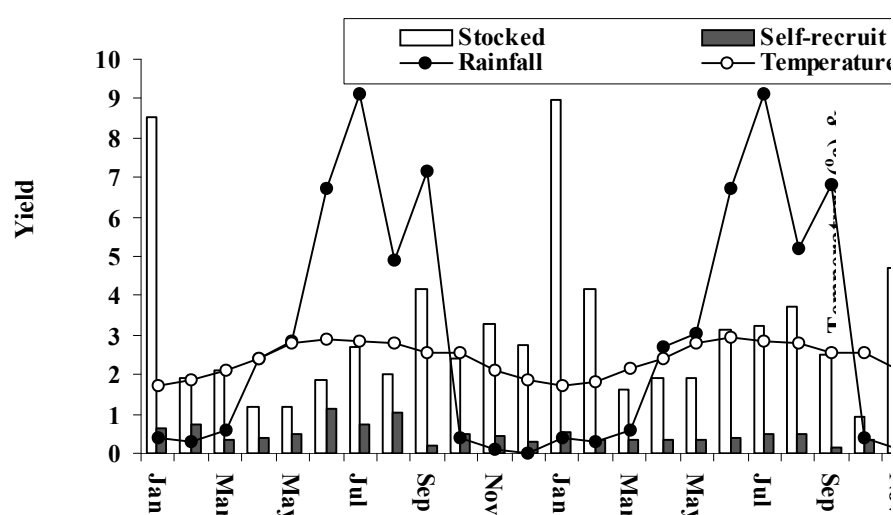
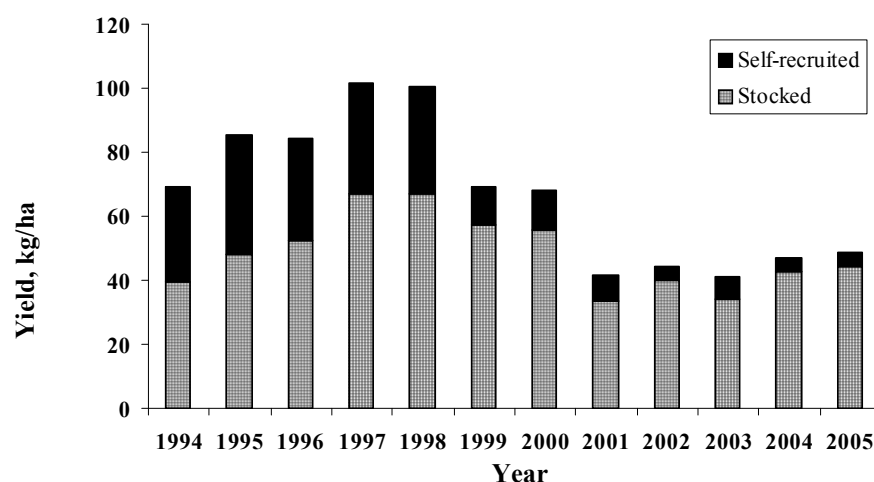


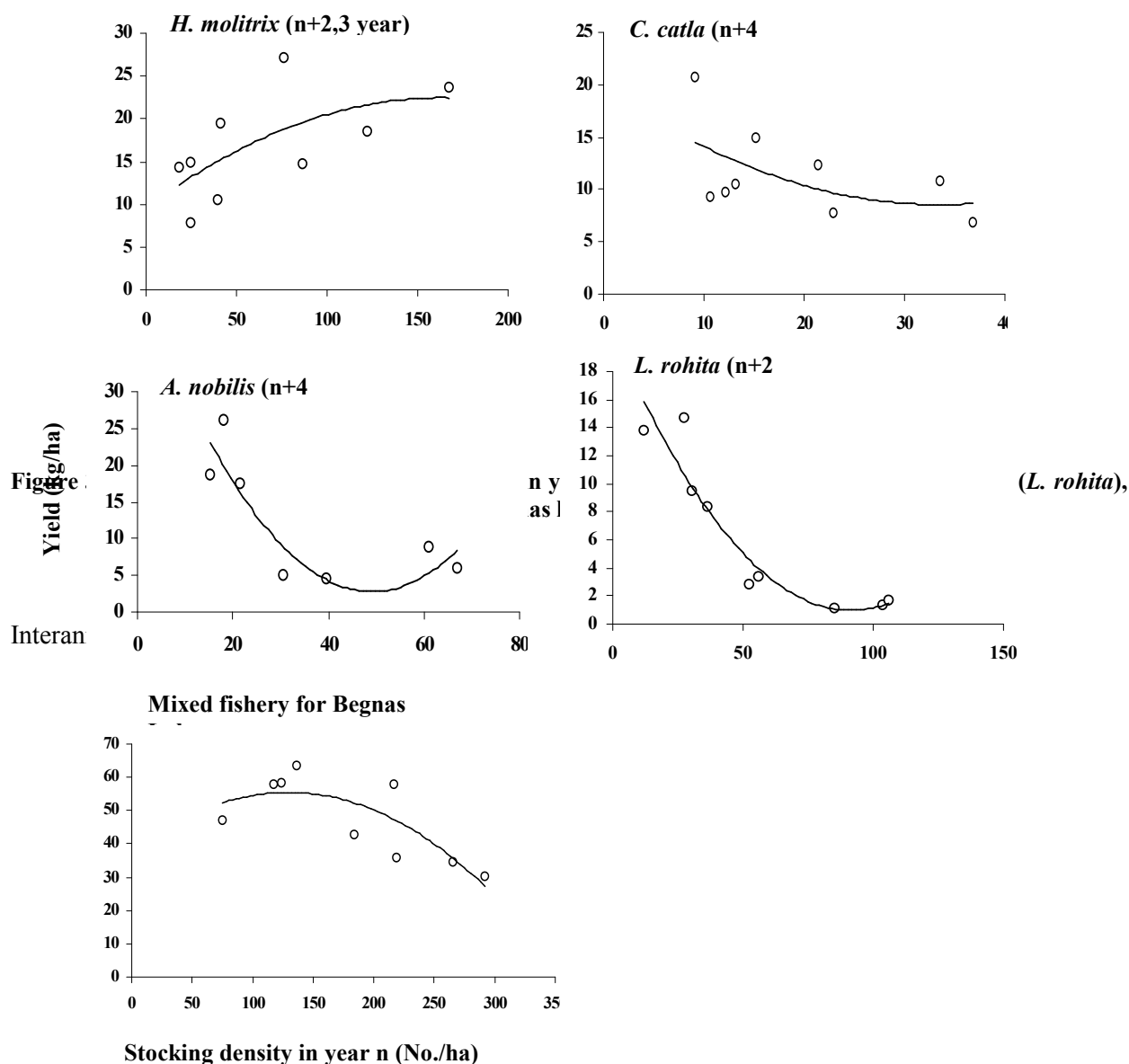
Table 2. Mean ($\pm$ SD) landing size (i.e. body weight) of the main fish species of the Begnas lake fishery in 1994, 2000 and 2005

Species	Body weight (kg)		
	1994	2000	2005
<i>Hypophthalmichthys molitrix</i>	10.5 $\pm$ 2.6	5.4 $\pm$ 1.6	6.8 $\pm$ 2.4 ^b
<i>Aristichthys nobilis</i>	11.7 $\pm$ 3.1	13.6 $\pm$ 5.9	11.3 $\pm$ 4.8 ^a
<i>Labeo rohita</i>	2.0 $\pm$ 0.4	3.7 $\pm$ 1.4	4.5 $\pm$ 1.2 ^c
<i>Catla catla</i>	2.8 $\pm$ 0.7	9.2 $\pm$ 2.6	11.8 $\pm$ 2.6 ^a

Stocking and yield relationship

In the lake Begnas, a significant relationship ($P < 0.05$) was found between stocking density in year n (SD , $n \text{ ha}^{-1}$) and the yield of stocked fish in year $n+2, 3, 4$ (Y , kg ha^{-1}) (Figure 3):

A. nobilis	$Y (n+4) = 0.177 SD^2 - 1.74 SD + 45.52$	($r^2 = 0.77$, $P = 0.048$)
H. molitrix	$Y (n+2,3) = -0.004 SD^2 + 0.158 SD + 9.53$	($r^2 = 0.40$, $P = 0.215$)
L. rohita	$Y (n+2) = 0.002 SD^2 - 0.432 SD + 20.75$	($r^2 = 0.89$, $P = 0.001$)
C. catla	$Y (n+4) = 0.010 SD^2 - 0.676 SD + 19.88$	($r^2 = 0.28$, $P = 0.361$)
Combined of all stocked species	$Y (n+2,3,4) = -0.001 SD^2 + 0.276 SD + 37.54$	($r^2 = 0.62$, $P = 0.049$)



Annual variation in the yield of the commercially important fishery was investigated for 8 species (57% of the total) over the period from 1994 to 2005. The long term coefficient of variation (CV) was found to vary between 33 and 97 percent (Table 3). In general fishing community experience a variation in the catch of different species from one year to the next. The absolute variation (U_a) and relative variation (U_r) were 38.1 and 40.6 percent and the differences were not significant ($P>0.05$), indicating that variation was not directly related to yield.

Table 3 shows that the self-recruiting species have high long-term CV (70.2%) and U_a (39.2%), compared to 8 commercially exploited fish species (average CV= 64.1% and U_a = 38.1%). Among the self recruited species rewa (*Cirrhinus rewa*) showed higher average yield, but the values for $U_r > U_a$ suggests that large variation in yield occur because of the large variation in the annual recruitment pattern.

Table 3. Coefficient of variation (CV%), the indices (%) for absolute (U_a) and relative (U_r) short-time variation and the index for long-term trends (%) of historical yield (kg) of commercially important fish species of Lake Begnas, Pokhara valley, Nepal

Species	n	Year range	Yield (kg)	CV	U_a	U_r
<i>H. molitrix</i>	12	1994-2005	4711	48	27	11
<i>A. nobilis</i>	12	1994-2005	3759	66	41	20
<i>C. catla</i>	12	1994-2005	3702	33	30	8
<i>L. rohita</i>	12	1994-2005	2525	85	50	40
<i>T. putitora</i>	12	1994-2005	506	67	28	8
<i>C. rewa</i>	12	1994-2005	3243	97	36	96
<i>Puntius spp</i>	12	1994-2005	790	68	47	140
<i>Barilius spp</i>	8	1994-2001	2367	49	46	2

The yields of artificially stocked species have relatively low long-term CV (58%) and U_a (37%) higher than U_r (19.7) indicating that variation was directly related to yield and stocking. *H. molitrix* and *C. catla* has showed a stable or increasing yield over a 12 year period (Figure 3). The CV of these species was found to have lower than moderate (40.5%) and small interannual differences (28.5%). This stable combination may be able to exist for a certain period without change in trend, if fishery patterns are consistent over the time.

Determination of yield rate

Trends in yield rate of major fish species for the last 12 years reveals sharp declining rate of self recruiting species (Table 4 and Figure 4). The average declining rate was approximately 25.8 percent. The highest rate of declining trend was found in *Cirrhinus rewa* (45.2%, $r^2=0.80$); *Tor putitora* (20.2%, $r^2= 0.55$) followed by *Barilius spp* (17.7%, $r^2= 0.80$), which are alarming. Yield of *Puntius spp* was increasing at a higher rate of 22.5 percent ($r^2= 0.48$).

The yield rate of stocked species declined at a slower rate (1.8%). Among stocked species the highest yield rate was found for *H. molitrix* (12.6%, $r^2= 0.80$). The yield of *L. rohita* was found declining at faster rate (20.2%, $r^2= 0.41$). As a whole, all species considered together, the fish production in Begnas lake is decreasing at an annual rate of 1.98 percent (Table 4).

DISCUSSION

Begnas Lake is known to harbour a very diverse fish fauna (Wagle and Bista 1999). The fish production of this lake was primarily dependent on self recruiting fish species before and few years of stocking program. Changes in community structure, with respect to stocking of non-recruiting species and shifting habitat of native species, has contributed substantially in total landing in recent years. This is not uncommon in Asian reservoir fisheries, where fishery is augmented by stock and recapture (Phan and De Silva 2000). The Chinese (*H. molitrix* and *A. nobilis*) and Major carp (native to many Nepalese river systems: *L. rohita* and *C. catla*) are not known to reproduce in locustrine waters, even within their natural range. These species are the most commonly used, in various combinations, in stock and capture fisheries

in southeast Asian reservoirs (Li 1988, De Silva and Amarasinghe 1997), and are known to give high yield (Petr 1989).

Table 4. Determination of the yield rate of different categories of important fish harvested during 1994 to 2005 from Begnas Lake, Pokhara Valley

Category of fish	Yield rate- β (%)	t-value	Adjusted r^2	F-value
<i>All species combined</i>	- 1.98	- 8.56**	0.880	$F_{(1,10)}$ 73.38**
<i>Self-recruited species</i>	-25.8	-8.12**	0.868	$F_{(1,10)}$ 65.91**
<i>Tor putitora</i>	-15.10	-4.51*	0.671	$F_{(1,10)}$ 20.38*
<i>Cirrihinus rewa</i>	-45.23	-6.48**	0.807	$F_{(1,10)}$ 42.02**
<i>Puntius spp</i>	22.53	1.73	0.231	$F_{(1,10)}$ 3.02
<i>Barilius spp</i>	-17.71	-1.73	0.374	$F_{(1,8)}$ 2.91
<i>Stocked species</i>	- 1.8	-1.37	0.159	$F_{(1,10)}$ 1.90
<i>H. molitrix</i>	12.61	6.81**	0.822	$F_{(1,10)}$ 46.38**
<i>A. nobilis</i>	-5.28	-1.02	0.094	$F_{(1,10)}$ 1.04
<i>C. catla</i>	-4.27	-1.94	0.274	$F_{(1,10)}$ 3.78
<i>L. rohita</i>	-20.18	-3.21*	0.508	$F_{(1,10)}$ 10.36*

Yield rate are computed by fitting semilog trend function $\ln Y = \alpha + \beta t$, where Y= yield, α and β are parameters and t is time ($t=1, 2, 3 - 12$); α and β indicate the significance level at 1%. F-ratio of analysis of variance, adjusted r^2 , proportion of variation in the dependent variable y, explained by the relationship between y and x expressed in the regression line.

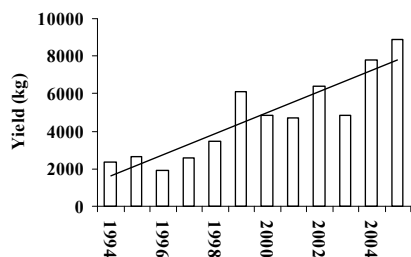
However, the fish yields of Lake Begnas have decreased steadily since last five years and the production rate is far below than the some most productive reservoirs and lakes in Asia (Phan and De Silva 2000, Sugunan and Katiha 2004, Nissanka and Amarasinghe 2000, Ahmed et al 2001). A number of factors may have contributed to the decrease in fish yield in recent years. Out of these, the most important ones are decrease in eutrophication (Husen et al 2007) and an increase in stocking density. In Lake Begnas, stocking density of fry/fingerling attained to a maximum of 300.ha⁻¹.year which corresponds to a decreased fish yield (Figure 3). The negative correlation between stock and yield in Begnas lake did not corroborated with high stocking density (1500-3000 ha⁻¹) in medium sized reservoirs (70-670 ha) in China and Vietnam for increased fish yield (Sugunan and Katiha 2004, Phan and De Silva 2000).

At present the fishery of Begnas Lake is operating its lowest capacity with respect to ongoing stocking structure, as indirectly indicated by the declining curve of the SD versus yield curves (Figure 3). The most effective SD is shown to be ≈ 100 fry.ha⁻¹ and beyond a SD of 100.ha⁻¹ the yield begins to decline with increasing SD. Considering the inclined yield curve with increasing SD (Figure 3), the stocking density of *H. molitrix* could be further increased as their yields are positively correlated with increased stocking density, and increased growth rate (Table 4). An increased density of *A. nobilis*, *C. catla* and *L. rohita* did not conform higher yield in Begnas lake as indicated by Yield-SD curve. The stocking number of these species may be cut down in future stocking program of Begnas Lake. These species at low density favors Lorenzen's (1995) view that yield increased almost proportionally to stocking at low density, but rate of increase in yield declined as density increased. A detailed analysis of density dependent mortality and growth for each species included in the stocking program of Begnas Lake should shed light on this hypothesis.

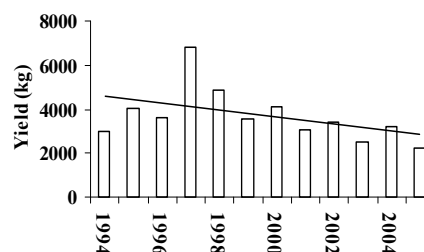
Despite of the decreased fish yield in lake Begnas, the proportion of stocked components to the total fish yield has increased over the years (Figure 1). The quantitative contribution (18.4 $\pm$ 13.8 kg.ha⁻¹) of self-recruiting native species has decreased significantly ($P<0.01$) for 12-year period investigated. This trend may be indicative of an unbalanced fishery between two groups of stocks in Begnas Lake.

The catches of stocked species in Begnas Lake appeared to be related to seasonal changes, which is occurring predominantly in the mid winter season (Figure 2). Transparency and water level of the Begnas Lake subsides to a minimum during this period of a year. However, these assumptions contradict with Muchiri's (1997) findings that the significant positive relationships between highest catches and increasing water level of Turkana and Naivasha (Kenya's Rift Valley Lakes). Seasonal changes in yields in relation to general changes in hydrology are not uncommon (Karengi and Kolding 1995, Beam 1983)

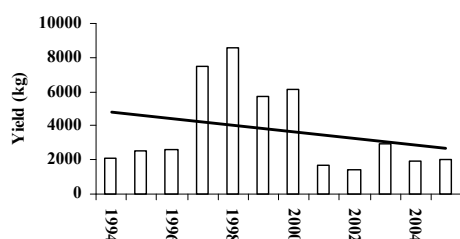
in lacustrine and riverine freshwater fisheries. Interaction of numerous factors such as behavioral changes in fish species, gear effectiveness and vulnerability of gear, acting individually or in combination would lead to changes in fish catch (Phan and De Silva 2000). Seasonal pattern of catch has not been seen for self recruiting species in Begnas lake. However, high catch rates have been experienced for self-recruiting species in Begnas lake in most of the years during the monsoon when the water level reaches to maximum.



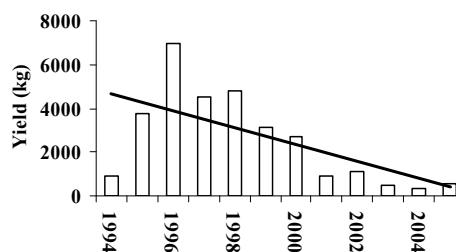
$$H. molitrix Y = 560.91 t + 1065.4, r^2 = 0.8084$$



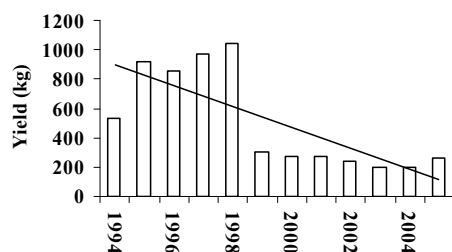
$$C. catla Y = -155.52 t + 4712.9, r^2 = 0.2151$$



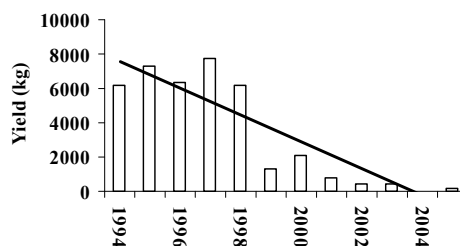
$$A. nobilis Y = -190.52 t + 4997.2, r^2 = 0.0756$$



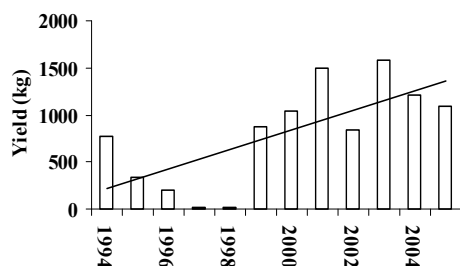
$$L. rohita Y = -382.55 t + 5011.3, r^2 = 0.411$$



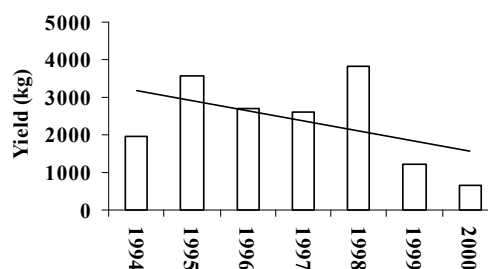
$$T. putitora Y = -70.39 t + 963.3, r^2 = 0.55$$



$$C. rewa Y = -784.57 t + 8342.7, r^2 = 0.80$$



$$Puntius spp Y = 104.21 t + 112.38, r^2 = 0.48$$



$$Barilius spp Y = -262.7 t + 3418.1, r^2 = 0.24$$

Figure 4. Annual landings and predicted yield of stocked species from Lake Begnas. (□) y, (—) predicted y

In general, fisheries experience a variation in the catch of different species from one year to the next in Begnas Lake. There is ample evidence of annual variations in fish yield from different categories of water-body throughout the world (Buijse et al 1994, Ahmed et al 2001). Various reasons are involved in causing variations in yield. In most of the cases, principle reasons for variability in yields are: fluctuations in recruitment, loss of breeding ground, growth and survival rate of self-recruiting species, irregular stocking of non-recruiting species, alterations in mesh sizes and fishing efforts (Buijse et al 1991). A high variation in recruitment and high fishing effort in Begnas Lake could have resulted in a high uncertainty. As recruitment is often difficult to manage for a certain water body, because of uncertainty between stocking (artificial) and recruitment (natural) relationships (Ahmed et al 2001), the stabilizing management strategy should be mainly to reduce fishing effort.

Table 4 shows that except *H. molitrix* and *Puntius spp*, the catch (growth) rates of all species have declined by 4.3 to 45.2 percent annually in Begnas Lake. Most of the gears used in this fishery are non-selective and harvest more than one species. Irrespective of size classes, fishing is carried out daily without any regulation on mesh size of the gears (gill net). It is probable that recruitment pattern of the self recruiting species has been affected from the beginning of the introduction of gill net in this lake. Hauling of large mesh-size gill nets are decreasing gradually because of constant declining of the catch per unit effort (CPUE). Presently, the fishing community gradually tends to shift in cage fish culture activities as their livelihood threatened with the uncertainty and reduce in annual catch.

Therefore, to stabilize the fishery, the existing stocking structure needs to be reorient and strengthened urgently and should be implemented properly so that the stocking success of both natural stocking (auto-stocking from natural spawning) and artificial stocking could be achieved. Gill nets should be restricted for a given area either for the whole season or limited time period. Also, an effective stock protection policy (constant quota or constant effort) can be initiated for this fishery to make a trade-off between maximizing the yield and minimizing the variation in yield.

ACKNOWLEDGEMENTS

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Participatory Evaluation of Growth and Production Performance of Domesticated Sahar (*Tor putitora*) in Pond Condition in the Terai and Hill of Nepal

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ABSTRACT

Sahar (*Tor putitora*) formed a substantial natural fishery in the major riverine and lacustrine ecosystem of Nepal. Biological diversity of this species is being threatened by various anthropogenic activities. In view of the conservational value and the aquaculture potential of *T. putitora*, significant development in artificial propagation of this species has been achieved. Information and data on growth and production of Sahar in captive environment are meager. Farmers' perception on raising this species and analysis of comparative advantage over other cultivated carp species are essential whether or not Sahar could be established in current aquaculture setting.

Participatory studies were carried out in three terai district (Kanchanpur, Chitwan, Sunsari) and one hill district (Kaski) to evaluate the growth and yield of Sahar in pond condition. Larvae of hatchery bred Sahar were stocked at a density of 50 larvae/m² for nursing for two month. Later the resultant fry were used at density 10000 fry/ha in grow out systems for eight month. Survival rates ranges between 87.3 to 91 percent obtained in hill and terai, respectively, during nursing were not significantly different ($P>0.05$) among the locations. Average growth of fry (0.7 ± 0.2 g) was also not significantly differed ($P>0.05$). Growth and yield of Sahar from 28 participating farmer's ponds have been used to analyze the interaction among locations.

Key words: Participatory evaluation, Sahar growth, aquaculture potential

INTRODUCTION

Sahar, *Tor putitora* (Cypriniforms: Cyprinidae) is one of the most popular freshwater sport fish throughout the trans-himalayan mid hill waters (Shrestha 1997). Sahar formed a substantial natural fishery in the major riverine and lacustrine ecosystems in Nepal (Gurung et al 2003). Sahar comprises one of the main species of fisheries resources in the region, sustaining livelihood of fisher folks (Bista et al 2002). Despite their importance, their biological diversity is being threatened by various anthropogenic such as urbanization, habitat fragmentation, over-exploitation and ecological alterations and physical changes in natural environment (Swar 2001, Gurung et al 2003). In view of the conservational value of *T. putitora*, there has been a concerted effort to artificially propagate and evaluate aquaculture potential of this species.

One of the major impediments for developing the aquaculture production technology of Sahar is an inadequate knowledge on dietary formulation. Despite of better performance in animal protein feed, the growth rates Sahar is slower than the carp species used in current aquaculture system (Bista et al 2001). Similarly little is known on growth response of Sahar in different agroeco region, since this species

naturally distributed in cool waters of mid hills and relatively warmer water of inner terai (Gurung and Wagle 2000). Distribution of Sahar in wide temperature range has been supported by the Bista et al (2002). In natural water system Sahar is known to achieve as much as one meter in length and 45 kg in body weight (Shrestha 1997) suggesting that this species has a high growth potential. Although several studies have been made on the growth performance of Sahar in response to feed management, evaluation related to the growth response of Sahar in ecoregions represented by varied thermal profile and ecosystem management are extremely meager. The purpose of this study was to examine and analyze the growth potential of Sahar of different age cohort in mid hill and terai regions corresponding to different ecological regions.

MATERIALS AND METHODS

Growth experiments of Sahar were conducted in earthen ponds range from 150 to 300 m² Mid-hill (Pokhara, Kaski) and terai districts (Kanchanpur, Chitawan and Sunsari) for a period of seven months (April to October) in farmers field. One farmer in each district was selected for nursing of Sahar fry. Except fertilization, standard practices were followed for pond preparation, which includes drying, liming and water feeding. Fry (0.42 g) of Sahar for growth evaluation were obtained from the captive breeding of domesticated lines of F3 generation of Sahar maintained at Fisheries Research Centre, Pokhara. For nursing and rearing experiments the larvae were stocked at a density of 50 larvae/m² for three months in each district. Later the resultant fingerlings were stocked at density 10000 fry/ha in grow out systems for seven months in duly prepared pond of the designated farmer in each location.

The experimental fish were fed twice daily with crumble ration approximately containing 30 percent protein for all locations. Daily feeding was 5 percent estimated weight of biomass for the fry and 3 percent for the grower size fish. The growth experiment ran for 240 days in mid-hill at water temperature ranged between 20-30.5°C, while Sahar grown in terai at temperature ranged between 25.1-35°C.

Monthly experimental fish were sampled to monitor intermediate gain in body weight and length. Final growth evaluation and enumeration of survivors were made upon harvest. Differences in monthly body weight gain and total body weight gain between treatments were analyzed by ANOVA using software Stat Graphics plus 3.0 versions. Body weight data were regressed against length data of Sahar by power function (Hopkins 1992), using Excel.

RESULTS AND DISCUSSION

Survival rates in hill (87.3%) and terai (91.6%) obtained during 90 days nursing period were not significantly different ($P>0.05$) among the locations (Table 1). Growth in weight of small size fry in nursing increased at each intermediate growth sampling in both locations. However, final body weight gain of fry at the end of three months of nursing was significantly different ($P<0.05$) between ecological regions.

Table 1. Survival and growth of Sahar (*Tor putitora*) fry nursing in terai and hill of Nepal

Nursing attributes	Hill	Terai
Stocking, No./m ²	30	20
Initial size, g	0.42	0.42
Growing days	90	90
Survival %	87.3±5.2 ^a	91.6±7.6 ^a
Final weight, g	7.9±0.9 ^a	9.7±1.7 ^b

Different superscripted letters within rows are significantly different ($P<0.05$)

Although body weight gain of Sahar fry at the end of first month of rearing did not differed among the ecological regions, later fish grew significantly ($P<0.05$) and attained final weight of 39.0 g in mid-hill and 60.8 g in terai at the end of growing period of 210 days, respectively (Table 2). Location specific comparison of the growth of Sahar revealed that the net cumulative weight gain in terai at each growing

months was significantly higher ($P<0.05$) than the net weight gain obtained in Mid-hill (Figure 1). The average growth rate of Sahar in grow out ponds was 0.28 g.day^{-1} in terai and 0.18 g.day^{-1} in hill.

The relationship of fish lengths and weights expressed by power functions revealed that the power values were normal for Sahar grown in mid hill and terai region (Figure 3). Body shape of Sahar is more symmetrical ($L^{2.98}$) in terai than Sahar grown in the mid-hill ($L^{2.55}$). Hopkins (1992) suggest that slope of the length weight regression line when applying power function should have values between 2.5 to 3.5 with the high correlation coefficient (>0.9) for aquacultured fish species. However, the body shape of Sahar was more symmetrical than the Sahar raised in ponds in mid hill as indicated by the differences in power function of body length.

Table 2. Summary of growth of Sahar in grow out ponds in hill and terai, Nepal

Month	Hill	Terai
Stocking weight, g	3.6 ± 1.2^a	3.6 ± 0.74^a
Final weight, g	39.0 ± 5.8^a	60.8 ± 10.4^b
Net weight gain	32.8	50.6
Rearing period, day	210	210
Growth rate, g.day^{-1}	0.18	0.28

Different superscripted letters within rows are significantly different at $P<0.01$.

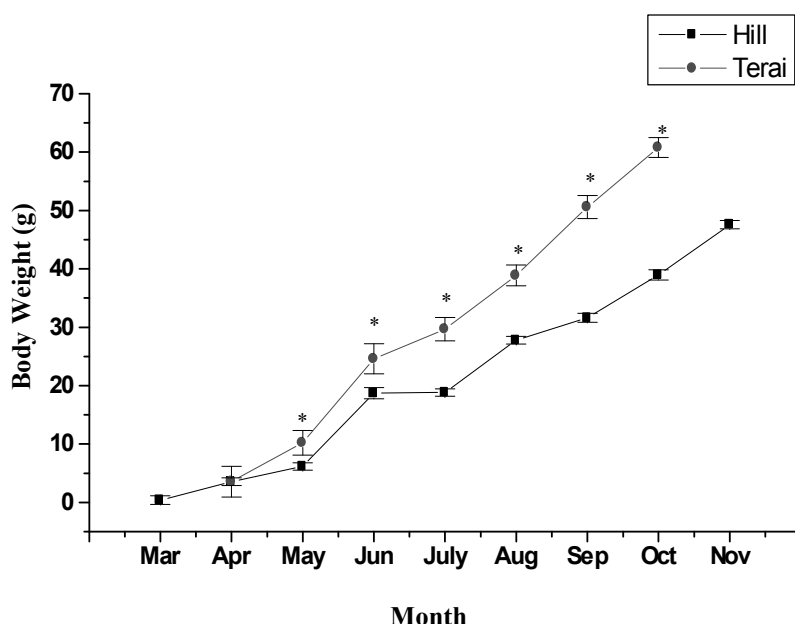


Figure 1. Monthly growth ($\text{g} \pm \text{SE}$) of Sahar (*Tor putitora*) in hill and terai

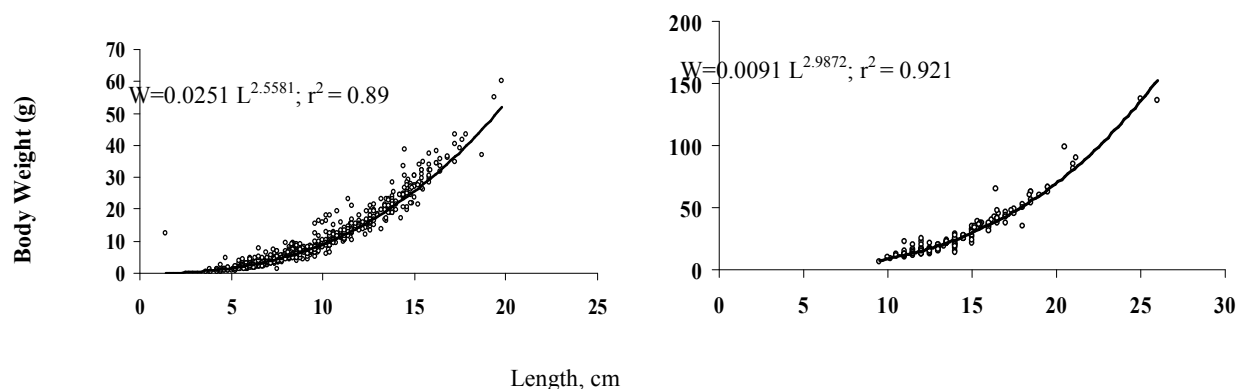


Figure 2. Length-weight relationship of Sahar in mid-hill and terai

Temperature tolerance of Sahar for growth and reproduction is similar to other carps. Bista et al (2001) observed that Sahar can survive and thrives well at water temperature over 30°C in summer season in rearing pond and cages in lakes of Pokhara valley without any adverse effect on its growth. In the present study, Sahar of different sizes from hatchling to fingerling were raised in ponds of mid hill and terai at ambient temperature between 22- 33.4°C and 20-32°C temperature in Mid-hill, respectively during the study period. Bista et al (2001) reported merely 0.12 g.day⁻¹ growth rate of Sahar at temperatures ranging from 15-18°C. The higher growth rate of Sahar in terai in all months observed in this study might be the results of favorable temperature during grow out period.

Significant differences in cumulative net weight gain of Sahar reared in the mid hill and terai suggest that warmer region is more favorable for the grow-out of Sahar in captive environment. Relatively high growth rates of Sahar in terai region was also reported by Rai et al (2007). However, observed daily weight gain (0.18 to 0.28 g/day) of Sahar are far below then the growth of other carp species being used in fish farming systems of the country.

The growth potential of Sahar observed in captive environment in different ecological regions provides the opportunity to include this species in current aquaculture setting of the country. However, sustainable inclusion of Sahar in aquaculture could be assured by the development of a suitable breeding and rearing technology which requires knowledge on the nutritional requirement and feed formulation for different development stages of Sahar. At present very limited information on feed, feeding and nutritional requirement of Sahar is available. Nutritional studies, focusing on requirement level of different nutrients for the different stages of fish and utilization of locally available resources, are needed to accelerate the growth and to ensure affordability by the growers. Further, well designed multidisciplinary experiments could explain the pond productivity of Sahar in mono and polyculture as well as the level of interaction with other carp species for production and economics in polyculture fish farming.

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Identification of Bacterial Isolates Collected From Fresh Water Fish

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ABSTRACT

Bacterial diseases are among the most important and common problems faced by aquaculturist worldwide. Identification and treatment of causative agent based on gross sign are sometimes not very effective because several isolates of the pathogens are associated with other aquatic vertebrate diseases. In this study, bacterial isolates were isolated from two different places, FRD Godawari and FRC Pokhara and diagnosed by obtaining pure culture followed by phenotypic test (morphological, physiological and biochemical test) and compared with existing diagnostic scheme. Based on certain uniformity such as Gram-negative and positive reactions for catalase, oxidase and fermentative reaction on glucose enables to identify the isolates, *Aeromonas hydrophila*. Some sugar utilization and decarboxylase test showed differences in strains of *Aeromonas hydrophila*.

Key words: *Aeromonas hydrophila*, bacterial isolates, causative agent

INTRODUCTION

Cultured fish species suffer a wide variety of diseases including bacterial, viral, parasitic and fungal infections (Austin and Austin 1993, Adams et al 1995). Bacterial diseases are of frequent occurrence in fish. In Nepal, *Aeromonas* sp., *Streptococcus* sp., *Pasteurella* sp. and *Flavobacterium* sp. had been identified in different years from cultured fish species. Motile aeromonad septicaemia is a typical disease of fresh water cyprinids caused by pathogenic *Aeromonas hydrophila* pathogens (Stickey 2000). It is facultative, opportunistic pathogens instigate infection in freshwater fish when the host resistance has been lowered by environmental stress factors such as high organic load, over crowding and sub lethal oxygen levels (Snieszko 1974, Sinderman 1979). Such conditions are very common in Nepal in old pond, hatcheries and intensive cultured fish species like trout.

It causes many kinds of serious diseases in fish by its hemolysin, enterotoxin and other mechanism (Ellis 1988) and credited with causing several distinct pathological conditions including tail/fin rot and haemorrhagic septicaemias. Disease symptoms is characterized by the presence of small surface lesions which lead to the sloughing off scales, local haemorrhage in body, ulcers, exophthalmia and abdominal distension (Austin and Austin 1993, Inglis et al 1993). Natural fish kills on lakes and reservoirs in the spring are often results of motile aeromonad septicemia (Hawke 1974). Torres (1990) suggested that *A. hydrophila* serotype I was the causative agent of EUS. Diseases are more pronounced in young fry due to lack of immune competence in fish at this early stage of life (Swain et al 2002). It affects a number of fish species like common carp *Cyprinus carpio*, Rohu *Labeo rohita* (Kozinska and Antychowicz 2001), Snakehead *Ophiocephalus striatus*, catfish *Clarias batrachus*, rainbow trout *Oncorhynchus mykiss* (Lio-Po et al 1992, Llobrera and Gacutan 1987, Cahill 1987) and hybrid catfish *Clarias gariepinus* (Tonguthai et al 1993).

Although loss depends on magnitude and duration of infection, great losses of fish due to this bacterium have been reported in South Asia (Areerat 1987, Llobrera and Gacutan 1987) and other regions of the world (Amin et al 1985). In Nepal, economic losses resulting from bacterial disease was unreported because of limited work on identification of species specific bacteria. Loss (31.8%) of commercial sized rainbow trout (FRD 1998) due to *Aeromonas cavia* was reported. Loss of fish production from 15 to 20 percent (Anonymous 1991) in eastern region of Nepal was also reported due to EUS infection. Disease control is therefore an essential component of successful fish cultivation.

The most shortcomings in diagnosis of disease are identification of bacterial isolates. In Nepal currently bacterial diseases are identified and treated based on gross signs. Identification and treatment of causative agent based on gross sign are sometimes not very effective because quite often mixed infection may occur; this complicates the diagnosis of specific disease. Therefore, isolation of pure culture of bacterial pathogen is of primary significance to distinguish between different types of symptoms.

MATERIALS AND METHODS

Two isolates from common carp, Rohu and Kande were taken at Pokhara and Godavari at different time frame. The fish were sacrificed by incision. Samples for bacterial isolates were obtained aseptically from liver and kidney and inoculated directly into Brain Heart Infusion (BHI) agar. The culture was incubated at 37°C for 24 hour. The dominated isolates were purified and identified based on biochemical and other tests outlined by Buchanan and Gibbons (1974). Bacteriological investigations were done after confirmation of specific sign of infectious disease by external examination.

RESULTS AND DISCUSSION

Growth of isolate on Brain Heart Infusion (BHI) agar media after 24-h culture period showed round, raised and yellowish colonies. The results showed that isolates were Gram-negative, motile, short-rod, facultative anaerobes with catalase and oxidase positive. Other characteristics are summarized in table 1. Various morphological and biochemical test included in this study to characterize the stock of isolates which were comparable with previously described strains. Biochemical method of bacterial identification had been featured in many reports (Boulanger et al 1977, Poff 1984, Plumb 1999, Stickney 2000).

These observed characteristics were similar with results of Stickney (2000) that reported *Aeromonas hydrophila* as a facultative anaerobe, oxidase positive and gram-negative rod. The isolates produced acid from maltose and manitol. Both gas and acid were produced from glucose. Acid from sucrose, maltose and lactose utilization showed negative results. The reaction was negative for ornithine decarboxylase but hydrolyzed arginine and lysine. The isolates utilized citrate as a sole source of carbon. The reaction for methyl red (MR) was negative but showed positive reactions for Voges-Proskauer (VP) test and indole test. Oxidative-fermentative test (O-F test) showed fermentative reactions but hydrolyzed only glucose from triple sugar iron (TSI) test. The results of this study were also supportive to Kaper et al (1979) findings who found isolates of *Aeromonas hydrophila* gave an alkaline reactions, indole positive but not produced H₂S. The species was also very much related to those of Frerichs (1984), Austin and Austin (1993), Buchanan and Gibbons (1974) and Burke and Rodgers (1981) description of *Aeromonas hydrophila*. However differences were noted in acid production from sucrose which was negative in present study while these workers reported positive for this test. The positive reaction for lysine decarboxylase was also contradictory with the results of Frerichs (1984) who found negative reactions. Differences in some sugar utilization of present isolates to previously described strains of *Aeromonas hydrophila* might be due to heterogeneity within the species descriptions. Austin and Austin (1993) mentioned phenotypic variation within species of *Aeromonas hydrophila*. However based on certain uniformity such as Gram-negative reactions, positive reactions for catalase and oxidase and fermentative

reaction on glucose enables to identify the isolates obtained in this study was *Aeromonas hydrophila*. However, many other additional morphological, biochemical and physiological tests are always essential to obtain the exact identification of microorganism at species level.

Table 1. Biochemical reactions of bacterial isolate used in present study

Characteristics	Isolate 1 (Common carp)	Isolate 2 (Rohu)	Isolate 3 (Kande)
Gram-stain	-	-	-
Shape	Rod	Rod	Rod
Motility	+	+	+
Catalase	+	+	+
Oxidase	+	+	+
Sugar utilization			
Glucose	+/Gas	+	+/Gas
Sucrose	+	+	-
Lactose	+(Weak)	Variable	-
Manitol	+	+	+
Maltose	+	+	+
Salicin	+	+	NA
Indole test	+	+	+
Methyl red test	+(Weak)	-	-
Voges-Proskauer test	+(Weak)	+	+
Triple sugar iron test	K/A (alkaline)	K/A	K/A Gas
Citrate utilization	-		+
O-F test	+/+ Fermentative	+/+	+/+
Esculin hydrolysis	+	+	NA
Starch hydrolysis	+	+	+
Gelatin hydrolysis	+	+	NA
Nitrate reduction	+ weak	+	+
Decarboxylase test			
Arginin	+	+	+
Lysine	+ Weak	Variable	+
Ornithin	-	-	-

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Occurrence of *Ichthyophthirius multifiliis* on Snow Trout Fry (*Schizothorax richardsonii*) in Godawari Fish Farm, Nepal

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ABSTRACT

The protozoan parasite identified as *Ichthyophthirius multifiliis* Fouquet (1876) was first time noticed on snow trout (Asala) fry (*Schizothorax richardsonii*) reared in Godawari Fish Farm. The parasitism of *I. multifiliis* to Asala fish is a new occurrence in Nepal. Site of occurrence of *I. multifiliis* was observed in wet smear of skin, fin and gills scraping as well as in the underlying musculature of skin in histological studies. Diameter of isolated organisms *I. multifiliis* was measured ranges from 0.0505-1.1666 mm under microscope. The mean prevalence of *I. multifiliis* to Asala fry during rainy season (June 2007) estimated was 64.1 percent. The daily mortality rate of Asala fry, observed for nine days, due to *I. multifiliis* infestation ranged between 0.2 to 12.6 percent.

Key words : *Ichthyophthirius*, protozoan parasite, prevalence, occurrence, rainy season

INTRODUCTION

Ichthyophthirius multifiliis Fouquet (1876), the pathogen of ichthyophthiriasis, is a holotrichous and ciliated protozoan parasite that infects the skin and gills of freshwater fish (Robert and Moeller 2008, Maki et al 2001). It is known as one of the most dangerous pathogens to food and aquarium fish. The geographical distribution of the parasite is very wide. Schaperclaus (1954) observed the Ichthyophthiriasis (white spot disease) is not only reported among all fresh water fish species but also among coral fish and red bream too. Thoesen (1994) and Roberts (1978) also reported that white spot is one of the most common disease encountered in cultured fresh water fishes of Southeast Asia. Paperna (1980) has been studied the Carp and Cyprinids fishes of India and Israel are very susceptible and frequently succumb to *I. multifiliis* infection.

In Nepal, among Cyprinidae fishes, Asala (Snow trout) is considered as high valued cold water riverine fish. Since 1971, visualizing the livelihood of hilly region people research has been successfully carried on breeding and culture aspect of Asala fish species namely *Schizothorax plagiostomus* and *Schizothoracichthys progastus* at the Fisheries Research Centre Trishuli. Preliminary studies on feeding aspect of an Asala fish species known as *Schizothorax richardsonii* is being carried out at Fisheries Research Division, Godawari since 2006. But during feeding trial period suddenly mass mortality of Asala fry was reported in FY 2007 at Godawari. Therefore this high valued potential Asala fish species has been studied in disease aspect. The main objective of this study was to diagnose and identify disease that suddenly occurred in snow trout (*Schizothorax richardsonii*) fry at Godawari Fish Farm.

MATERIALS AND METHODS

Study on surveillance of fish parasite was carried out during rainy season when Asala fry (*Schizothorax richardsonii*) in a feeding trial was died suddenly at Godawari Fish Farm. Raceway ponds (1.89 m² each) stocked with Asala fry at density 170 fry/m² were continuously irrigated with spring water. The fish fry under feeding trial receiving a ration approximately contained 35percent crude protein.

Moribund fish were sampled during 3-13 July, 2007 when parasitic infestation in Asala fry was noticed. Basic water quality parameters including temperature, pH and dissolved oxygen were measured during the collection of fish samples. The weight and length of sampled fish ranged between 0.67 g to 0.78 g and 4.17 to 4.37 cm, respectively. Wet smear of gills, skin and fin of Asala were examined under microscope to observe *I. multifiliis* parasites. Taxonomic identification was based on diameter measurement of *Ichthyophthirius multifiliis* (protozoan parasite) using light microscopy as adopted by Schaperclaus (1991), Paperna (1980), Thoesen (1994) and Roberts (1978). Prevalence rate of *I. multifiliis* to Asala fry were calculated using following formula:

$$\text{Prevalence rate (\%)} = (\text{No. of attacked fish with parasite} / \text{Total No. of examined fish}) \times 100$$

Histological examination involved the dissection of skin and underlying musculature from live Asala fry and fixation of tissues in 10% formalin for 24 hours, then into 70% alcohol for storage. Fixed tissues were cut into 5 mm thick sections and placed in cassettes for processing over night (12 hours). Processed tissues were then embedded in 56°C wax. The prepared blocks were sectioned at (5 µm) using a rotary microtome. Sections were placed on slides after floated out in 45°C water bath. Then the slides were kept overnight in an oven at 36°C followed by 60°C for 30 minute to complete drying. Dried slides were stained using Haematoxylin and Eosin stain. All stained slides were permanently mounted in Depex and placed overnight in the oven at 36°C for drying to study the status of tissue structure under microscope.

RESULTS AND DISCUSSION

Asala fry were reared at water temperature between 19 to 21°C, pH 6.5 to 6.9 and dissolved oxygen 7.0 to 7.2 mg/lit during the parasite *Ichthyophthirius multifiliis* outbreak. The water depth of raceway (rearing unit) was 0.6 m and the water flow rate was 62 lit per minute.

Occurrence of *Ichthyophthirius multifiliis* Fouquet (1876) of phylum protozoa was first time noticed in Asala fry reared in Godawari Fish Farm. The parasite *I. multifiliis* to Asala fish is proposed new occurrence in Nepal. Asala fry of 0.67 to 0.78 g in body weight and 4.17 to 4.37 cm in total length has shown *I. multifiliis* infection. Site of occurrence of *I. multifiliis* was observed in skin, fin and gills scraping (Figure 2). Histological study revealed that underlying musculature of skin also infected with *I. multifiliis* (Figure 3).

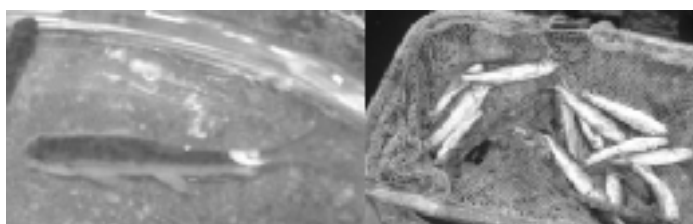


Figure 1. Size of *Ichthyophthirius multifiliis*-infected Asala fry (*Schizothorax richardsonii*)

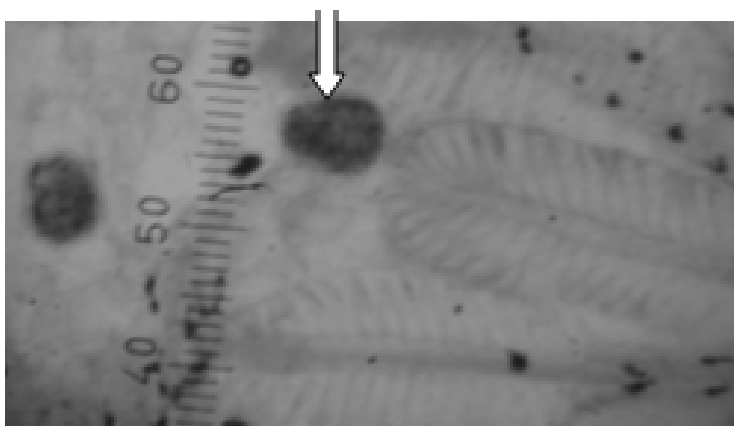


Figure 2. Gills of Asala fry infected with *Ichthyophthirius multifiliis*

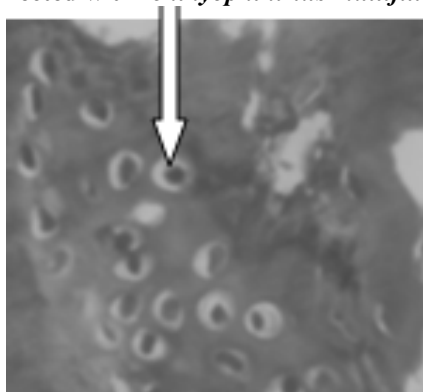


Figure 3. Abundance of *Ichthyophthirius multifiliis* in underlying musculature of skin of infected Asala
Ichthyophthirius multifiliis isolated from gills, skin and fins of Asala fry were round to oval in shape under microscopic investigation. The organism cell contains macronucleus and micronucleus (Figure 4). Existence of both macro and micronucleus *Ichthyophthirius multifiliis* Fouquet (1876) has been reported by Schaperclaus (1991), Paperna (1980), Thoesen (1994) and Roberts (1978). Diameter of *I. multifiliis* was ranged between 0.0505-1.1666 mm under microscope (Table 1). The total body length of 21 organisms/specimens was ranges from 0.0505 to 0.3535 mm long and 0.0202 to 0.3535 mm wide (Table 2). Similar observation in diameter and length of 21 organisms *Ichthyophthirius multifiliis* Fouquet (1876) made by Schaperclaus (1991)

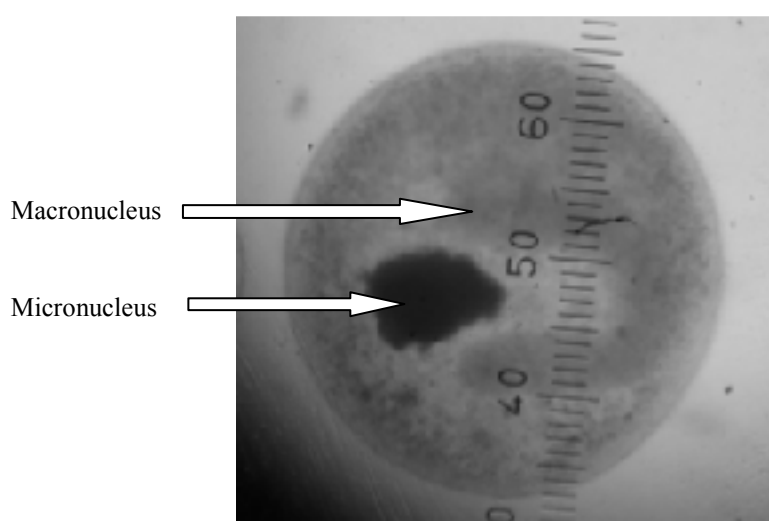


Figure 4. Nucleus of *Ichthyophthirius multifiliis* in Asala fry

Table 1. Morphometric measurement of organism *Ichthyophthirius multifiliis* Fouquet (1876) isolated from Asala fry at Godawari Fish Farm

S. No.	Total body length (mm)	Total body width (mm)	Total organism diameter (mm)
1	0.2323	0.2525	0.2424
2	0.1515	0.1616	0.1565
3	0.1111	0.1111	0.1111
4	0.1818	0.1818	0.1818
5	0.0909	0.0909	0.0909
6	0.1212	0.1212	0.1212
7	0.0909	0.0202	0.05555
8	0.1414	0.1414	0.1414
9	0.1818	0.1515	1.1666
10	0.0808	0.0808	0.0808
11	0.0505	0.0505	0.0505
12	0.0707	0.0707	0.0707
13	0.1212	0.1515	0.1363
14	0.1515	0.202	0.1767
15	0.2222	0.2222	0.2222
16	0.1313	0.1313	0.1313
17	0.1414	0.1414	0.1414
18	0.3535	0.3535	0.3535
19	0.2323	0.2323	0.2323
20	0.1212	0.1212	0.1212
21	0.2525	0.2121	0.2323
Mean	0.1539	0.15246	0.20079
SD	0.0724	0.07631	0.23313

The mean prevalence of *I. multifiliis* to Asala fries was 66.8% with range between 28.6 to 100 percent during 9 days of observation (Table 2). Mortality of *I. multifiliis* infected fish fry ranges between 0.2 to 12.6 percent per day (Figure 5). Cumulative mortality of fish in nine days of *I. multifiliis* infestation was 35.1 percent out of 2883 fry. The infestation of *I. multifiliis* in Asala fry during rainy season (July) assumed to be the cause of adverse environmental condition in term of polluted (silt load) water supply in raceway ponds at Fisheries Research Station, Godawari.

Table 2. Prevalence of *Ichthyophthirius multifiliis* in Asala fry reared in raceway ponds at Godawari Fish Farm, Lalitpur

Date	Fry No.	Percent prevalence	Dead No.	Percent mortality
3 June, 2007	2883	28.6	183	6.3
4 June, 2007	2700	86.7	34	1.3
5 June, 2007	2666	100.0	175	6.5
6 June, 2007	2491	-	278	12.6
7 June, 2007	2213	-	30	1.4
8 June, 2007	2183	-	4	0.2
9 June, 2007	2179	52.0	11	0.5
10 June, 2007	2168	-	11	0.5
11 June, 2007	2157	-	23	1.2
12 June, 2007	2134	-	0	0.0
13 June, 2007	2134	-	0	0.0
Average±SD		66.8± 32.5	83.2± 101.2	3.4± 4.2

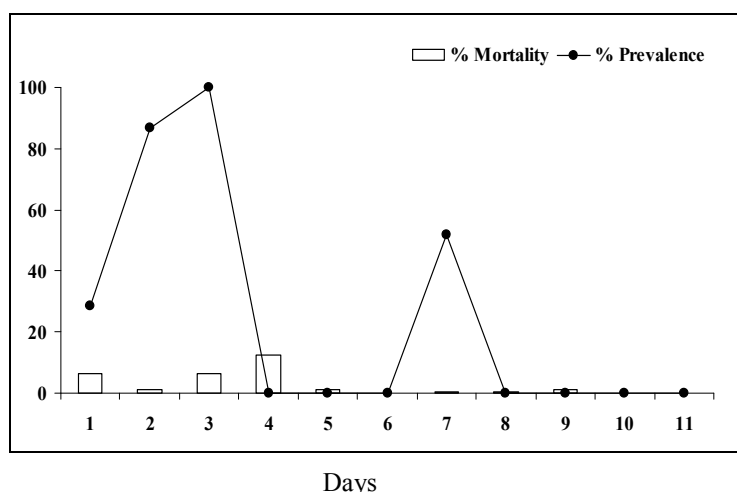


Figure 5. Percentage prevalence of *Ichthyophthirius multifiliis* in Asala fry and fish mortality caused by the parasite

Combined treatment of Formaldehyde at 200 ml/m³ water and malachite green at 0.15 mg/lit was found effective to minimize the *I. multifiliis* infection in Asala fry. Treatment was carried 6 days for 25 minutes/day with slow running water along with aeration and then the treated water was completely flushed out.

This observation revealed *I. multifiliis* of phylum protozoa can be considered pathogenic to Asala fish at fry stage during unfavorable environmental condition. In the present study, outbreak of *I. multifiliis* in cold water fish Asala was observed when water temperature raises between 19-20°C. Bauer (1959) found that carps with 6-8 mm in body length are highly prone to *I. multifiliis* parasite at water temperature 20°C. The observed pH value (6.5 to 6.9) of water could have insignificant effect on the occurrence of *I. multifiliis* in Asala fry, since a higher value (7.3 to 7.9) of pH is considered optimum for *I. multifiliis* outbreak in carps (Wagner 1960). Beside water temperature, the outbreak of *Ichthyophthirius* in Asala fry could be linked to host fish size, stocking density, and supply of turbid water (silt laden) and rate of water flow in fish rearing tanks.

CONCLUSION

General conclusion of this study may be existence of *Ichthyophthirius multifiliis* on Asala fry is new occurrence in Nepal. It is speculated that to great extent unclean/contaminated and insufficient water may stimulate *Ichthyophthirius* diseases to Asala fry. Rational stocking density of fish, supply of balanced ration and maintenance of water quality (temperature, transparency) and quantity (volume, discharge rate) in fish rearing unit would be the preventive measure. Prophylactic treatment in combination of formaldehyde and malachite green at preliminary stage of infection could be suggested to cure the fish from the *I. multifiliis* infestation.

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Emerging Food Security Challenges and Sustainable Management Strategies in Nepal

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ABSTRACT

Nepal having 31 percent of the population below poverty line is now an importer of food grains. Agricultural productivity of Nepal is gradually declining though agriculture contributes about 33 percent of GDP. The total food grain production is lower than the total food grain requirement showing some deficit in food grains availability. This is due to the fact that most districts in the high hills and hills are food deficit due less arable land compared to population, long gestation period for crop growth and high per capita consumption of energy. Food security is influenced by three parameters- food availability, access to food grains and utilization of food grains. Urban areas are better off than the rural areas due to well-organized transportation and food distribution system. Food insecurity is caused by various social, economic, political, physical and environmental factors. Marginalized and low caste communities throughout Nepal have poorer access to food grains, water, sanitation, hygiene, and health making them more food insecure and prone to malnutrition. The major victims of food insecurity are subsistence farmers, the low caste, tribal communities, girls and female-headed households. Food security can be improved by increasing food availability by utilizing natural, physical and human resources, input supply, increasing land fertility and productivity. Food security can also be improved by increasing access of poor people to food through commercialization, improved processing, income generation activities, effective distribution and transportation network. Lastly, food security can also be improved by making proper utilization of food grains in terms of consumption pattern through awareness and education. The comparative advantage of hills and mountains lies in producing high value horticultural produce for the Terai market rather than food grains. The cereals and other high volume foodstuffs produced in Terai can be transported up in the hills. Thus Hill-Terai integration strategy should be followed with improvement in transportation network for shuttle exchange of high value commodities and food grains respectively to achieve sustainable food security in the country.

INTRODUCTION

Nepal as a whole remains poor and a significant proportion of its people live in poverty. The per capita income of Nepal is US \$ 311 that is low compared to other countries in the world. About 31 percent of the population is below poverty line. The re-structuring of the economy has been insufficient to generate the kind of industrial and service sector growth, which could compensate for a slow-moving agrarian economy. Nepal remains heavily dependent on its agricultural economy, and food security remains to be a major issue. The predominantly subsistence agrarian economy appears unable to maintain food self-sufficiency in all regions and districts across the country. The emergence of an economy in which food security could be assured by the purchase of food in the market with incomes earned in other sectors, as in more developed economies – has only just begun. If the population is unable to import or purchase additional food grains to make up the gap as a result of their low purchasing power then the district will suffer from a lack of food availability. Actually it is poverty that gives rise to food insecurity. There are some regions in Nepal in serious difficulties; experiencing general food shortages and that within those regions there will be significant numbers of the less well-off whose food security will be in extreme jeopardy. Some 40 percent of the population as a whole is estimated to live in poverty and of these;

roughly half could be regarded as extremely poor, though this proportion varies considerably from region to region. Most of the rural poor rely on laboring for the bulk of their income and most are in debt. Many also suffer from various forms of social and cultural discrimination by virtue of their caste or ethnic affiliation, their gender or their age. Those with least control over and access to the means of production, or reliable alternative sources of income, are the most dependent on their own labor, and are particularly vulnerable to exploitation and oppression. In Nepal, poor rural households have always tended to face relatively high levels of insecurity and low levels of goods and services enjoyed and have always been vulnerable. Bonded labor, 'untouchability', gender discrimination, and other forms of exploitation, oppression and social injustice remain widespread and deeply entrenched in the rural areas.

Food is the most basic need of mankind besides shelter, clothing, education and health. People who cannot fulfill these basic needs are categorized as the poor. Food is the first and foremost need to sustain thread of life. Food security is the subject of prime concern of all organizations like Governments, NGOs, INGOs, international cooperation missions and donors etc. It is necessary to increase food grain production to meet the needs of rising population. Every year, millions of people are bound to lose their lives due to famines and hunger and the poor countries are unable to protect lives of their citizens. Food security system can be developed at family, society, national and international levels. The basic objective of food security is to maintain a stock of food grains for minimum requirement and certain period of time.

Rich countries pay attention to the quality of food grains too but the backward and poor countries are bound to pay attention to the quantity of available food grains instead of their quality. Food security and sustainable livelihoods are the areas of prime concern to the marginal communities and backward women. It is the duty of the state to address these aspects to ensure their basic human rights. 16th of October is celebrated as World Food Day to ensure food security in the world with relevant slogans.

DEFINITIONS OF FOOD SECURITY

Food security is the state which creates situation for all to eat well. World Food Summit meeting of 1996 held in Italy has defined Food Security as a condition that allows people to be economically and physically capable to secure healthy and nutritious food of necessary quality and quantity for their proper health and activity. This definition is widely accepted. Food security should be taken in relative terms rather than on absolute terms and it is interrelated rather than isolated. Food security depends mainly on availability of food grains, access to food grains and capability to utilize food grains. Food security is negatively influenced by human activities, needs and interest, civil war, social conflict, rising population, unscientific agricultural system, declining production, unbalanced distribution of production etc. If the country's food grains can meet the needs of population, then the country is said to have food security balance. The difference between food grain requirement and food grain production availability as well as extent of self sufficiency in food grains are the indicators of food security. Food security is thus defined as creation of the condition which can protect the lives of the people through management and utilization of adequate food grains. Mankind needs nutritious food for his life and activity and food security is thus his basic right. Food security is to provide continuous access to necessary food items for everybody physically and economically and to develop food purchasing capacity through distribution of inputs for production of food grains.

AGRICULTURE AND FOOD SECURITY

The agricultural sector dominates Nepal's economy, producing 38 percent of GDP and employing about 66 percent of the population. However, Nepal's agricultural productivity has been gradually declining over the years (Tiway 2002). This happened because Nepal's agricultural sector has stagnated due to gradual decline in soil fertility (Gill 1996). Over the past decade, Nepal's agricultural GDP has grown at a sluggish rate (1.7%) compared to population growth (2.3%) causing a decline in per capita production (Table 1). Cereal grains have contributed about 33.38% of GDP followed by livestock (27.66%), horticultural crops (fruits and vegetables, 15.8%), cash crops (9.59%), forestry (9.24) and fishery (0.99%). With production failing to keep pace with population growth, the country that was exporter till 1980 has been a net importer of cereals since then (Koirala and Thapa 1997).

Table 1. Contribution of Agriculture to Gross Domestic Product (GDP in crores)

Sector	2005/06			2006/07		
	Rs	%	Growth Rate %	Rs.	%	Growth Rate %
Agriculture	21282.7	38.1	1.7	22867.7	31.78	0.7
Non-agriculture	34504.2	61.9	2.8	49080.0	68.16	-
Total	58294.8	100	1.9	71947.7	100	2.5

Of the total cultivated land of 31 lakh hectares, only 11 lakh hectares of land (31%) is irrigated and rest depends on rainfall. Agriculture is thus the gamble of rainfall improving in good rainfall years and declining in adverse years. Due to climate change, unpredictable monsoon pattern and lack of timely rains, agricultural production is subject to seasonal fluctuations. As a result, the country is experiencing food scarcity problem quite often. There is every possibility for outbreak of famine and hunger in some parts or region of Nepal due to decline in agricultural production in contrast to rise in population. Due to lack of modernization and commercialization of agriculture, the country's food security is at stake. Though agriculture is considered as the basis of subsistence of majority of population in Nepal, alternative means of employment opportunities are not being created. Population engaged in agriculture has reduced from 81 percent to 65.7 percent and the contribution to the gross domestic product has reduced from 72 percent to 38 percent with diminishing annual growth rate of 1.7 (2005/06). It indicates that there is still excessive dependence and pressure of population on agriculture. The agricultural productivity of the country has also gradually declined. The disguised unemployment is 45 percent in agricultural sector. However, there is ample scope to manage poverty, hunger, unemployment and migration problems through agriculture. We are not able to develop organized market due to absence of coordination between producers, consumers and traders. The evolution of food scarcity and lack of agricultural entrepreneurship are the results of backward and traditional agriculture and production system.

POVERTY, LIVELIHOODS AND FOOD SECURITY

The livelihoods of rural population in Nepal are often vulnerable and insecure, and this situation had been worsened by the long-running Maoist uprising, out-migration, traditional agrarian and land tenure system, unequal structure of ownership, changing pattern to food access and power structures in the country. It is clear that millions of small farmers, landless rural families, and unskilled urban workers are food insecure. Poverty has further increased from 33 percent in 1977 to 42 percent in 1995/96 in both absolute and relative terms. Poor communications, low purchasing power and lack of market are major constraints in the hills, mountains and Terai. Food security is not an isolated phenomenon, but is associated with socio-economic, political and environmental factors. Farm households depend on both off-farm and on-farm income sources. A small proportion of the rural population is able to survive on the basis of food self-sufficiency and some on their own farm production while larger proportions are food-deficit and thus insecure.

The incidence of poverty is high and apparently growing in relative, as well as absolute, terms ranking Nepal as 13th from the bottom of 90 developing countries (HD Report 2001) and almost 38 percent of the population fall below the 'dollar a day' poverty threshold (UNDP 2001). It is estimated that the incidence of poverty has increased from 33 percent in 1977 to 42 percent in 1995/96 (UNDP 2002) with percentage of undernourished remaining constant throughout the 1990s. Participatory poverty assessments among rural communities across the developing world tend to identify poverty as the most basic cause of food insecurity. In a relatively large-scale study in Nepal, the three most-cited indicators of food security were access to land, livestock ownership and having skilled labor (Adhikari and Bohle 1999, WFP 2001). The government's assessment is that the principal groups of poor people are subsistence farmers, those of 'occupational' castes, *dalits*, tribal communities and female-headed households (HMG 2002). According to WFP (2001), the following variables 'explain' the poverty and food security status of households: (i) literacy of the household head, (ii) proportion of household

members who are able-bodied, (iii) land ownership, (iv) access to irrigation, (v) tenancy status, (vi) ownership of draught animals, (vii) ownership of other animals, (viii) bonded labor households, and (ix) access to improved drinking water. The same study established that the occupational and disadvantaged castes as well as the remote areas were regarded as more food insecure.

CONFLICT AND FOOD SECURITY

The long Maoist insurgency immediately followed by current Madheshi movement that appeared as civil war have exacerbated food insecurity and owe much to stagnation in economic development during the peace process since 1963. In a conflict situation that engulfed the country for about 10 years (1996-2006), food security was at stake (Gill 2003). There was wide male migration pattern, increase in the vulnerability of women and children, and reduced food production. The insurgency caused heavy loss of casualties (>15,000 people), destruction of Government premises, bridges and restriction in the movement of people and food to deficit areas. It seriously disrupted traditional livelihood activities such as the collection and sale of non-timber forest products, requisitioning of food supplies by the insurgents and looting of WFP and Government food stocks. As a consequence, there was general economic slow-down, including a sharp reduction in tourism and closing down of important livelihood opportunities. Even after the cease-fire and peace agreement, food security situation has not improved.

Agricultural as well as food production has been adversely affected by the conflict to a limited extent through displacement of small landowners. Food insecurity exists in several regions of Nepal, but it is unclear to what extent this is a result of the conflict. The conflict has disrupted local economies and this might have significantly affected rural livelihoods. The food security situation is likely to be very precarious in remote mountain regions such as Karnali and other western high hills. The conflict that led to political insecurity in the recent past has affected food production, distribution, and traditional livelihood opportunities through decreasing mobility, market activity and employment. Food insecurity is causing increased migration.

STATUS OF FOOD SECURITY IN NEPAL BY ECO-REGIONS

Agricultural production is not able to meet the food grain requirement of the rising trend of population growth at 2.25 percent per annum. The total food grain requirement of the country is less than the total production of the country showing deficit in food grains as indicated by the figures of 2005/06 and 06/07 (Table 2). Among the regions, central and far-western regions are found food deficit.

Table 2. Food Balance (MT) Showing Security Situation of Nepal (2001/02 & 2005/06)

Region	Production	Requirement	Surplus/Deficit
A. By Region (2001/02)			
Eastern	1117348	1013672	103676
Central	1429440	1550745	-121305
Western	1021366	891949	129417
Mid-Western	601422	584409	17013
Far-Western	373473	422252	-48779
B. By Eco-Zone (1998/99)			
Himal/Mountains	194,883	322,648	-127,765 (16)
Hills	163,8491	202,1624	-383,133 (33)
Terai	226,4238	193,5219	329,019 (6)
Nepal	409,7612	427,9491	-181,879 (55)
Total / Nepal (2001/02)	4543049	4463027	80022
Total / Nepal (2005/06)	4867,825	4890,933	- 23,108
Total / Nepal (2006/07)	4753,340	4941,089	- 187,749

Source: Statistical Information on Nepalese Agriculture, 2001/02 & 05/06 (Figures in parenthesis are the number of food deficit districts)

Food insecurity problem is more prevalent in the hills occupying 38.7 percent of the cultivated land where 53.4 percent of the population live compared to Terai where 46.6 percent of the population lives. Due to higher soil fertility status, Terai is known as the granary of Nepal and the total production of Terai can feed its population for 1.5 years while the production of the hills cannot sustain its people for more than 7 months. The adverse agricultural production coupled by decline in rice production due to adverse rainfall has been causing food insecurity in adverse years quite often. 38 districts of Nepal are food deficit districts while rest 37 districts are food surplus districts. Among the food deficit districts, Kathmandu is number one followed by Banke, Lalitpur, Achham, Makawanpur, Mahottary, Dolakha, Bhaktapur, Baitadi, Rautahat, Doti and Rolpa. The food surplus districts of Nepal are Jhapa (1.1 lakh tons), Bara, Morang, Syangja, Parsa, Saptari, Bardia, Siraha, Kanchanpur, Dang etc. The districts that face food problem every year are Jumla, Humla, Mugu, Dolpa, Kalikot, Bajhang and Bajura. These remote food deficit districts do face food problem every year due to lack of transportation while other food deficit districts like Kathmandu and other districts of Terai do not face food problem due to road accessibility and transportation facility. Food security is of greater concern in remote and inaccessible districts with less development infrastructures. Some remote hilly and Himalayan districts do face food insecurity and hunger problems due to lack of well organized food grain distribution system. Families below relative poverty line do face food insecurity problem due to inability to maintain stock of food grains in time. As a result, food scarcity and hunger problem is being created in the hills and high hills every year. So hill-terai integration strategy should be adopted to address the food insecurity problems.

Food security issues in Nepal are governed by extreme topographical variation and consequently wide ecological, agricultural and economic diversity and poor connectivity. In terms of food production potential, the mountain districts are extremely disadvantaged, for three reasons- less arable land (0.3%) compared to population (7.3%), long gestation period for crop growth (one crop a year) and high per capita consumption of energy in terms of food. The food availability situation with respect to cereals is shown in Table 3.

Table 3. Cereal production-consumption balance by ecological division (mid 1990s)

Division	Production ('000 MT)	Consumption ('000 MT)	Surplus/deficit	
			'000 MT	Proportionate
Mountain (16 districts)	163	290	-128	79.0% deficit
Hill	1,340	1,831	-491	36.6% deficit
Terai	1,895	1,761	134	7.1% surplus
Nepal	3,398	3,883	-485	14.3% deficit

Source: Gill (1996) Table 1.2

All 16 mountain districts are classified as food-deficit due to their rugged terrain and lack of transport infrastructure that makes it expensive and difficult for food to reach them from outside. There are also serious food availability problems in the hills too with most of them classified as food-deficit.

Thus poverty, and therefore food insecurity, has an important spatial dimension, with the Central Region having only half the poverty incidence found in the Far (Table 4) Western Region due to unequal landholding structure and the feudalistic social relationships that prevail there. Within a given region, the mountains are poorer than the hills, and the hills are poorer than the Terai. However, some mountain districts like Mustang and Manang are better off due to livestock, tourism and trade.

However, urban areas are significantly better off than rural areas in terms of poverty indices, as can be seen from the Table 5.

Marginalized and low caste communities throughout Nepal have poorer access to water than the high caste, due to prevailing social norms. Only one in three families and schools have a latrine (even fewer in the rural areas). This could contribute to malnutrition in children due to diarrhea, dehydration and other water and air-borne diseases (UNICEF 2003).

Table 4. Incidence of poverty (%) by region and ecological division

Development Region	Ecological Division			Nepal
	Mountain	Hill	Terai	
Eastern	57	68	27	43
Central	48	31	34	34
Western	52	46	44	45
Mid-western	72	66	47	59
Far-western	80	73	49	65
Total	63	50	37	45

Source: UNDP 1998.

Table 5. Urban and rural poverty incidence (poverty line of NPR 4,404/person/yr)

	Head-count index (% Population below poverty line)	Poverty gap index	Squared poverty gap Index
Urban	23	0.070	0.028
Rural	44	0.125	0.051
National average	42	0.121	0.050

Source: NPC 2002, Table 1

MOBILIZATION AND DISTRIBUTION OF FOOD GRAINS IN NEPAL

The hills and mountains have comparative advantage in high-value produce and the Terai in food grains and there is need to capitalize on this through prospect through improvement of a broader transport systems approach. There is a great difficulty and weakness in the proportional distribution and marketing of food grains to remote rural areas due to geographic handicaps and transportation difficulties in Nepal. At the moment, Government is making genuine efforts through subsidies to distribute and drop food grains in remote areas and thus checking possible scarcity of food grains. Food Corporation of Nepal (FCN) is responsible to launch such activities in the country. FCN is also making constant efforts to stabilize prices of food grains in the accessible areas and thus maintain a balance in food grain supply.

Proportional distribution of food grains produced in the country is not possible due to geographic diversity, transportation problem and social conflicts. It is not of common interest to distribute and sell food grains in the remote areas due to more profit obtained from accessible areas. Food distributed by one group can be looted by another group during social conflicts. Thus there is possibility of obstruction on food security leading to hunger in deficit production areas. As a result, food security measures will be weak due to decline in food grain production and food scarcity problem will arise in food deficit areas due to lack of well organized distribution system of food grains. Due to open border, the surplus food grain produced in Terai is exported to India while it is difficult to transport food grains produced in Terai to remote hills and mountains that are food deficit. The nationwide food scarcity problems observed in the fiscal year 2059/60 in particular and other adverse years in general were due to low agricultural production caused by drought.

CAUSES OF FOOD INSECURITY AND THEIR IMPACTS

Food security is maintaining of adequate stock of food grains for possible future needs, emergency and rising population and its proper distribution. Food insecurity that is reverse to this leads the society and country into famine and hunger the consequences of which will be death and mal-nutrition. Food security issues of the country are governed by extent of food availability, extreme topographical variation and consequently wide ecological, agricultural and economic diversity and poor connectivity. About 15-20 percent of food grains are being lost through wastage and damage every year as post-harvest loss. Bulk of this loss (7-10%) is accounted for in the storages as damage by insects, rats, molds and birds. Since faulty and traditional storage structures and methods are one of the causes, it is necessary to improve them. The causal factors of food insecurity identified in Nepal are as follows.

Agriculture-related factors

- One kind of cropping pattern leads to decline in agricultural production while crop diversification, cropping systems and patterns could increase production.
- Decline in agricultural production
- Predominance of small farmers
- Rice-based subsistence
- Inability of food distribution system
- Misuse of food grains
- Lack of food production statistics

Socio-economic and political factors

- The social and political system that check the proportional access of marginal communities, women and rural poor people to sources of production and public property
- Interference of powerful lobbies on natural resources and environment
- The social, economic and political policies and organizations that limit use of results of development and social services to marginal farmers and women
- The policies and activities that have obstructed the landless, small farmers and women from the equitable use of nutrition, education, health, employment and fundamental human rights on the basis of caste, gender, religious and group exploitation, violence, discrimination and poverty.
- The open market culture that has widened the gap between the rich and the poor
- High production cost
- Open international border
- Increase in population
- Low purchasing power

Physical and operational factors

- The incomplete physical infrastructures present at local and national level
- There is also post-harvest loss of food grains during storage, processing, handling and transportation.
- Due to lack of transportation, the food grains produced in Terai cannot be transported up and marketed in the hills while the high-value horticultural and livestock products of remote hills and mountains have not received market.

Environmental factors

- Continuous deterioration of environment has led the natural resource-based livelihoods of poor people at stake. The input intensive inorganic farming has led to deterioration of decline in productivity of agricultural land, removal of soil fertility, pollution of water and air. It has also caused loss of forest resources, natural herbs and biodiversity.
- A decline in social and economic status and health of marginal communities and women is noticed due to deterioration of land and other natural resources and led to social disturbances and division.
- Agricultural lands are being washed away by soil erosion following torrential or excessive rains and causing decline in agricultural production.
- Due to lack of irrigation and erratic rainfall, there is decrease in agricultural production and productivity. Agricultural production will also decline due to low rainfall and drought.
- Natural calamities and disasters like storms, hurricane, fire, earthquake etc. The natural calamities damage crops and livestock and thus affect agricultural production and productivity.
- The pre and post harvest loss of food grains that are in large quantity are caused by biotic factors like insect pests, rats, birds, molds and fluctuations in storage conditions. It is necessary to develop post-harvest technology to minimize food losses.
- Geographic remoteness

Impacts of food insecurity will be more pronounced in disabled, aged, children and pregnant women (Table 6). Lack of proper nutrition will adversely affect the growth of newly born babies and pregnant women. Protein-calories malnutrition and under-nutrition problem has been observed in poor people particularly on children who can not eat good food. The disabled and aged poor people are more affected by food insecurity. Lack of proper nutrition among pregnant women will lead to birth of abnormal children, increased child and infant mortality and increase in economically inactive manpower. The major victims of food insecurity are subsistence farmers, the low caste, tribal communities, girls and female-headed households. Women, especially pregnant and lactating women, and children are also adversely affected by food insecurity in the form of mal- and under nutrition. Women, particularly pregnant and lactating women and housewives working in kitchen are particularly susceptible to nutritional insecurity and those who look after the kitchen are very commonly food-insecure, because they eat only the leftovers. Iron deficiency anaemia is by far the most common nutritional problem in Nepal. Children are major victims of food insecurity right from birth (low birth-weight) to young age due to malnutrition and nutrient deficiency (UNICEF 2003).

Table 6. Survival and nutritional indicators for Nepal

Indicator	Male	Female
Child mortality rate (per thousand live births)	45.5	56.5
Crude death rates (per hundred births)	12.9	13.6
Maternal death rates (per hundred thousand live births)	-	8.3
Life expectancy at birth	55.0	53.4
Nutritional status of children:		
Percent stunted	47.0	50.0
Percent severely stunted	19.0	22.0

Source: FAO (forthcoming) Table 3.22

There is also evidence of intra-household nutritional discrimination against girls in Nepal compared to boys.

NEED FOR FOOD SECURITY MEASURES

The Agriculture Perspective Plan (1995–2010) has aimed to reverse declining food availability. Government policies to improve food access have included fertilizer subsidies, grain procurement and distribution to food deficit areas, but assessments show the benefits went to the better-off. The PRSP/10th Plan aimed at high, sustainable and broad-based economic growth, social sector and infrastructure development, targeted programmes and good governance, but there is still stagnation due to prolonged gestation period for the logical conclusion of the peace process. Poverty reduction plans under APP (1995-2010) that failed to be pro-poor could not control rising food prices, increase farm incomes and new job opportunities. Pro-poor growth automatically translates into growth of the agricultural market which in turn stimulates agricultural growth. In Nepal, therefore, issues of food access should be closely tied up with issues of food availability. There is urgent need to address and focus pro-poor programs such as poor food quality, micronutrient deficiencies and poor food utilization. More needs to be done to channel food to the needy, improve access in remote rural areas and break the remoteness-food insecurity link by improving cross-zonal linkages. These are the challenges before the new Government in the context of formation of new constitution and reconstruction of New Nepal.

The government's chief policy instrument for addressing the problem of declining food availability is the Agriculture Perspective Plan (APROSC-JMA 1995) that is growth-focused (3 to 5%) rather than poverty-focused. Poverty reduction is viewed essentially as a consequence of this growth through falling food prices, increasing farm incomes, and the generation of employment opportunities for the rural poor through multipliers that rapidly expand the rural non-farm economy. APP has concentrated official service delivery mechanisms on the more favored parts of districts without much reducing rural inequality. The Tenth Plan (2003–2008) and PRSP (Poverty Reduction Strategy Paper) document have

viewed broad-based growth and employment generation as the principle means of transforming economic development for both alleviating poverty (NPC 2002) adopting four strategies as follows:

- High, sustainable and broad-based economic growth
- Social sector and infrastructure development
- Targeted programmes for the poor
- Good governance

If successfully implemented, all of these policies could have contributed to improved food security, particularly in the shape of better food access among the poor and disadvantaged. However, due to concentration and mobilization of all resources and money to the management of current political crisis and insurgencies (Maoist/Madheshi) in the country, the development efforts including food security management could not be given due attention. Donor like DFID, ADB, UNICEF, WFP and many others have been providing support for the pro-poor programs in Nepal but they are worried as the funds are not actually reaching the poor and thus not properly utilized. The country requires action on all three food security fronts -availability, access and utilization as well as action to reduce people's vulnerability to food insecurity as follows.

Increasing food availability

It is necessary to increase food production and at the same time maintain quality. It is also necessary to utilize natural and physical resources through development of human resources. Adoption of crop diversification system will help sustainable development of agriculture. The adoption of import substitution to meet internal demand and export promotion to earn foreign exchange will assure food security. The available ecological and genetic diversity can be utilized to produce diverse crops and livestock products in the country. The improvement in post-harvest management and processing will also help increase production. The marginal lands, steep slopes and rainfed lands can be used for horticultural crops. There should be improvement in the causes of low productivity as follows.

- Unequal distribution and unplanned fragmentation of land
- Exclusion of social and religious values and norms
- Lack of qualified and trained manpower in agriculture
- Poor access and participation of farmers
- Lack of infrastructures like irrigation, rural electrification, roads and communication
- Lack of location specific agricultural technology and production system
- Inadequate and untimely availability of production inputs
- Predominance of subsistence agriculture
- Lack of seasonal training to farmers
- Low export due to poor quality and standards
- Lack of local organizations and institutions
- Lack of improvement of processing technology

Increasing access to food grains

Though the population engaged in agriculture is gradually, it is not able to maintain a balance with industrialization and commercialization. To increase access of population to food grains, it is necessary to commercialize agriculture and the producers. Agricultural development should promote income generation activities to minimize disguised unemployment in agriculture. So it is necessary to promote micro-enterprises, processing, commercialization and agro-tourism in agriculture for entrepreneurship development and export. Production of cash crops and high-value low-volume products will help increase income and purchasing power of farmers to secure food grains. Food available and surplus in one place should be transported to another deficit place through well-organized marketing and distribution system.

Increasing utilization of food grains

More than half of population in Nepal is bound to manage with 1800 calories of food instead of 2100 calories. Cereal grains particularly rice that are the staple foods of Nepalese people are the major source

of nutrition that are in deficit. As a result, there is low production, low saving, low consumption and low investment in agriculture. It is necessary to obtain nutrition through proper consumption pattern from the production locally available. So people should be aware of nutrition and its utilization in daily diet. Women and children who are the victims of poor nutrition due to lack of education though the former are involved in the kitchen. Location, climate, religious background and sources of food grains directly influence the consumption pattern. So, people particularly women should be involved in the decision making process and livelihood programs.

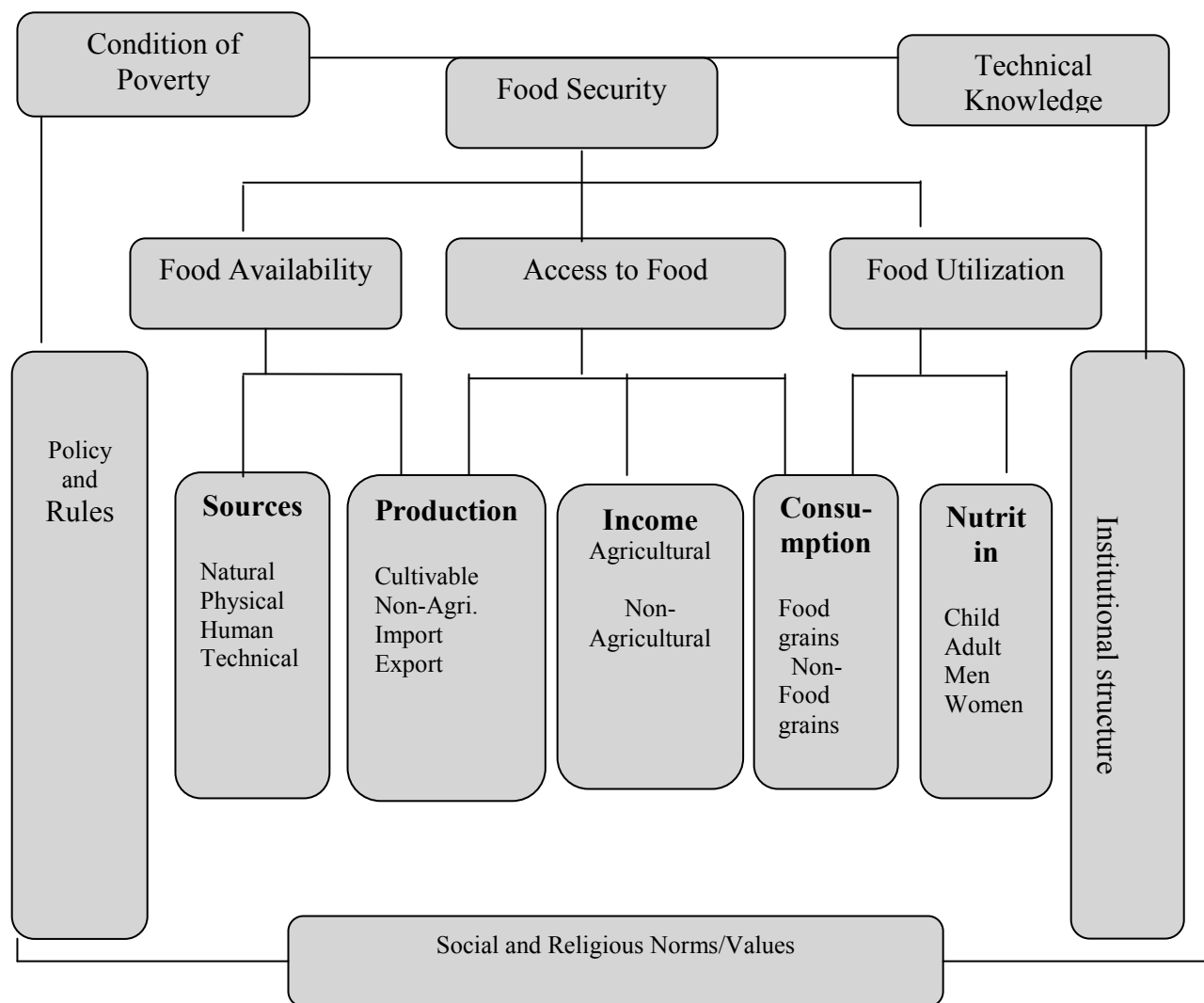


Figure 1. Model of Food Security Analysis and Management (Source: FAO)

SUSTAINABLE MANAGEMENT STRATEGIES SUGGESTED

The management strategies to be adopted for ensuring food security in the country should be as follows:

Potentials and priorities

1. The comparative advantage of hills and mountains lies in producing high value horticultural produce (fruits and vegetable seeds) for the Terai market rather than food grains. The cereals and other high volume foodstuffs produced in Terai can be transported up in the hills. On the basis of comparative advantage, the Terai's obvious market should be the food deficit districts of the hills and mountains.
2. The comparative and competitive advantage of food deficit districts should be harnessed to increase income that can be utilized to procure food stuffs.
3. Improvement in plant protection, post-harvest management and cooking may contribute to food security.
4. Promoting traditional food habits
5. Discouraging external assistance in food supply

Land use

1. Cultivation of steep slopes should be banned using sloping agricultural land technologies. People cultivating marginal vulnerable lands should be rehabilitated elsewhere.
2. Equitable distribution of land and other natural resources among the local communities ensuring land tenancy rights and access to forest, drinking water and irrigation.
3. Land-use management and location specific hill crops development
4. Rehabilitation of dwellers in the marginal steep lands providing them alternate employment.
5. Revolutionary land reform measures are needed to end inequality.

Production

1. Increase in food grain production and its self sufficiency in the remote hilly areas through
 - a. Improvement of hill crops and increase in their production
 - b. Proper use of cultivable land
2. Focus on high yielding tuber crops, temperate crops and multipurpose forestry could help reduce food deficiency.
3. Nepalese hill and mountain farmers could gear their livestock production to meet the market demands of meat during festivals like *Dashain* and wool for industrial purpose.

Income generation

1. Priority needs to be given to industrial, high value and cash crops to increase income of farmers
2. Intensive cultivation of income generating crops
3. Cultivation of income generating vegetables, fruits, NTFPs and potential cash crops should be promoted in the hilly areas along highway corridors.
4. Promotion of off-season vegetables, vegetable seed production fruits and medicinal herbs
5. Investment in high-value low volume products will support income generation of the households

Integrated programs

1. Research, extension and development should be integrated for development of sustainable technology.
2. Livestock development integrating forestry and agriculture.
3. Integrated agricultural development programs including forestry, roads, irrigation, rural electrification, cottage industries etc.
4. There is need to mobilize sustainable community forestry programs and to enhance livelihoods in hill and mountain districts. The agro-forestry involving production of fodders, pastures and livestock should be promoted.
5. Investment in clean water, nutrient supplement and sanitary toilet facilities must go hand-in-hand with health, hygiene and nutrition education to improve food security for children and women.

Alternatives/Enterprises

1. Farmers and others with seasonally disguised unemployment should be mobilized in industries based on agriculture and forestry to increase their purchasing capacity. The labors should be allowed to acquire shares of the enterprises they are associated with to develop ownership feeling.
2. There is need of increasing purchasing power in the hills and mountains through improving livelihood opportunities, thereby providing a market for *Terai* produce and a boost for its productivity.
3. The occupations related to agriculture and other alternatives should be commercialized and income generating.
4. Brewing alcohol using food grains should be banned.

Procurement and distribution of food grains

1. Improvement in food grain procurement and distribution system
2. Distribution of food should be based on food habit.
3. A self-reliant food production and distribution system/program should be developed otherwise a resettlement program should be chalked out for the vulnerables.
4. Sufficient buffer-stock of food grains should be maintained. Present quota of food supply to hard-hit mountain areas or districts should be increased.
5. Private sector should be involved and promoted in food supply.

Developing infrastructures

1. Priority in setting up a road transport network in remote rural areas and dense settlements
2. Connecting dense and remote rural settlements through a transportation road network and infrastructures of development.
3. Infrastructures like irrigation, roads and rural electrification should be developed.
4. A road network connecting mountain districts including Tibet route should be developed for food supply.
5. There is need to increase road accessibility of mountain districts with possibility to route supplies through Tibetan road transport network

Promoting agro-ecotourism

1. Promoting agro-eco-tourism conserving biodiversity and natural genetic resources.
2. Awareness should be created on the nutritional importance and special food preparations of local indigenous secondary hill crops among the tourists and visitors to replace imported canned and readymade foods.
3. Community or agro-ecotourism should be developed linking with biodiversity in touristic areas to increase employment opportunities.

Resource Allocation and Mobilization

1. Involving local people in every stage of participatory planning and programming.
2. Proper allocation of subsidies and support in agricultural production and products
3. There is need to resource allocation such as investment in food, improved seed and fertilizer supply needs to be increased
4. Information on vulnerable household types about their location, and causes should be available and intervention should benefit the population in need.
5. People should be involved every forums in identifying their real needs and causes of insecurity. The technical, financial, economic and social feasibility study of program intervention should be carried out.
6. Food for work program should be continued giving priority to marginalized and disadvantaged groups and equal wages to women.
7. The experienced and progressive farmers interested to both quality and quantity of production should be developed as resource persons through training.
8. Local communities should be encouraged for creating awareness on food and nutrition.

CONCLUSION

Nepal which was a net exporter of food grains in the past has now been converted into an importer of food grains. The total food grain production of the country is not adequate enough to feed its own population. The major causes of food insecurity in Nepal are less priority given to agriculture sector, lack of proper irrigation, inadequate efforts towards modernization and commercialization of agriculture. It is true that country could not give adequate attention to agricultural development due to a decade-long Maoist insurgency and political instability in the country. However following the constituent assembly election, there is now political consensus among the major political parties to restore peace and stability in the country through formation of a democratic federal republic and drafting of the new constitution of Nepal. So it is the prime duty of all concerned to contribute to the increased agricultural production of the country leading to self sufficiency as well as export marketing of the food grains. There is need to make conservation of and promotion natural resources involving women and local communities.

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Agricultural Technology Transfer in Asia: A Case of Nepal

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ABSTRACT

Commercial application of technology is a process of moving research results from a research environment to a successfully marketable product. A product after products follows different steps, has to be defined as a product, what type of is it, testing its feasibility, completing product development and design, starting a manufacture product to the marketing and sales department. All these steps needed to be transferred from small scale to large scale and the Asian countries are running on the phase of globalization. Examples of the successful stories on the paper are based on the "seminar on best practice of agricultural technology transfer and commercialization" held on Pakistan during the year of 2006. In addition to this discussion of APAARI meeting and FAO Regional office about the technology transfer and commercialization are the issues taken. The paper deals with the successful stories and the steps followed to transfer the technology by the different Asian countries, which are in the vicinity of the Nepal. Successful steps followed by the different Asian countries to transfer the technology are mass media, good training to trainers, strong tie up with research, academia and the extension. In the case of subsistence, farming like Nepal where the farmers have small and the fragmented land seems to be united in homogenous group. Good governance with decentralized mechanism may create ownership to the farmers and is important factor for good transference and the adoption of the technology.

INTRODUCTION

Since long time Asian countries have been a fertile ground for generating various types of agricultural technologies by aiming using them in economic development. Side by side the countries have been trying to transfer the technologies to their ultimate users throughout the nation from producers basically farmers up to consumers. In the process of transfer some technologies has had varied the degree of success as in the difference of time taken, cost variability, difference of the niche of countries, social norms and values. Technologies have been intervened the number of producers who adopted the technologies are also denied by the number of producers even try to initiate the methodology leading of the technology. Meanwhile private organizations have picked the technologies and grab the knowledge. Some technologies have been adopted well and performed but not continued due to various reasons such as field problem, focused research agenda, difference in the perception of researcher and unavailability of products and inputs in appropriate quantity, quality and amount. Higher emphasis on academic knowledge rather than practical and techno know how, weak extension strategies and methods are other factors hindering the speed of transfer rate.

Better marketing services have been demanded by various countries and geared up by producers because of insufficient marketing facility mislead to adoption of technology and can be hang. Now a days emphasis is given to good marketability and marketing of the agricultural goods produced towards agribusiness ventures and the phase of commercialization. This paper describes some pertinent issues that provide feedback for process of technology transfer in relation to Nepal and other Asian countries.

METHODOLOGY

Best and successful stories vary with many acting and reacting forces of social norms, customs, climate and the environment. Technology, which is successful in one ecology and circumstance, may not be successful in other ecology and environment. The Asia Pacific Association of Agricultural Research Institutions (APAARI) and Food and Agriculture Organization (FAO) Regional Office, Asian Productivity Organization has been seen quite interested and are influencing on the activities of and to dig out the successful stories. What are their implications how they are initiated and adopted? But the paper is based on those successful stories of the Asian countries, which was the issue of the seminar on best practices of agricultural technology transfer and commercialization held on 4-8 December 2006. Along with this among the different successful stories the most successful stories and the background of which may be similar to Nepalese context will be presented by the aim one can extract useful information from these examples which could be helpful in undertaking similar ventures in the future.

FINDINGS

Agricultural technology transfer and their success

China: Hybrid rice cultivation and groundnut farming are the most successful stories of China. The countries like Philippines, Bangladesh and Vietnam are still waiting to adopt the technology. The yield potentiality is 20 percent higher than the normal rice varieties. The research on hybrid rice was started on early 1964 and after 12 years of its initiation the technology was released and recommended to farmers. The technology recommended was on the basis of seedling vigor, vegetative growth and improved harvest index.

The steps followed to disseminate the technology was government's first step for campaign in the presence of mass media as newspapers, radio etc. Second step was different types of training for right person who can dissolve with the field environment, mainly targeted persons like senior officials from academic institutions, local technicians and the innovative farmers. Different types of extension methods were applied as model plots and field experiments, which can perform the best example of comparative advantages of the crop among different one to other. The credit of success was given to good government approach with strong linkage for extension and research institutions.

Pakistan: Cotton and wheat cultivation practices show the most successfully disseminated and acceptable technology. However, wheat cultivation practice is the most successful technology which could be useful for the country like Nepal.

In Pakistan, small groups consisting of farmers with homogenous characteristic are formed and handed over the proven technology package of wheat. The technology package is comprised of precision laser-land leveling of each farm, turning the mud channels into cemented, specific fertilizer dose application along with the soil type and governmental facilitation for the availability of fertilizer and quality seed, farm machinery and credit through a revolving fund. Mainly academia and students of extension also have direct link and supervise and provide technical guidance to the farmers. Active governmental support in the form of coordination, counterpart funds and commitment to follow-up was visualized. It elicit close tie up among the research, academia, extension consisting of technology transfer and continuation effort for the adoption ground level farmers accelerate the technology along with the path of adoption.

India: Dairying, hybrid cotton, oil seed, sericulture, biological pest control are the successful stories of the India. The most prominent steps followed for the transfer of the proven technology were (i) group formation and supporting farming activity by financial aid from village level rural developmental programs (ii) technology dissemination supported by the short-term and long term training programs (iii) demonstration of technology. Initially the commercialization theme was initiated by the governmental support. In those periods active participation of the involved farmers in the every step was being watched. If the sluggishness in the steps appeared the reason of sluggishness was identified and possible measures to check the problems were done.

All the presented example of the different Asian countries depicts the fact, which emphasizes with the focus involvement of homogenous characteristic of the group approach and was supported by the follow up and monitoring of different responsible governmental and non-governmental organizations.

Institutional Arrangements for Technology Transfer in Nepal

Technology transfer and the means of intervention through various programs in Nepal have conventionally been at district level. The principle behind such an approach is to create viable economic systems with sustainable livelihood at local level. There have been a number of actors at district level working on technology transfer and fostering agriculture commercialization. Broadly, the institutions working for technology transfer and commercialization can be categorized into: Public sector (government, autonomous council, corporations etc.), academia (educational institutions), I/NGOs, donor agencies, private sector (agro-vets, individual farmers, wholesalers and retailers).

Nepal Agricultural Research Council (NARC) is the apex mandated agricultural research organization in Nepal. Besides NARC various I/NGOs such as ICIMOD, SSMP, LIBIRD, CEAPRED, FORWARD, and ABTRACO etc are also conducting agricultural research and development activities. Some private sectors such as Agro-Enterprise Center (AEC), Seed Entrepreneurs Association Nepal (SEAN) etc. have also increasingly involved in agricultural research and development activities. Institute of Agricultural and Animal Sciences (IAAS) and Himalayan College of Agricultural Science and Technology (HICAST) are two important agricultural educational institutions involved in graduate level agricultural teachings. In addition to these institution various institution in root level are being emerging day by day aiming with different vocational training and may enhance the skill of different people who are affiliated with.

Mandated public sector agencies for technology dissemination and extension are the Department of Agriculture (DoA) and Department of Livestock Services (DoLS) under the Ministry of Agriculture and Cooperatives (MoAC). There are several commodity specific divisions under the departments, which focus on dissemination of technologies pertaining to specific commodity. In five development regions, there are regional directorates of these departments. At 75 districts, there are district offices of agriculture and livestock. Service centers and sub-centers are the grass root service providing agencies of government. These centers have the immediate contact with the farmers. Most of these centers have one or two technical staffs. District offices have subject matter specialists (SMSs), who provide expert service and advice on technical matters related to agriculture.

Present status of technology transfer

Although there are various numbers of proven technologies in Nepal but a few technologies as trout production program and the off-season tomato production are the most prominently visible in recent years. It was mentioned in the presentation by FAO in the seminar of technology transfer held in Pakistan in 2006 as well as in APAARI and the Nepalese trout farming technology has been cited by Paroda (2005-2006). Nepal being a hilly and mountainous country has plenty of fresh running cold water available through out the year. Rainbow trout fish is a cold-water fish. Since 1989 two fisheries research centers have been involved in the technology generation. A case of Purna B. Lama, a innovative farmer of trout production shows the total cost incurred is during trout production is NRs. 654,376.6, gross income (prod x price, after deducting 20% mortality) of the trout NRs.13, 75, 000 and total net profit/year

is NRs.720, 623.4. Net profit per kilogram of trout is NRs.261.76. Impressive net profit, input output ratio should have to be a good lesson for other interested farmers.

Nepal Agricultural Research Council has followed different steps for technology transfer. Extension methods like radio, television and publications have been found the most efficient means for awareness creation, knowledge generation and technology transfer. Farmers' awareness creation, technology demonstration and verification in the farmers' fields with the involvement of commercial farmers are the major thrust of the technology transfer. Success factors included direct support by a major donor: Japan International Cooperation Agency (JICA/JOCV), good cooperation among different institutions development agencies and private sector. DOA in testing and promotion of the technology consisting of good margin, support by favorable government policy through direct assistance support for materials and development of physical facilities has been an important aspect of the cooperation.

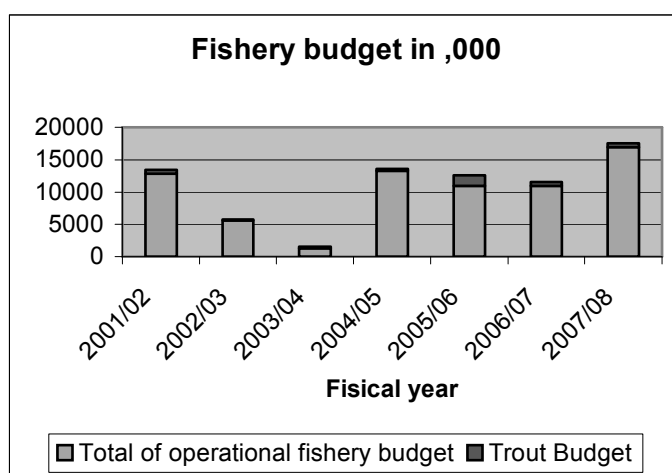
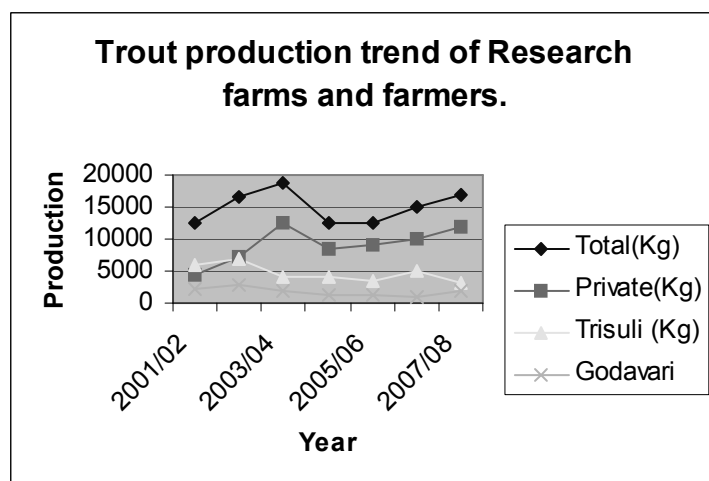


Figure 1. Budget allocated for fishery research at NARC

Figure 1 depicts the budgetary details of 2000/2001 to 2007/8. In the year of 2005/06 the budget flow for trout research and the development was highest.

Figure 2 shows the increasing trend of trout production in Nepal. Trout has been adopted successfully in Nepal (Rai et al 2005). The trout farming shows potentiality of successful farming in Nepal. FAO database for aquaculture production does not show any production of rainbow trout in India, China, Thailand, Malaysia, Indonesia, Nepal, New Zealand, Pakistan and Sri Lanka. It is most likely that trout farming in these countries has not yet been commercialized and is still in the research and development phase (Rai et al 2005). This could be a big opportunity for the commercialization in Nepal with better competitive advantages. A good policy environment is similarly needed for rapid diffusion of those improved technology.



Relevant issues and constraints in technology transfer in Nepal

Technology transfer and commercialization is an issue that is directly linked to governmental policies like science and technology policy, economic policy, agricultural policy, and industrial policy among others. Proper coordination between the policy implementation bodies is also very crucial to produce desired result. The institutional framework of donor agencies, I/NGOs, private sector, CBOs, autonomous sector specific organizations and government bodies should be analyzed in order to mainstream efforts in a desired direction.

Many factors still hold back poor farmers in the process of commercialization. These include insufficient technology for production and post-production, limited access to market, credit and poor infrastructures. Market development as well as product diversification is also a major issue in commercialization of agricultural products at local level. Limited agricultural land and natural resources to support the growing population has created serious social and economic problems since the capacity of the manufacturing and service sectors to absorb the surplus population is very limited. Substantial efforts are needed to lead economy from subsistence to market oriented production and from subsistence-based to an enterprise-based production pattern with enough emphasis on comparative advantage of the regions. Enterprise development, even in products with comparative advantages and unique opportunities, is severely constrained in the absence of effective technology development and transfer mechanism. Access to markets is, of course, the main problem and niche-based products are often new and markets have to be developed for them. All of these also demand marketable products or services, which are nowadays possible only by applying technologies that are cost effective and assurance about quality of products and services. Product security agricultural marketing and credit availability are the need of the time.

National effort to transfer agriculture in Nepal

Nepal's agricultural policy is guided by the periodic plan prepared by National Planning Commission in every five years, which started only in 1956. In all 10 periodic plans till date, agricultural development has always been in top priority. Agriculture Perspective Plan 1995-2015 (APP) incorporated the most rigorous and detailed analysis of agriculture sector in Nepal till date. APP aims to modernize, diversify and commercialize crop and livestock production by expanding the use of technology and increasing the access of farmers to modern agricultural inputs credit and access to road.

APP Support Program was launched in early 2003 to support implementation of APP priorities in 20 districts under support from DFID for 5 years. The program has created a District Agriculture Development Fund at district level. Farmer groups, NGOs, private sector can access the fund through submission of proposals in line with APP priorities. This is one of the major programs of MoAC at present. Previous programs such as Agriculture Research and Extension Program (AREP) and Hill Maize Research Program (HMRP) has also been noteworthy in their contribution to transfer agricultural technology and commercializing agriculture and to strengthen the livelihood of hilly people. The policy

regime for sound agricultural technology generation and effective dissemination/transfer of technology through different and most successful steps seems to be convincing in Nepal. However, in implementation part there are always problems and loopholes.

RECOMMENDATIONS

Nepal's existing situation while entering into WTO and thereby resulting repercussions in the local economic environment has to be studied in depth so that the country can reap maximum out of it. Different Asian countries are running with the strong desire to bridge the gap of the technological outputs in the way of dissemination up to the root of the agricultural management hierarchy. After a technology has been recommended the dissemination in the right time with right competence would be needed.

Specifically following recommendations are made to transfer/commercialize agricultural technologies effectively in Nepal: Example of different Asian countries depict the homogenous group approach should be prioritized to flourish the strong dissemination mechanism in the country like Nepal where most of the farmers are working the whole day and are below subsistence level.

Private sectors (agro-vets, CBOs and individual/group of farmers), local governments, local schools and colleges have to be oriented and strengthened through raising awareness for transfer of technology effectively. Local level functional linkages between Service Centers, VDCs and schools should be established and strengthened for enhancement of technology and skill.

- Government should support for availability of the inputs in time and required quantities. For this, strengthening farmers groups, cooperatives and local institutions should be followed.
- A specific change in the educational system is need of the time. Educational institutions are very important in technology transfer as they not only provide skilled human resource but also guide technology to appropriate direction. Schools are appropriate place for technology dissemination. Incorporating practical skills on specific technologies at school curriculum is a must because students are good learners and they are future farmers of Nepal.
- Products from organic farming have higher demand on market and a commercialized farming of organic products should be to be prioritized.
- Irrigation, transport infrastructure should be developed. Electricity is the most important factor for e-communication therefore has to be prioritized.
- Programs like *Grameen Bank* are popular among rural Nepalese. But various programs like DLGSP, Poverty Alleviation Fund couldn't cover significant population. CBOs at local level should be encouraged to involve in saving/credit activities. Implementation of programs identified by APP should be accelerated.
- Transport infrastructure should be developed. Other priorities of APP, which are partly dealt above, should be implemented in a coordinated manner. The institutions identified above should be strengthened and functional linkage between the institutions should be established.

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Enhanced Soil Fertility and Crop Productivity of Bariland through Integration of Groundnut in the Western Hills of Nepal

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ABSTRACT

With the aim of identifying and promoting the suitable genotypes of groundnut, participatory research and promotional activities were conducted in three consecutive seasons of 2004-2006 under rainfed *bariland* (upland) condition in the mid hills of Nepal. Promising genotypes of groundnut (*Arachis hypogaea* L.) that were tested in the past were verified with or without rhizobium and molybdenum seed inoculation in diamond trials with 2 x 2 factorial design and 10 replications. The best genotypes were further promoted through larger plot demonstrations. Differences in yield and related attributes were significant due to the genotypes and seed inoculation with rhizobium bacteria. Irrespective of genotypes seed treated with rhizobium and molybdenum influenced significantly to produce the higher numbers of pods per plant, seeds per pod, shelling percentage, test weight, root nodules per plant and kernel yield except the plant population at harvest in both the years of 2005 and 2006. Yield increment due to seed inoculation over non inoculation was 29.5 percent from Jayanti of groundnut under front line demonstration trial. Partial budgeting revealed that the seed inoculated with rhizobium and molybdenum surpassed the net benefit as compared to non-inoculated on Jayanti tested under front line demonstration during 2006. Jayanti was preferred by the farmers due to its high and fertile kernel yield and high recovery rate over B-4. The technologies need to be further promoted through participatory research in the western hills of Nepal.

Key words: *Arachis hypogaea*, participatory research, rhizobium, yield attributes, increment, net benefit.

INTRODUCTION

It has been realized that the productivity of maize-based cropping system in *bari* land of western hills is either stable or reduced due to declining soil fertility. In the past several technologies to improve the fertility status of soil have been recommended but very few of them are in reach of poor hill farmers. Among the various components of soil fertility legumes, if suitably inoculated, can fix 100 kg nitrogen per hectare to the soil (Khatri-Chhetri 1991). Grain legumes are dual purpose crops as these not only produce protein-rich grains but also fix considerable amount of nitrogen in the soil. Moreover, when after their harvest the crop residue is incorporated into the soil in situ which helps greatly in improving physico-chemical properties of the soil. Inclusion of legumes in cropping system can result reduction in nitrogen fertilizer requirements for succeeding crop. Soybean increases yield of the following maize and most of the increase is due to their nitrogen contribution (Baldock et al 1981). Where no N fertilizers was used, maize yields on lands which had previously grown winged bean (*Psophocarpus tetragonobus*) were 52-92 percent higher than those where maize was the previous crop (Weil and Samaranayaka 1991) and the apparent nitrogen contribution by winged bean was found to be 70 kg N ha⁻¹. In case the field lacks rhizobia, prior to sowing, legumes seeds need to be inoculated with specific rhizobium culture to ensure effective nodulation and higher rates of nitrogen fixation. An experiment conducted by Fischer and Herridge (2008) in Vietnam have shown that fertilizer N input could be reduced to basal dose (<10 kg N/ha) replaced by inoculation in

legumes. Similarly the profitability was increased by up to Aus \$ 760/ha through inoculation and reduction of fertilizer N inputs from high levels (30-150 kg N/ha) down to less than 10 kg N/ha. Among the grain legume species groundnut is one of the potential catch as well as cash crops in the mid hills of Nepal. None of the improved genotypes released so far in Nepal were in reach of the remote hill farmers that too of Myagdi. Since, some of the traditionally groundnut growing pockets were using the local cultivars having poor yield, susceptible to many diseases and pests and longer crop duration. Since, there was a significant area of *bariland* left uncultivated with the legume crops this experiment was conducted with the objective to (i) verify the promising varieties of groundnut for the *bariland* cropping system and promote the verified technologies in wider areas.

MATERIALS AND METHODS

Two varieties of groundnut, Jayanti and B4, with two treatments comprising seed treated with Rhizobium + soil treated with Molybdenum and untreated were tested under the diamond trial in the field of 10 farmers of 5 different Village Development Committees (VDCs) in Myagdi during 2005 and 2006. The plot size in each treatment combination was 250 m². Molybdenum (5 gram/kg seed) in the form of Ammonium molybdate (54% Molybdenum) was applied in soil during land planting of groundnut.

Recommended doses of fertilizers was applied at the rate of 20:40:20 kg NPK/ha. All husbandry practices other than those tested were used as farmer's normal management practices. A total of 10 diamond trials were conducted during last week of April with one farm representing one replication. During 2006, Jayanti variety of groundnut was demonstrated in a 500 m² plot with or without seed inoculation under front line demonstration. Seed was collected from the concerned commodity programs and rhizobium inoculums from soil science division, NARC. Benchmark soil samples were collected during the land preparation. Similarly, the final samples were collected immediately after the crop harvest and were analyzed by specific methods at soil laboratory of RARS, Lumle. Five random samples for each treatment plots from the depth of 15 cm were collected and prepared for major soil nutrient and pH analysis. The number of pods/plant and kernels/pod, shelling percentage, 100 kernel weight (gm) and average kernel yield kg/ha were recorded. Shelling percentage (SP) was calculated as $SP = \frac{\text{weight of kernels}}{\text{weight of pods}} \times 100$. Nodule population (pink coloured) was recorded from hypocotyls and stem during the pod filling stage (50 DAS). Farmer's feedbacks were also recorded while conducting the experimentation. Following procedure was adopted for inoculation of seed with rhizobium:

- Two teaspoonful of sugar was mixed and stirred well in a half glass of boiled water to prepare the slurry and kept until it was chilled.
- Mixed the required amount of seed in chilled water.
- Five gram of rhizobium culture was mixed in a kg of seed so that the inoculum was adhered perfectly on the seed coat.
- The treated seed was kept under shade for at least 10 minutes and then planted in the field.

RESULTS AND DISCUSSION

Number of plants per m²

Variation due to groundnut genotypes with or without treatment by rhizobium and molybdenum on plant stand was no significant in both the years of 2005 and 2006. Combined analysis over the years also revealed that the difference in plant population was not significant. It might be due to the quality of seed, uniform emergence and establishment of seedlings (Table 1, 2 and 3).

Number of pods per plant

Differences in number of functional pods per plant were significant due to the treatment in both the years. Variation was distinct not only due to the genotypes but also seed treatment in both the years. The highest number of pods per plant was recorded under the treatment combination of genotype Jayanti and treatment by rhizobium and molybdenum in both the years. Similarly, the interaction effect of treatment and year for the trait was evident. It might be due to the better crop season during the second year of planting (Table 1, 2 and 3).

Number of seeds per pod

Significant variation among the tested treatment combinations in producing the seeds was observed in both the years of 2005 and 2006. Effect was distinct not only because of the genotypes but treatment in both the years. The highest number of seeds per pod was recorded in the treatment combination of genotype Jayanti and treatment by rhizobium and molybdenum in both the years. Similarly, the interaction effect of treatment and year for the trait was evident. It might be due to the better crop season during the second year of planting resulted the higher seed yield (Table 1, 2 and 3).

Shelling percentage

The result showed the significant differences among the treatments under consideration in case of shelling recovery in both the years of experimentation. It indicates that the genotypes and the treatment with rhizobium and molybdenum have positive effect in the shelling percentage over the years. Similarly, highest shelling recovery was found in treatment combination of genotype B-4 and treatment by with rhizobium and molybdenum in both the years. The result further revealed that the interactive effect of the treatment and year over the attribute was also evident. It might also be due to the bulky grains consequently the higher test weight of the B -4 as compared to Jayanti (Table 1, 2 and 3).

Test weight

Significant variation among the treatments was observed for seed weight in both the years. Effect of genotypes and treatment with rhizobium and molybdenum on test weight of groundnut was evident in both the years. Genotype B-4 with seed inoculation surpassed the bulkiness of seed over the Jayanti having rhizobium and molybdenum treatment. Influence of year and treatment on this trait was also evident. The reason behind it might be the dominance of treatments over the years (Table 1, 2 and 3).

Grain yield

Grain yield of groundnut varied significantly due to the treatment effects in both the years. Irrespective of seed treatment by rhizobium and soil by molybdenum, Jayanti out yielded the B-4 in both the years. Similarly, irrespective of the genotypes, treatment by rhizobium and molybdenum influenced the grain yield for both the years. Mean grain yield of groundnut was 2057.13 kg/ha and the percentage increment of grain yield due to seed inoculation over non inoculation was 7.07 and 7.43 respectively in Jayanti and B-4 (Table 1, 2 and 3). Becking (1991) pointed out that on application of Molybdenum in groundnut, nitrogen uptake was increased and Mo accumulated at the site of N₂ fixation. Mo is the component of nitrogenase enzyme that fixes the N₂ in legumes (Bond 1970). Rajbhandari and Mishra (1989) pointed out that significant positive correlation of pod yield was observed with number of pods per plant, number of pegs per plant and test weight.

Days to flowering

Differences on days to flowering were significant for the genotypes during 2005 and 2006. However, the distinction was not observed due to the seed treatment by rhizobium and soil by molybdenum on duration of flowering in groundnut. Longer duration for flowering was taken by the genotype B-4 (average of 40 days) than Jayanti (average of 35 days) in both the years (Table 1 and 2).

Days to maturity

Distinction on days to maturity was obvious between the genotypes; however the effect of seed treatment by rhizobium and soil by molybdenum was not evident in both the years. The difference on days to maturity between Jayanti and B-4 was about 15 days (Table 1 and 2).

Nodulation

Differences among the genotypes were not distinct in producing the number of nodules per plant whereas the differences were distinct due to the seed treatment by rhizobium and soil by molybdenum in both the years for this trait. The result suggests that the nodulation in groundnut can be enhanced due to rhizobium inoculation. The positive correlation was observed for rhizobium inoculation and population of root nodules (Table 2).

Table 1. Effect of genotypes and inoculation techniques on the performance of groundnut, 2005

Treatment	No. of plants /m ²	Days to flowering	Maturity days	No. of pods / plant	No of seeds/ pod	Shelling %	Test weight (gram)	Kernel yield (kg/ha)
Jayanti + treated	30.2	35	125	20.1	3.7	71.1	43.8	2398.6
Jayanti + untreated	29.3	35	126	19.2	3.6	70.6	43.0	2076.3
B4 + treated	29.9	40	141	15.9	3.1	73.1	45.1	1781.7
B4 + untreated	28.9	40	141	15.0	3.1	72.6	44.3	1533.9
Mean	29.57	38	38	17.56	3.37	71.85	44.0	1947.6
CV%	5.2	3.46	4.52	5.34	9.33	1.04	1.36	11.4
LSD (0.05)	ns	0.6	0.5	0.86	0.29	0.68	0.55	219.3

Soil fertility status

The fertility status of soil was assessed by taking the soil samples before and after the harvest of the crop. Bench mark soil analysis of the experimental plots was carried out before the trial establishment during the first year and the final status of soil nutrients were assessed after the second year's crop harvest. The laboratory analysis report revealed that the improvement on major soil nutrients, organic matter and pH was observed after the second year's crop harvest. It might be due to the effect of molybdenum activity in the soil. Higher yields of groundnut in the experimental plots might be due to the available pH status in the soil. Studies have shown that the higher grain yields of groundnut are attained on slightly acid soils with pH 6.0-6.5. The findings of the experiments are in accordance with the findings of Woodroof (1987). Increment of organic matter percentage was least (0.15) in the soils with no seed inoculated and the highest was 0.38 in Jayanti followed by B-4 (0.20) with seed inoculated. Increment on the status of soil nitrogen was meager ranging from 0.01 percent in B4 without seed inoculation to 0.05 percent in Jayanti with seed inoculation and hence, was found to be influenced by the seed inoculation. The studies on the contribution of biologically fixed N to the total nitrogen requirement of groundnut plants have shown that its root nodules can fix atmospheric nitrogen to an extent of 200-260 kg/ha (Williams et al 1998). In case of available phosphorus content in soil, the variation was 10 ppm in B-4 without seed inoculation to 22 ppm in Jayanti with seed inoculation. Since it is an essential component of DNA, and plays role in metabolism of leguminous plants. Since, P is one of the slow releasing nutrients and its uptake efficiency is also slow (Reid and Cox 1986). Similar was the case with available potassium, where the increment variation was less under non inoculated condition than the seed inoculated condition (Table 4 and 5).

Table 2. Effect of genotypes and inoculation techniques on the performance of groundnut, 2006

Treatment	No. of plants /m ²	FD	MD	No. of pods/ plant	No. of seeds/ pod	Shelling %	No. of nodules/ plant	Test weight (gram)	Kernel yield (kg/ha)
Jayanti + treated	30.5	35	127	20.5	3.40	71.3	117.34	44.0	2488.6
Jayanti + untreated	30.5	35	127	19.3	3.30	70.8	74.35	43.0	2181.9
B4 + treated	30.6	41	141	16.6	3.00	72.8	114.25	44.5	1806.1
B4 + untreated	30.0	41	141	15.1	2.90	72.6	74.46	43.4	1506.7
Mean	30.4	38	134.0	17.87	3.15	71.87	95.1	43.72	1995.8
CV%	2.17	2.52	2.02	6.45	11.1	0.97	12.83	1.99	15.5
LSD (0.05)	NS	0.5	2.5	1.07	0.321	0.64	11.2	0.801	287.8

FD – Flowering days, MD – Maturity days, NS - not significant

Table 3. Effect of genotypes and inoculation techniques on the performance of groundnut combined over years (2005-06)

Treatment	No. of plants /m ²	No. of pods / plant	No of seeds/ pod	Shelling %	Test weight (gram)	Kernel yield (kg/ha)
Jayanti + treated	30.3	20.3	3.5	71.2	43.9	2543.64
Jayanti + untreated	29.9	19.8	3.4	70.7	43.1	2375.64
B4 + treated	30.2	15.8	3.1	72.95	44.8	1713.92
B4 + untreated	29.4	15.2	3.0	72.60	44.1	1595.32
Mean	29.9	17.77	3.26	71.86	43.9	2057.13
CV%	4.71	5.97	11.64	1.39	2.07	14.74
SED for year (Y)	NS	0.335	0.121	0.315	0.288	NS
SED for treatment (T)	NS	0.237	0.085	0.223	0.0204	95.84
SED for Y X T	NS	4.474	0.169	0.445	NS	135.54

Table 4. Effect of rhizobium and molybdenum treatment on soil pH, organic matter (%) and total nitrogen status of groundnut field during 2006

Treatment	pH			Organic Matter (%)			Total N (%)		
	bench mark	After harvest	change	bench mark	after harvest	change	bench mark	after harvest	change
Jayanti-treated	5.6	5.7	0.1	1.62	2.00	0.38	0.22	0.27	0.05
Jayanti-untreated	5.6	5.7	0.1	2.10	2.25	0.15	0.15	0.16	0.01
B-4 treated	5.7	5.9	0.2	2.01	2.21	0.20	0.16	0.18	0.02
B-4 untreated	5.7	5.8	0.1	2.54	2.59	0.15	0.16	0.17	0.01

Table 5. Effect of rhizobium and molybdenum treatment on available phosphorus and potassium of groundnut field during 2006

Treatment	Available P (ppm)			Available K (ppm)		
	bench Mark	after harvest	change	bench mark	after harvest	change
Jayanti-treated	47	47	47	210	216	06
Jayanti-untreated	57	57	57	210	223	13
B-4 treated	55	55	55	210	234	24
B-4 untreated	58	58	58	210	233	23

Economic analysis

Yield increment due to seed inoculated crop over non-inoculated was 29.5 kg in Jayanti and 5.94 kg/ropani in B-4 (Table 5). Partial budgeting of both the genotypes with or without seed inoculation revealed that the net benefit was the highest of NRs.4440.00/500m² area in Jayanti with seed inoculated by rhizobium and molybdenum followed by the same treatment of B-4 having NRs.4253.75/500m² area of land (Table 6).

Table 6. Performance of promising genotypes of groundnut with or without treatment by rhizobium and molybdenum in groundnut, 2006

Genotypes	Grain yield (Kg/500m ²)		Yield increment (kg/500m ²)
	treated	non treated	
Jayanti	98.0	68.5	29.5
B-4	85.7	79.76	5.94

Table 7. Partial Budgeting for Jayanti variety with or without seed inoculation

Particulars	Jayanti		B-4	
	treated	non treated	treated	non treated
Average yield (Kg/Rop)	98.0	68.5	85.7	76.5
Gross field Benefit (Rs/Rop)	5390.0	3767.5	4713.5	4331.8
Cost of treatment by Rhizobium (Rs/Rop)	459.7	0.00	459.7	0.00
Total cost that Vary (Rs/Rop)	459.7	0.00	459.7	0.00
Net Benefit (Rs/Rop)	4440.0	3767.5	4253.7	4209.1

Note: Price (Rs) of Groundnut: 55/kg; Molybdenum: 29400/kg; Rhizobium: 24/20 gram pkt

CONCLUSION

Jayanti variety of groundnut over B4 was found superior in terms of pod length, test weight and pod yield. Similarly, irrespective of genotypes, effect of rhizobium and molybdenum treatment on yield and related other attributes and nodulation was significant. Irrespective of genotypes, the treatment of rhizobium and molybdenum was found economically profitable over control. Contribution of seed treatment with rhizobium and soil by Molybdenum on soil fertility improvement was obvious. Nevertheless, better prospects do exist for the integration of promising species and varieties of legumes in the hills of Nepal. As hills have the potential for its promotion with high pay-off. The findings also imply that there is a possibility of practicing rhizobium and molybdenum treatment in legumes, if availability is assured. Role of rhizobium and molybdenum in the N needs to be quantified in the farmers' field.

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Graham's Colorimetry as an estimate of Soil Organic Carbon in Chitwan Valley Soils, Nepal

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ABSTRACT

Soil organic carbon (SOC) influences soil physical and chemical processes, and serves as repository source of plant nutrients. Limited information is available concerning SOC status of different layers in Nepalese soils. Two hundred soil samples from five different soil depths (0-5, 5-10, 10-15, 15-30 and 30-50 cm) of Rampur and Baireni, were analyzed to evaluate the precision of Graham's colorimetric method of SOC analysis. The SOC values obtained from Graham's colorimetric method were compared with dry combustion SOC values for the same soil samples. The least square regressions between these two methods were significant for Rampur as well as Baireni experiment. The coefficient of regression for Rampur and Baireni soils were 0.95 and 0.96, respectively. The coefficients were not significantly different from each other. The regression lines were close to 1:1 line. The colorimetric method is a rapid, less expensive and accurate method for estimating SOC content of Chitwan valley soils.

Key words: Colorimetric method, dry combustion, soil organic matters, soil texture

INTRODUCTION

Soil is the greatest heritage of mankind. Its degradation is one of the serious environmental problems having environmental and soil fertility implications. Soil organic carbon (SOC) sequestration can give life to soil and combat soil degradation. Nearly twice as much carbon is stored in world soil ($1,600 \times 10^{15}$ g) as compared to 700×10^{15} g in the atmosphere or 600×10^{15} g in vegetation (Trumbore et al 1996).

Soil organic matter (SOM) serves as the source of nutrients for crop plants (McGrill and Cole 1981). SOM promotes favorable soil conditions, increases soil microbial population and regulates nutrient cycling in soils (Wallace 1994). Without SOM, earth surface would be a sterile mixture of weathering minerals (Craswell and Lefroy 2001). Role of SOM in formation of stable soil aggregates has major implication for air-water balance and surface strength of soil (Scholes et al 1994). Moreover, soil carbon pool and soil processes are important regulators of CO₂ in atmosphere (Lal et al 1999). SOC is a promoter of favorable soil physical conditions and soil biota population (Goh 2004). Impact of increasing SOC level in soils have resulted in to increased crop yields in many long term experiments (Gami et al 2001, Regmi et al 2002; Sharma et al 2003). There is no doubt about importance of SOC in fertility, productivity and sustainability of agricultural and natural ecosystems (Crasswell and Lefroy 2001), the most considerable role being regulation of nitrogen in soils.

Very scanty information is available about SOC status, its turnover rate, mineralization rate and various SOC fractions of Nepalese soils (Sitaula et al 2004). Actual data are obtained through selection of suitable laboratory techniques. Current interest in carbon cycling and soil C sequestration study requires

standard technique to measure OC concentration of soils (Kimble et al 2001). Laboratory measurement of SOC can be assorted depending on the ease of use, health and safety concerns, cost of analysis, and comparability to standard reference methods (Schumacher 2002). Dry combustion procedure is considered as the most precise and accurate procedure today but the high cost of dry combustion apparatus is major limitation to many laboratories (Konen et al 2002) especially of developing countries.

Walkley-Black method is universally accepted as a standard method of measuring SOC since long time but this have significant uncertainties regarding oxidation of constituents other than SOM and proportion of total SOM that is oxidized (Konen et al 2002). In general, all of newer methods including spectrophotometric determination have comparable or greater SOC recoveries and greater precision than Walkley-Black method (Schumacher 2002). Spectrophotometric technique of SOC determination measures Cr^{3+} in place of $\text{Cr}_2\text{O}_7^{2-}$ which is more desired and considered to be more accurate method (Nelson and Sommers 1982). The technique eliminates need of indicators to be added to the digestate. The method has distinct advantage over manual titration since the end-point is not dependent upon operators' optical determination of exactly when color changes (Schumacher 2002). However, it requires more skill in operating instrument and interpreting result. Therefore, an attempt is made to use colorimetric method to substitute highly sophisticated dry combustion method of SOC analysis for teaching and research purposes by comparing the Graham's Colorimetric method of SOC analysis with dry combustion method.

MATERIALS AND METHODS

Soil organic carbon content of 200 soil samples from five different soil depths (0-5, 5-10, 10-15, 15-30 and 30-50 cm) of Rampur and Baireni of Chitawan district were analyzed by Graham's colorimetric method (Graham, 1948) in central soil and plant analysis laboratory of Institute of Agriculture and Animal Science, Rampur, Nepal. Soil samples were collected in November 2003 from Baireni and Rampur field experiments. Eighty soil samples of Baireni and one hundred twenty soil samples of Rampur were used for the study. Rampur soil was sandy clay loam in texture whereas Baireni soil was clay loam in texture up to 15 cm soil depth and loamy type below 15 cm soil depth. Clay content of entire soils ranged from 20 to 30 percent and sand content ranged from 27 to 66 percent. Soil samples are representative of rice-wheat production pocket of Chitwan valley.

Organic carbon concentration of the study soils ranged from 0.12 to 3.17 percent. The soil samples for analysis were collected from at least five sampling locations in field, composited, dried and ground to pass through 0.2 mm sieve. Total carbon measured was presumed to be equal to organic carbon as no calcareous soil samples were analyzed in this study.

One gram of soil sample was treated with 10 ml of potassium dichromate solution. Concentrated sulphuric acid was applied two times the amount of potassium dichromate solution. Soil samples were stirred gently to facilitate oxidation and allowed to cool down the sample. Sixty milliliters water was applied in the mixture and left overnight. Standard was run on the same way where sucrose was used as a source of carbon. Spectrophotometric determination of SOC was made in 625 nm of wave length. Thirty samples were run in a batch and separate standards were used for each batch of analysis. Same soil samples were analyzed by dry combustion method in soil analysis laboratory of Cornell University, UAS with internal laboratory standards and data obtained were compared to determine precision of colorimetric method to estimate SOC content of soils. Data from laboratory analyses were subjected to analysis of simple linear regressions and correlations. Statistical computer software Microsoft excels (2000) and, Sigma Plot (2000) was used for data analysis.

RESULTS AND DISCUSSION

Organic carbon content of one hundred twenty soil samples from Rampur experimental field and eighty soil samples from Baireni experimental field were analyzed by Graham's colorimetric method. Colorimetric soil organic carbon values compared with Cornell university dry combustion SOC value showed strong linear relationship between colorimetric and dry combustion SOC values for both locations (Figure 1). The coefficients of regression (R^2) for colorimetric carbon values with dry combustion carbon values were 0.95 (SE of estimate ± 0.11) for Rampur soils and 0.96 (SE of estimate ± 0.06) for Baireni soils. The regression was very close to 1:1 line for both the locations. Similar result was found by Soon and Abboud (1991) that in a large scale comparison study they found the same recovery of spectrophotometric method as the combustion method within experimental error (slope $\pm$ standard error = 0.98 ± 0.02).

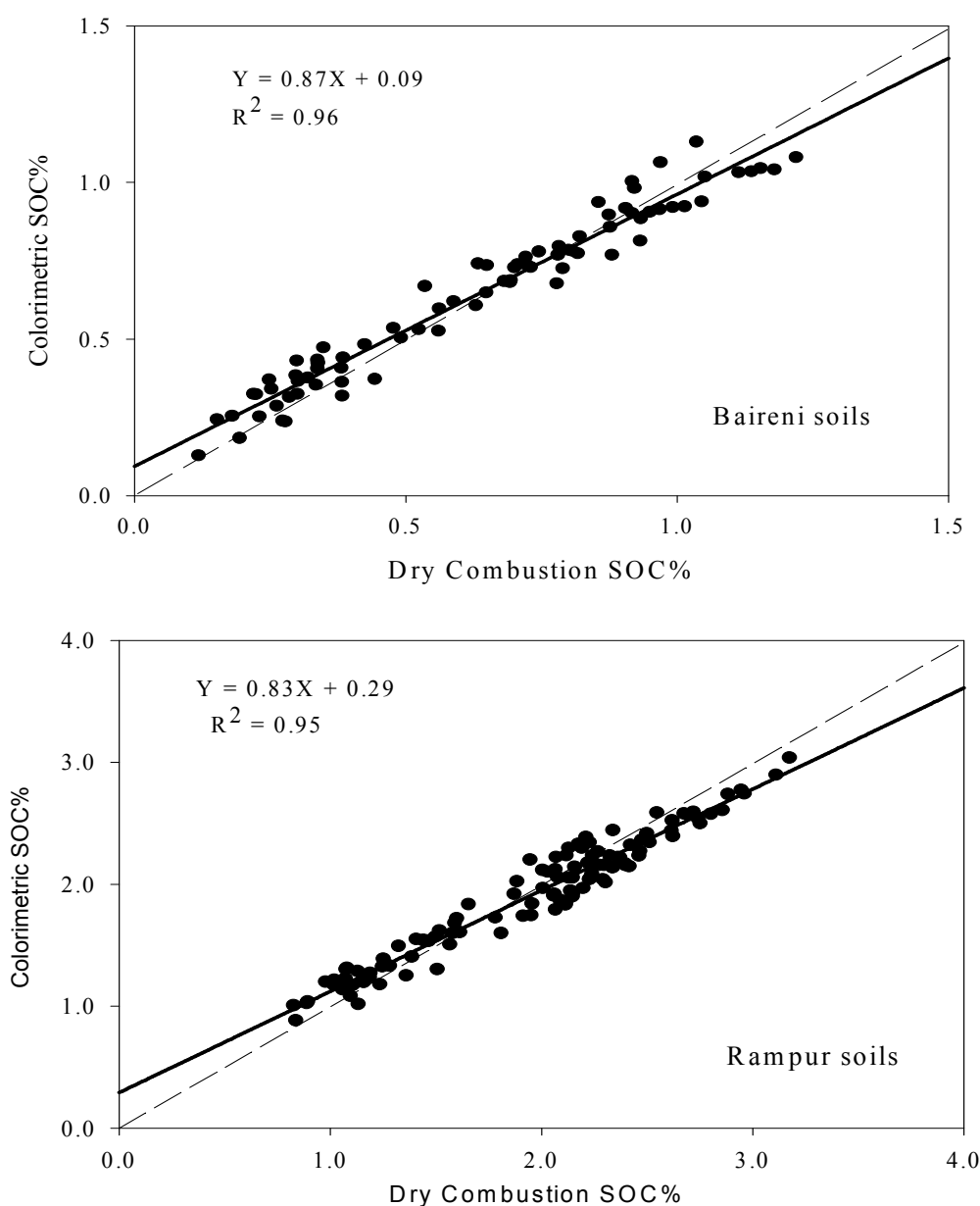


Figure 1. Comparison of colorimetric and dry combustion methods of soil organic carbon analysis in Baireni and Rampur soils

Correlation and regression analysis showed that correlation coefficient for Rampur soil was 0.97 whereas it was 0.98 for Baireni soils. Colorimetric method of SOC analysis gave precise result when compared with standard SOC values from dry combustion method of analysis (Table 1). Sims and Haby (1971) also indicated the high precision of this method for SOC analysis. This method had same recovery of organic carbon as dry combustion method within experimental error. Thus, Graham's colorimetry is more desired and considered to be more accurate quantitation method (Nelson and Sommers 1982) of SOC.

Table 1. Precision of colorimetric method of soil organic carbon analysis as compared to Cornell university dry combustion method

Methods of analyses	Soil organic carbon (% and standard deviation)			
	Rampur soil		Baireni soil	
	Mean	S. D.	Mean	S. D.
Dry combustion	1.92	0.59	0.63	0.30
Colorimetric	1.88	0.50	0.64	0.26

S.D. = Standard deviation

The slope and standard error of slope by colorimetric method for Rampur and Baireni soils were 0.83 ± 0.02 and 0.87 ± 0.02 , respectively. The Baireni soils has steeper slope of equation than Rampur soils. The reason for this might be due to difference in texture and mineralogy (Konen et al 2002) of soils. Baireni soils have higher clay content than Rampur soils. Konen et al (2002) reported higher SOC sequestration with higher amount of silt + clay content of soils. However, the analysis result indicated that the precision of the colorimetric determination is not affected by clay mineralogy and indicates broader applicability of the method for SOC analysis.

Graham's colorimetric method, thus, is cheap, rapid and precise method of SOC analysis that can be used to accurately predict SOC content of light and heavy soils of Chitwan valley similar to that of dry combustion method. Advantages of this method include large sample numbers that can be run simultaneously and low cost of equipments as compared to dry combustion method. Moreover, the method avoids manual titration as in Walkley Black method of SOC analysis, thus the end-point is not dependent upon operators' optical determination of exactly when the color changes. However, it requires more skill in operating the instrument and solution should be free of turbidity. Tabatabai (1996) indicated that the turbidity in the solution misleads the result of this method.

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Quality Improvement of Farm Yard Manure and Response in Crops in Western Hills of Nepal

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ABSTRACT

Verification and demonstration activities on quality improvement methods of farm yard manure (FYM) were conducted in different agro-ecological zones of the western hills of Nepal during 2003-2007. FYM samples prepared from different methods were collected for nutrient content (N%, P% and K%) from farmers field. Nitrogen content were found 2.08 percent in urine soaked FYM as against 1.56 percent in farmers' practice, EM treated FYM 2.05 percent as against in 1.62 percent farmers' practice, FYM covered with black polythene sheet 2.21 percent as compared to 1.65 percent farmers' practice and FYM covered with thatch roof was 1.59 percent contrary to 1.47 percent in farmers' practice. The increment over farmers' practice was 23.08, 26.54, 33.94 and 8.16 percent higher, respectively over farmers practice. Similar results were found for potassium content, in urine soaked FYM with 2.4 percent over 1.94 percent in farmers' practice. In EM treated FYM 2.18 percent over 1.86 percent farmers' practice, 2.21 percent in FYM covered with black polythene sheet over 1.65 percent farmers' practice and FYM covered with thatch roof 2.3 percent as against 1.9 percent in farmers' practice. Potassium content was found 23.7, 17.2, 31.19 and 13.79 percent higher, respectively over the traditional practice of farmers. Decomposition period of FYM was reduced under EM-treated FYM. Similarly, decomposition process was hastened by FYM covered with black polythene sheet. FYM prepared through different methods were applied @ 20t/ha on maize crop in order to find out their impact and the grain yield of maize in improved variety was increased by 35.36 percent and in farmers' local by 25.77 percent with the application of FYM treated with EM against conventionally prepared one. Likewise, grain yield of maize in improved variety was increased by 34.49 percent followed by 9.98 percent in farmers' local with the application of FYM soaked with urine against conventionally prepared one. Similarly, grain yield of maize in improved variety was increased by 24.99 percent followed by 15.79 percent in farmers' local with the application of FYM covered with black polythene sheet over conventionally prepared one. Similar result of significant yield increment by 20 and 35 percent was found in potato with the application of FYM treated with EM and urine soaked FYM respectively. Interestingly, the response of quality FYM over conventional FYM was significantly superior when tested in maize and potato.

INTRODUCTION

Nitrogen is the most limiting nutrients for crop production. Nitrogen is required to complete different growth stages of maize crop. FYM, prepared by farmers in open heaps is generally of poor quality not only because nutrients are lost due to volatilization and leaching but from less decomposition. (Tripathi et al 2001/2002). Traditionally farmers have been applying organic manure such as FYM, compost and leaf litters in order to sustain soil fertility and maintain maize production. Yields of almost all crops in the hills of Nepal have declined over the last 20 years (ADB/HMGN 1982). Sthapit et al (1988) reported that the fertility status in the Bari land is declining and is becoming a major constraint to production. Turton et al (1995) reported that the use of high fertility demanding improved varieties and the diversion FYM/compost away from Bari land to meet the increasing fertility requirements of Khet land might be important factors contributing to the decline in soil fertility on Bari land. FYM, prepared by farmers in open heaps is generally of poor quality not only because nutrients are lost due to volatilization and

leaching but from less decomposition. A study on quality (covered with black plastic sheet) FYM was conducted at Chambas, Pakuwa and Bhakimli in 2001 and its effect on maize grain yield was compared with normal FYM (open heap- farmers' practice). Results showed 35 percent yield increment of maize grain yield by using quality FYM (Tripathi 2002).

A study on quality (covered with black plastic sheet) FYM was conducted at Chambas, Pakuwa and Bhakimli in 2001 and its effect on maize grain yield was compared with normal FYM (open heap-farmers' practice). Results showed 35 percent yield increment of maize grain yield by using quality FYM (Tripathi 2002). The concept of EM (Effective Microorganism) was developed by Dr. Teruo Higa, University of Ryukyus in the 1980s. By the use of one litre of EM 500 kg compost can be prepared which is called Bokasi. Experiment conduct at Kakani area showed that traditionally prepared FYM/compost took six to eight months for well decomposition whereas FYM/compost was found ready to apply in the field within fifteen days which was prepared by using EM (CWDS 2053BS). Application of EM improves the physical, chemical and biological environment of soil and reduces the incidence of diseases and insect pest.

MATERIALS AND METHODS

For urine collection small pit was prepared using locally available material (plastic bucket). Number of participating farmers in each experiment was eight as a replication. Bedding materials and FYM was soaked with collected urine. Farmers' practice was compared with improved practice mainly by nutrient content analysis and visual appearance. After two hours of its preparation, bedding materials and FYM was soaked with EM solution (mixed two ml. EM with two gram Molasses, Veli in /liter water). Farmers' practice was compared with EM-treated FYM mainly by nutrient content analysis and visual appearance. Bedding materials and FYM was kept under the thatch roof. Farmers' practice was compared with FYM kept under the thatch roof mainly by nutrient content and visual appearance. FYM was covered with black polythene sheet to compare with farmers' traditionally prepared FYM (Open method). Farmers' practice was compared with improved practice mainly by nutrient content in FYM; yield parameters visual appearance and farmers' perceptions. The experiments were conducted with eight replications in different sites; Chambas, Tanahun, Tulsibhanyang Syangja ,Pala , Baglung, and Ratnechaur Myagdi, district. The plot size for each treatment was 45 m² (12 rows of 5m long) for maize. FYM was applied @ 20 ton ha in each treatment. The experiments on potato was conducted in Tulsibhanyang Syangja and Pala, Baglung. The plot size for each treatment was 45 m². FYM samples were collected for N, P and K analysis from different methods of FYM preparation (farmers' field). Agronomic parameters were recorded at harvest and statistical data analysis was carried out using GENSTAT 5 release 3.2 second edition.

RESULTS AND DISCUSSION

Effect of covering FYM heap/pit with black plastic sheet in FYM quality

It was observed that the decomposition period of FYM was reduced (visual observation). N, and P content percentage was highly significant in the FYM covered with black polythene sheet in comparison with traditional method of preparation. Nutrient content was increased in black polythene sheet covered FYM as compared to farmers' practice (Table 1). Nitrogen, phosphorous and potassium content in black polythene sheet covered FYM was found 1.70-1.99, 0.37-63 and 1.4-2.8 percent over 1.27-1.42, 0.35-0.54 and 1.4-2.1 percent, respectively in FYM without covering (farmers' practice).

Mean nitrogen content of different location were found FYM covered with black polythene sheet 2.21 percent (farmers' practice 1.65%) Similar types of results were found in potassium content; in FYM, covered with black polythene sheet 2.21 percent (farmers' practice 1.65%). It was 31.19 percent higher than farmers practice.

Table 1. Effect of covering FYM with black polythene sheet

Research site	Treatments			P value	LSD05	CV%
	Covered	Uncovered	Mean			
Chambas(Tanahu)						
N%	1.73	1.37	1.55	<0.01	0.16	5.6
P%	0.45	0.35	0.40	<0.01	0.066	7.8
K%	2.1	1.8	1.96	0.022	0.26	8.3
Tulsibhanjyang,(Syangja)						
N%	1.85	1.39	1.62	0.01	0.14	7.8
P%	0.41	0.38	0.40	0.09	0.21	9.1
K%	2.7	2.1	2.4	0.008	0.17	10.3
Ratnechaur,(Myagdi)						
N%	1.84	1.42	1.63	0.007	0.13	7.5
P%	0.37	0.36	0.37	0.078	0.24	8.7
K%	2.1	1.5	2.3	0.007	0.13	7.5
Pakuwa,(Parbat)						
N%	1.7	1.4	1.5	0.01	0.122	12.5
P%	0.39	0.37	0.38	0.16	0.19	11.9
K%	2.0	1.4	1.9	0.021	0.348	5.9
Deurali, (Palpa)						
N%	1.95	1.41	1.68	0.01	0.18	7.8
P%	0.42	0.39	0.41	0.12	0.24	9.2
K%	2.2	1.6	1.9	0.01	0.12	8.6
Bhakimli (Myagdi)						
N%	1.99	1.27	1.63	0.001	0.12	13.1
P%	0.63	0.54	0.58	0.07	0.17	6.2
K%	2.1	1.6	1.85	0.012	0.31	22.3

Effect of urine application FYM quality

Nutrient content was increased in urine soaked FYM as compared to farmers' practice (Table 2). Content of nitrogen, phosphorous and potassium in urine-soaked FYM was found 1.86-2.16, 0.40-0.42 and 2.0-2.22 percent against 1.45-1.84, 0.30-0.38 and 1.30-1.83 percent, respectively in FYM farmers' practice. It was observed that the decomposition period of FYM was also reduced (visual observation). N, P and K content percentage was highly significant in urine soaked FYM in comparison with traditional FYM. Mean Nitrogen content were found 2.08 percent in urine soaked FYM (farmers' practice 1.69%), It was 23.08 percent higher than conventional practice. Similar types of results were found in potassium content; in FYM, urine soaked FYM 2.4 percent (farmers' practice 1.94%), Potassium content was found 23.7 percent higher over the traditional practice of farmers.

Table 2. Effect of Urine on FYM quality (2006-2007)

Treatment	Chambas, Tanahun			Tulsibhanjyang, Syangja			Pala/Bhimpokhara, Baglung		
	N %	P%	K%	N %	P%	K%	N %	P%	K%
Urine soaked	1.86	0.40	2.0	2.16	0.40	2.08	2.21	0.42	2.11
Non soaked	1.45	0.30	1.3	1.84	0.32	1.70	1.75	0.38	1.83
Mean	1.66	0.35	1.6	2.00	0.36	1.89	1.98	0.40	1.97
P value	<0.01	0.016	<0.01	0.01	0.08	0.001	0.007	0.12	0.01
CV %	12.3	7.9	9.6	8.5	11.4	10.1	9.1	5.9	9.8
LSD	0.138	0.07	0.39	0.201	0.23	0.31	0.01	0.29	0.12

Effect of effective microorganisms (EM) application in FYM quality

Nutrient content was increased in EM treated FYM as compared to farmers' practice (Table 3). Nitrogen, phosphorous and potassium content in EM treated FYM was found 1.94-2.18, 0.38- 0.41 and 1.85-2.8 percent against 1.50-1.79, 0.33-0.38 and 1.63-1.79 percent, respectively in FYM without EM (farmers' practice). It was observed that the decomposition period of FYM was also reduced (visual observation). N,

P and K content percentage was highly significant in EM- treated FYM in comparison with traditional FYM. Mean nitrogen content was found EM-treated FYM 2.05 percent (farmers' practice 1.62%). It was 26.54 percent higher over the farmers' practices. Similar types of results were found in potassium content; in FYM, EM treated 2.18 percent (farmers' practice 1.86%). Potassium content was found 17.2 percent higher over the traditional practice of farmers. There was not significant change in phosphorous content.

Table 3. Effect of Effective Microorganism (EM) on FYM quality

Treatment	Chambas, Tanahun			Tulsibhanjyang, Syangja			Ratnechaur, Myagdi			Pala/Bhimpokhara, Baglung		
	N %	P%	K%	N %	P%	K%	N%	P%	K%	N%	P%	K%
EM treated	1.95	0.41	2.8	2.18	0.38	1.97	2.12	0.41	2.10	1.94	0.38	1.85
non treated	1.50	0.33	2.4	1.79	0.37	1.73	1.65	0.38	1.69	1.53	0.36	1.63
Mean	1.73	0.37	2.6	1.99	0.38	1.85	1.89	0.40	2.40	1.74	0.37	1.74
P value	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	<0.01	0.08	<0.01	<0.01	0.09	<0.01
CV %	9.8	7.5	6.6	11.1	9.7	6.8	7.3	8.5	7.9	10.1	8.7	7.9
LSD	0.218	0.026	0.22	0.12	0.11	0.09	0.12	0.21	0.13	0.10	0.19	0.11

Effect of covering FYM heap/pit with thatch roof in FYM quality

Nutrient and potassium content was high in FYM heap/pit covering with thatch roof as compared to farmers' practice (Table 4). Especially nitrogen content in FYM kept under the thatch roof was found highly significant against farmers' practice. Nitrogen, phosphorous and potassium content in covering FYM heap/pit with thatch roof was found 1.59, 0.46 and 2.3 percent against 1.47, 0.37 and 1.9 percent, respectively in FYM without EM (farmers' practice). Nitrogen content was 8.16 percent higher over the farmers' practices. Similar types of results were found in potassium content; 13.79 percent higher over the traditional practice of farmers.

Table 4. Effect of covering FYM heap/pit with thatch in FYM quality (2004/05-2005/06)

Treatment	Nutrient content in FYM		
	Nitrogen (N%)	Phosphorous (P%)	Potassium (K%)
FYM heap/pit covering with thatch roof	1.59	0.46	2.3
FYM heap/pit without thatch roof	1.47	0.37	1.9
Mean	1.54	0.42	2.1
LSD05	0.075	0.066	0.35
P value	<0.01	0.023	0.019
CV %	7.5	6.4	8.1

Effect of different FYM management practices in the maize crop

The highest grain yield (4519 kg/ha) was found in improve maize variety (Rampur composite) with the application of urine-soaked FYM followed by FYM without urine soaked (3360 kg/ha) (Table 5). Similarly, the grain yield was found higher (2777 kg/ha) in farmers' local variety with application of urine soaked FYM followed by FYM without urine (2525 kg/ha). The grain yield of maize was increased by 34.49 percent with the application of urine soaked FYM in Rampur composite over without urine soaked (farmers' practice). Likewise, the grain yield of maize was increased by 9.98 percent with the application of urine-soaked FYM in farmers' local variety over without urine-soaked.

The highest grain yield (3028 kg/ha) was found in improve maize variety (Rampur composite) with the application of FYM treated with EM followed by FYM without EM (2237 kg/ha) (Table 6). Similarly, the grain yield was found higher (2557 kg/ha) in farmers' local variety with application of FYM-treated with EM followed by FYM without EM (2033 kg/ha). The grain yield of maize was increased by 35.36 percent with the application of FYM treated with EM in Rampur composite over without urine-soaked (farmers' practice). In the same manner, the grain yield of maize was increased by 25.77 percent with the application of FYM treated with EM in farmers' local variety over without urine-soaked. Similar results

of yield increment of 20 and 35 percent was found in potato with the application of FYM treated with EM and urine soaked FYM respectively (Table 7 and 8).

Table 5. Effect of urine-soaked FYM on maize grain yield (2004/05-2005/06)

Variety	Treatment	Grain yield (kg/ha)
Rampur composite	FYM with urine soaked	4519
	FYM without urine soaked	3360
Farmers' local maize	FYM with urine soaked	2777
	FYM without urine soaked	2525
Mean		3295
LSD05		658
P value		<0.01

Table 6. Effect of EM-soaked FYM on maize (2004/05-2005/06)

Variety	Treatment	Grain yield (kg/ha)
Rampur composite	EM treated FYM	3028
	EM untreated FYM	2237
	EM treated FYM	2557
Farmers' local maize	EM untreated FYM	2033
Mean		2464
LSD05		465
P value		<0.01

Table 7. Effect of application of urine-soaked FYM on potato 2007

Treatment	Potato tuber yield (kg/ha)	Yield increment %
EM treated FYM	14700	20
Non treated FYM	12280	0
Mean	26980	
LSD05	353.0	
P value	0.0006	

Table 8. Effect of urine-soaked FYM application on potato 2007

Treatment	Potato tuber yield (kg/ha)	Yield increment %
Urine soaked FYM	30500	35
Un soaked FYM	22600	
Mean	26550	
LSD05	556.0	
P value	0.006	

The highest grain yield (4397 kg/ha) was found in improve maize variety (Rampur composite) with the application of FYM covered with black polythene sheet followed by FYM without covering (3518 kg/ha) (Table 9). Similarly, the grain yield was found higher (3440 kg/ha) in farmers' local variety with application of FYM covered with black polythene sheet followed by FYM without covering (2971kg/ha). The grain yield of maize was increased by 24.99 percent with the application of FYM covered with black polythene sheet in Rampur composite over without covering FYM (farmers' practice). In the same manner, the grain yield of maize was increased by 15.79 percent with the application of FYM covered with black polythene sheet in farmers' local variety over without covering. The highest (8.29) value cost ratio (VCR) was found with the application of EM treated FYM followed by application of FYM covering with black polythene sheet (7.52) in maize crop (Table 10).

Table 9. Effect of FYM-covered with black polythene on maize yield (2004/05-2005/06)

Variety	Treatment	Grain yield (kg/ha)
Rampur composite	black plastic covered FYM	4397
	FYM without covering	3518
Farmers' local maize	black plastic covered FYM	3440
	FYM without covering	2971
Mean		3581
LSD05		475
P value		<0.01

Table 10. Economy of quality farm yard manure, VCR (Value cost ratio)

Location	Treatments	Grain yield (kg/ha)	Additional yield over farmers' practice	Gross return (NRs)	Addi. cost for quality impr (NRs)	Net return (NRs)	VCR
Chambas	Urine soaked FYM	5868	833	12495	3000	9495	3.17
	Farmers' practice	4985	0	0	0	0	0
Chambas	EM treated FYM	6012	658	9870	2000	7870	3.94
	Farmers' practice	5354	0	0	0	0	0
Ratnechaur	EM treated FYM	6411	1238	18570	2000	16570	8.29
	Farmers' practice	5173	0	0	0	0	0
Tulsibhanjyang	EM treated FYM	6549	1005	15075	2000	13075	6.54
	Farmers' practice	5544	0	0	0	0	0
Chambas	FYM covering with black polythene sheet	6370	839	12585	1500	11085	7.39
	Farmers' practice	5531	0	0	0	0	0
Ratnechaur	FYM covering with black polythene sheet	6156	852	12780	1500	11280	7.52
	Farmers' practice	5304	0	0	0	0	0
Tulsibhanjyang	FYM covering with black polythene sheet	6183	794	11910	1500	10410	6.94
	Farmers' practice	5389	0	0	0	0	0

Note: Cost of 1 bottle EM =NRs100 (which is sufficient for making 500 kg FYM/Ropani); Cost of 0.5 kg black polythene sheet =NRs75, for making 500 kg FYM/Ropani; Cost of urine collection=NRs 150 for making 500 kg FYM/Ropani; Price of maize grain per kg= NRs

CONCLUSION

- It was noted in this experiment that because of the large amount of manure that is applied, small changes in the quality of the manure could have a significant effect on the total amount of nutrients that are applied.
- If farmers apply more than 10 ton quality FYM /ha, nitrogenous fertilizer top dressing twice is sufficient instead of adding phosphorous and potassium fertilizer.
- Nutrient uptake is more in pipeline varieties (Population 45 and ZM 621) than in farmers' local ones.
- Application of urine and EM in FYM and FYM covered with black polythene sheet increased the nutrient contents (mainly organic matter, nitrogen and potassium) and its quality.
- Use of EM treated, urine soaked and FYM covered with black polythene sheet increased the maize grain yield by 35.6, 34.49 and 24.99 percent, respectively in improved maize variety against farmers' practices.

- The most effective things felt by the farmers for above technologies are to take less duration for decomposition, easy for carrying, quickly taken by crops, increased yield and reduced women's drudgery.
- In addition, improvement of cattle shed and urine collection is not only to improve FYM quality but farmers are using urine as a bio-pesticide (Gitimal) and at the same time as fertilizer (foliar spray and surface application).
- Hill farmers are reducing the use chemical fertilizers and adopting the technologies of FYM quality improvement for sustainable soil management (SSM).

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Can Organic Farming Sustain Crop Productivity in Nepal: A Review

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ABSTRACT

Balanced and adequate application of all nutrients is a key factor for enhancing crop productivity in a sustained basis. Organic farming has been gaining popularity in today's agriculture. Hence imitators and followers of organic farming are increasing day by day. In the present Nepali context, there has been a debate with the emergence of the concept of organic farming/sustainable agriculture. Research papers on sustainable nutrient management for increasing productivity were reviewed and debatable issues were analyzed. However, conclusions drawn from many countries with hundred years of experiments have shown that the use of organic manure yielded quality products but inorganic fertilizer is a must for increasing and/or maintaining yields in a sustainable way.

INTRODUCTION

Organic farming has developed very rapidly in the recent years and demand for organic food is growing at much faster rate as more and more consumers are willing to pay higher prices for organic products. Organic farming relies on farm-derived renewable resources, and management of ecological and biological processes and interactions to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests (Singh 2003).

Many eminent scientists have cautioned against complete reliance on capability of organic farming to feed world's hungry millions. Borlaug (2002) reported that switching on food production to organic would lower crop yields and use of all the organics that is available will not produce enough to feed six billion people. Similarly, Chhonkar (2003) opined that organic farming is an issue of significance of great national concern owing to its likely adverse impact on India's food security and well being of its people. Policy initiatives directed at reducing or eliminating use of chemical fertilizers will in long run prove disastrous for Indian Agriculture. Due to its lower productivity and high cost of production, organic farming will leave many more people hungry in the country.

With the emergence of non-governmental sector in Nepal and the process of globalization, Nepal too has been influenced by the organic movement. As Nepal imports parts of its food requirement, will it be wise to adopt organic farming that give low production compared to inorganic farming? Such questions have been faced by agricultural scientists from the initiation of organic movement. In this paper, attempt has been made to clarify different aspects of organic farming in terms of quality, production, hazards, effect of fertilizers, etc. However, importance of chemical fertilizer in the agricultural production is also reviewed.

FACTS

Fact 1. Present day

It has been a matter of argument from many years that organic food has lower levels of contaminants such as pesticides, antibiotics and nitrates but has higher levels of a variety of essential nutrients. And now it has been proved by some of the research. A number of studies have shown that when nitrates, a common element of N fertilizer, are converted to nitrosamines they may be carcinogenic (Clancy

1999) and the nitrate content of organically grown crops is significantly lower than in conventionally grown products (UN report 2000). Many studies have found that organic food contained more nutrients than conventional food with higher levels of various minerals and vitamin C. A twelve-year German study found that organic food contains higher levels of minerals. The largest differences were for potassium and iron; and magnesium, calcium, phosphorus and Vitamin C levels were also higher in organic vegetables (Shuphan 1973). An American study found that organically grown food contained much higher average levels of minerals than non-organic food. There was 63 percent more calcium, 73 percent more iron, 125 percent more potassium and 60 percent more zinc in organically produced foods. There was also 29 percent less of the toxic element mercury (Smith 1993). A UK MAFF shopping basket study revealed significantly higher levels of dry matter content in organic apples and carrots as well as more vitamins and potassium in other fruits and vegetables (Pither and Hall 1990).

Fact 2. There is no risk of pathogen contamination of organic food than non organic food

A survey conducted by PHLS, UK of over 3000 ready to eat organic vegetables found no evidence of dangerous microbes that might cause disease to humans, indicating that overall agricultural, hygiene, harvesting and production practices were good (PHLS 2001). A 21-year study at the Swiss Research Institute of Organic Agriculture found that biological process in the soil were improved under organic management and conversely, that mineral fertilizers used in non-organic farming systems actually decrease biological activity in the soil (Mader et al 2000).

Fact 3. Organic systems rely on prevention rather than cure

The encouragement and enhancement of biological cycles within the farming system is one of the fundamental principles of organic agriculture. Uses of agrochemical such as pesticides, soil fumigants and inorganic fertilizer have profoundly damaging effect on microbial soil communities and in turn organic matter degradation. Organic farming minimizes the need for chemical inputs, thereby limiting damage to human health and the environment.

Fact 4. Organic food cost higher

The cost of production of organic food is higher. Organic farming is only targeted to labor rich and resource poor farmers. The yield is lower and the cost of production higher. There is no hidden cost paid from public taxes. The true cost of a food product is not simply the price for which it is sold. In organic production there is no subsidies and taxation.

Fact 5. Mineral fertilizer promotes quantity

The belief that organic manure promotes quality while inorganic fertilizers promote quantity was shown to be over simplistic by Schuphan (1974) on the basis of trial conducted over a decade. Regardless of whether the nutrients are from organic or inorganic source, plants absorb the same in the form of inorganic ions: NH_4^+ , NO_3^- , H_2PO_4^- , HPO_4^{2-} , K^+ , etc. There is no evidence about the existence of any sensor mechanism in plant roots to distinguish between nutrients ions coming from organic or inorganic sources.

Fact 6. Quality is a function of genetic make up

The absorbed nutrients are resynthesized into compounds which determine the quality of the produce eg flavors, shelf life, etc that depends completely on the genetic make up of the plant (variety). The notion that organically produced food taste better is of psychological in nature (Placebo effect). Application of N improves protein and bread making quality. Factors like environmental and cultural influence nutritional composition of the produce. There is no difference between the protein content and other quality parameters such as vitamins, nutraceuticals and trace minerals of conventionally and organically grown crops but it is linked to varietal characteristics (Chhonkar 2003).

In this paper to elucidate the above statements as well as for other basic information research findings in most of the countries were studied and some of them are listed below:

1. Research findings in India

- Long term application of chemical fertilizers is known to increase organic carbon owing to higher root biomass production (Swarup and Wanjari 2000).
- Data from long term fertilizer experiment at Ranchi revealed that application of inorganic fertilizer alone may accentuate soil acidity and Al toxicity, whereas inclusion of lime with recommended dose of NPK helps to sustain the higher crop productivity (Chhonkar 2003).
- Long term fertilizer experiments conducted under varying agroclimatic conditions have shown that balanced application of chemical fertilizer over a period of three decades sustained crop productivity as illustrated by Table 1.

Table 1. Mean grain yield (t/ha) of crops under long term fertilization and manuring

Location and duration	Crops	Unfertilized	100% NPK	100% NPK + FYM	150% NPK
Barrackpore (27 years)	Rice	1.6	3.9	4.1	4.3
	Wheat	0.8	2.4	2.5	2.9
Bhubaneswor 22 years	Rice	1.6	2.8	3.5	3.0
	Wheat	1.4	3.0	3.7	3.3
Coimbatore 28 years	Fingermillet	1.0	3.0	3.5	3.2
	Maize	0.7	3.0	3.4	3.2
Ludhiana 29 Years	Maize	0.4	2.6	3.2	2.5
	Wheat	1.0	4.8	5.0	4.9
Jabalpur 28 years	Soyabean	0.9	2.1	2.2	2.1
	Wheat	1.1	4.2	4.6	4.4
Pantnagar 28 years	Rice	3.1	5.3	6.0	5.3
	Wheat	1.5	3.8	4.5	4.1
Palampur 26 years	Maize	0.3	3.2	4.6	4.0
	Wheat	0.3	2.5	3.3	3.0

Source: Swarup and Wanjari (2000).

2. Research findings in Rothamsted, England

- It is often claimed that yields cannot be sustained in monocultures based on inorganic fertilizers. The data show that they can (Table 2).
- Introduction of short stemmed varieties in 1968 doubled grain yields on plots receiving enough N, whether this N was supplied in organic or inorganic form. But total production of dry matter increased much less.
- The similarity in yields between plots receiving 144 kg/ha inorganic N and that receiving 35 ton FYM/ha shows that on this site extra soil organic matter present had no influence in grain yield.
- The Woburn soils are much lighter in texture (5-10% clay as against 18-28% for Rothamsted topsoil) and there the treatments receiving organic manure usually gave higher yields than comparable inorganically fertilized plots (Johnston 1986).

Table 2. Effect of inorganic fertilizers on winter wheat yields over years

Treatments	Findings	Year
Unmanured plot 144 kg N P K & Mg/ha/yr FYM 35 t/ha/yr	Winter wheat yields are higher than they were 100 years ago.	1852 to 1986

Long-term changes in soil organic matter content: SOM levels have increased markedly in plots receiving FYM and have still not reached equilibrium after nearly 150 years long. Continued use of inorganic fertilizer containing NPK and Mg has increased SOM levels but the increase is much less than that brought about by FYM (Jenkinson 1991).

The great stability of SOM is illustrated by the Hoosefield plot that received FYM for 20 years between 1852 and 1871, and nothing thereafter. More than 100 years after last edition, this particular plot still contains more organic matter than unfertilized control (Jenkinson 1991).

3. Research findings in USA

The Morrow plots

The Morrow plots on the University of Illinois are oldest agronomic research plots in US and include oldest continuous corn plot in the world (Mitchell et al 1991). By 1904, plots of continuous corn were yielding 2.2 ton of grain per ha (Odell et al 1982). Concrete conclusions drawn were as:

- Soils can be exploited and depleted
- Soils can be preserved and cropped

Morrow plots showed that low yields caused by continuous cropping of non-eroded soils were due to loss of plant nutrients and not to irreversible changes. Fertilization restored productivity immediately and dramatically, but did not completely off-set the effect of crop rotation. Crop rotation plus appropriate fertilization not only produced highest crop yield, but also maintained soil N and organic C at the highest levels among sub plots. Manure application with lime and residual P produced lower longer term corn grain yields than treatments fertilized adequately with N, P and K fertilizers.

The Sanborn Field (C. 1888)

Sanborn field at the University of Missouri Columbia contains the second oldest continuous research plots in North America. In 1921, Miller and Duley concluded that rotation alone could not put plant nutrients other than N back into the soil; and even N had decreased in soil from all plots. This led to the understanding that N loss from cultivation was a major reason cultivated soils lost productivity.

Following are other practical, agronomic findings from the Sanborn field.

- Continuous legume, legume systems or animal manures will not maintain soil productivity without supplemental addition of plant nutrients.
- Crop rotations alone will not prevent deterioration of soil productivity.
- Good yields can be produced only when proper amounts of essential elements are available at critical stages of plant growth.

The MAGRUDER PLOTS (C. 1892) of Oklohoma State University

- Commercial fertilizer applications have improved yields as much as application of animal manures (Webb et al 1980).
- Soil org. matter declined rapidly during the first 35 years, maintained a lower rate of decline during the next 52 year, and then stablized.

The OLD rotation (C. 1896) at Aaburn University, Albama)

- Cotton yields have increased linearly since the 1920's in all plots except where cotton is continuously produced without benefit of legume or fertilizer N (Mitchell 1989).

4. Research findings in Nepal

- Long term soil fertility experiment at different research station showed that balanced use of both organic and inorganic sources of nutrients sustain crop productivity especially rice, wheat and maize. In most of the studies, it is reported that continuous use of chemical fertilizer only increased soil acidity (Vista et al 2007).
 - Use of chemical fertilizer only for short term produced higher yield in most of the studies (Vista SP 2006).
 - In most of the long term soil fertility trial with major emphasis on production of crops with different sources of nutrients, the treatment with full dose of chemical fertilizer gave comparatively higher yield. One of the results by Gami and Sah (1998) is shown below in Table 3.

Table 3. Mean grain yield of rice (18 years) and wheat (15 years) at Parwanipur

Treatment (Rice)	Treatment (Wheat)	Rice (Mean of 18 yrs)	Wheat (Mean of 15 yrs)
0-0-0	0-0-0	1957	637
100-0-0	100-0-0	2826	1433
100-30-0	100-30-0	2934	1660
100-0-30	100-0-30	2965	1650
100-30-30	100-30-30	3160	2043
100-0-0	100-30-30	2948	1985
50-0-0	50-0-0	2430	1331
50-20-0	50-20-0	2656	1358
FYM 10t/ha	FYM 10t/ha	2673	1140
100-30-30+ 25 kgZnSO ₄	100-30-30	3106	2185
FYM 10t/ha + 50-0-0	100-30-30	3119	2147
Straw 10t/ha + 50-0-0	100-30-30	3000	2034

From this table it has shown that the treatment with 100: 30:30 kg N, P₂O₅ and K₂O/ha gave higher yield than FYM 10t/ha. Similarly, research conducted at RARS, Tarahara showed that rice yield at 100:30:30 kg N, P₂O₅ and K₂O/ha was slightly lower than FYM 10t/ha but wheat yield was higher in the plots treated with chemical fertilizer which is presented in Table 4 below.

Table 4. Mean grain yield of rice (18 years) and wheat (15 years) at Tarhara (Yadav et al 1990)

Treatment (Rice)	Treatment (Wheat)	Rice (1978 to 1996)	Wheat (1978 to 1996)
0-0-0	0-0-0	3018	1285
100-0-0	100-0-0	4027	2950
100-30-0	100-40-0	3968	3295
100-0-30	100-0-30	3861	3159
100-30-30	100-40-30	3837	3313
100-0-0	100-40-30	3931	3306
50-0-0	50-0-0	3645	2471
50-20-0	50-20-0	3877	2534
FYM 10t/ha	FYM 10t/ha	4027	2227

Similarly, research conducted at RARS, Khajura, Nepalgunj showed that both rice and wheat yield at 100: 30:30 kg N, P₂O₅ and K₂O/ha were higher in the plots treated with chemical fertilizer than other treatments and FYM 10t /ha which is presented in Table 5 below.

Table 5. Mean grain yield of rice (18 years) and wheat at Khajura, Nepalgunj (Bhattarai and Mishra, 1998)

Treatment (Rice)	Treatment (Wheat)	Rice (Mean of 18 yrs)	Wheat (Mean of 15 yrs)
0-0-0	0-0-0	1989	812
100-0-0	100-0-0	3498	1836
100-30-0	100-30-0	3531	2328
100-0-30	100-0-30	3598	2040
100-30-30	100-30-30	3634	2556
50-20-20	50-20-20	3025	1940
50-0-0	50-0-0	2783	1579
50-20-0	50-20-0	3073	1804
FYM 10t/ha	FYM 10t/ha	3248	1440

Experimental results of LTFT in Nepal: From long term – “FYM in combination with N and P produced better yield of wheat than the mineral fertilizers (Regmi 1998)

- Sharp yield decline was observed in P lacking treatment, where yield came down to zero by fifth year in early rice and by eighteen year in normal rice.
- Yield reduction in minus K treatments was observed in all the three crops.
- Response of N was not seen in the absence of P & K. Limitation of P & K supply reduced grain yield of rice and wheat.
- Overall system yield declined in all treatments including the NPK and the FYM.
- Application of P & K partially reversed the yield in P and K deficient plots.
- (From 1993-1997) Generally treatments applying inorganic fertilizers give comparatively higher rice grain yields as compared to other organic sources of treatments i.e. FYM and green manuring. Hence, judicious application of inorganic fertilizer also gives the sustainable yield of rice for long run (Pandey et al 1998).
- In the case of wheat also, treatments applying inorganic fertilizers gave comparatively better yield than other organic sources treatments like FYM and green manuring (Sherchan and Gurung 1998)
- The relative benefit of manure or fertilizer as a nutrient source to meet crop demand depends upon the season of application (Pilbean et al 1998).
- Inorganic treatments (120:60:40) gave highest maize grain yields from year one to four (Shakya et al 1998). Neupane et al (1997) also reported the high yield of maize from chemical fertilizer treated plots in mid hills under maize/millet relay cropping system.
- In Surkhet also, four year data of maize wheat rotation revealed that inorganic fertilizer gave higher yield than organic treatments (Tuladhar et al 1998).
- Combination of organic and inorganic fertilizers could be far better in maintaining and improving soil fertility as well as increasing crop productivity in long term in rice wheat and maize/finger millet system.(Tripathi 1998)
- Grain yields of maize and wheat are considerably greater (0.5t/ha) where both fertilizer and manures are applied together in an integrated nutrient package rather than individually (Pilbean et al 1998).

Lesson to be learnt: Organic farming disaster in China (Case study)

China imposed organic farming regime in 1950 to increase food production without investing in chemical fertilizer. As a result China suffered appalling famine with 30 million starvation death in 1959-60 and still has nearly 200 million malnourished citizens by late 1970s. Later, Chinese mobilized chemical fertilizer and there was corresponding increase in productivity of rice (2.24 to 6.27 t/ha as shown in Table 6). This was the biggest surge in food production ever seen anywhere in the world with grain output increasing from 242 mt in 1976 to 389 mt in 1990. This massive gain in food production without bringing additional area under cultivation was primarily chemical fertilizer driven, and also due to of utilization all available organic sources of nutrients. There is a lesson from it for every one.

Table 6. Total nutrient and percent of organic and inorganic fertilizers applied in China

Year	Total Nutrients	Inorganic	%	Organic	%	Wheat t/ha	Rice t/ha
1949	4.32	0.06	0.1	4.31	99.96	0.74	2.4
1965	8.68	1.94	22.4	6.74	77.6	1.09	2.94
1975	14.94	4.89	32.7	10.05	67.3	1.39	3.51
1985	31.52	17.76	56.3	13.76	43.7	2.94	4.2
1990	40.86	25.9	63.4	14.96	36.6	3.15	5.72
1995	52.25	32.95	67.9	17	32.1	3.54	6.02
2000	60.28	42.02	69.7	18.26	30.3	3.74	6.27
2005	66.31	49.73	75.	16.58	25.0		

Source: Chhonkar PK (2003).

Organic farming has twin objectives of the system being sustainable and environmentally sensitive. In order to achieve these two goals, it has developed some rules and standards which must be strictly adhered to. There is a very little scope for change and flexibility. Organic farming thus does not require best use of options that have been approved. These options are usually more complex and less effective than the conventional ones. The philosophy of the proponents of organic farming presents a difficulty to the scientists, as the organic movement generally resists the comparisons between the two systems (Chhonkar 2003).

Options for meeting the nutrient requirements

The present lower productivity of the system is simply the result of constraints that their practitioners have put upon themselves.

- Improving composting techniques for better quality and quantity.
- Recycling of organic waste/ residues.
- Green leaf manuring.
- In situ management/ Penning.
- Incorporation of legumes in crop rotation /cycle.
- Best utilization of available resources, etc.

CONCLUSION

- Balance and adequate application of all nutrients is a key factor for enhancing crop productivity on a sustained basis.
- Hundred years of experiments have not yet drawn valid conclusion, how the new started experiments in Nepal could draw concrete statement from such experiments. Such experiments have shown that use of chemical fertilizer is a must for increasing cereals yield in a sustained way.

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Performance of Silkworm Races Feeding on Different Mulberry Cultivars in Mid-hill Conditions

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ABSTRACT

Experiment was conducted to assess the optimum interaction between common silkworm races (J-12 and C-12) with different mulberry varieties (Kanva-2, Lun-40, K-22, Khumal-1 and Khumal-3) at Khumaltar, Lalitpur during the year 2004/05 and 2005/06. The bud initiation and senescence characteristics were found superior in Kanva-2 among the tested cultivars. The last instars larval weight was found more in Japanese strain of silkworm fed with Kanva-2, Lun-40 and K-22 cultivars while no much difference was observed in pupal weight. The mounting was faster in Chinese strains and percentage good cocoon recovery was slightly more in Japanese strains (82.75 to 90.74%) fed with Kanva-2 variety. Similar results were observed in the case of cocoon weight and shell ratio. The silkworm races feeding on Kanva-2 gave highest results on all post-cocoon characteristics (filament length, average non-breakable filament length and denier) followed by Lun-40 cultivar whereas Khumal cultivars gave the lowest. The difference between two silkworm races in post-cocoon characteristics was not observed in much extent. Although the highest value of TFL and ANBFL was observed in Chinese race feeding on Kanva-2 cultivar, the Japanese race of silkworm has also shown satisfactory results. In the case of denier, Chinese race feeding on Lun-40 cultivar gave the best result, closely followed by feeding on Kanva-2 cultivar. From the overall post-cocoon evaluation, Chinese race fed with Kanva-2 mulberry cultivar is slightly superior to Japanese race fed with Kanva-2 cultivar.

Key words: Cocoon quality, mulberry cultivars, silkworm strains

INTRODUCTION

Sericulture, the occupation of silkworm rearing and cocoon production, is one of the prioritized agro-enterprises by different agricultural plans of Nepal including Agriculture Perspective Plan (APP). The prevalence of suitable climatic condition for mulberry cultivation and silkworm rearing along with cheap agricultural labor strength has shown tremendous potentiality for the development of sericulture enterprise in Nepal. Recently various governmental and non-governmental organizations are involved in activities regarding distribution of mulberry plants and cultivation of silkworm for the upliftment of sericulture business.

Sericulture involves cultivation of mulberry plant and rearing of silkworm for the production of quality silk. Mulberry (*Morus* sp.), the protein rich plant, is the basic source of food for silkworm (*Bombyx mori* L.). Different studies have shown that nearly 70 percent of the protein content of raw silk is directly derived from the protein of the mulberry plant (Bongale 1990). As well as the capability of silkworm strains in producing quality cocoons is also equally important. Till now there are thirty four silkworm races recorded in Nepal, including the stocks selected from hybrids and latest parents of existing commercial races (SDS 2002). Among these, the Japanese (J-12) and Chinese (C-12) silkworm races are mostly used for commercial cultivation at farmers' level. Similarly among different mulberry varieties introduced, Kanva-2 is still the most popular variety whereas other varieties like Bhote, Lun-40, Kosen and few others are also cultivated.

In Nepal, although all these efforts are made in introducing different silkworm races and mulberry varieties, but only few are popular. Here, the important thing is not the characteristics of one factor only; the combination of both factors in producing quality cocoons is the key to success. So it is necessary to determine optimum interaction between the mulberry varieties, the quality of silk threads from the cocoons and the available races of silkworm.

METHODOLOGY

The study was performed for two years in the field and laboratory of Entomology Division (ED), Nepal Agriculture Research Institute (NARI), Khumaltar during the year 2004/05 and 2005/06. Rearing of silkworm was done at ED laboratory utilizing the mulberry plants of ED mulberry orchard. The orchard consists of eight years old five different varieties (Lun-40, Kanva-2, K-22, Khumal-1 and Khumal-3) of mulberry plants planted in rows. Each cultivar consists of 25 plants at experimental plot and another five each as mother plants nearby with the spacing of 1-m row to row and 75-cm plant to plant. After the last stage of defoliation, all these plants were base cut on second week of January in both years. Bordeaux paste was applied immediately after base cut. Well decomposed compost fertilizer at the rate of 3 kg per plant was applied during mid of January along with other agronomic practices and irrigation as and when required. Fifteen plants of each variety from experimental plot were selected randomly and marked for leaf plucking to feed silkworm races.

For silkworm rearing purposes, the rearing room, equipments, rearing materials and tools were disinfected by spraying 3 percent formaldehyde solution seven days before the start of experiment. Immediately after disinfecting, the rearing room was sealed for 24 hours, then after it is well ventilated for rest of the days. The temperature and relative humidity was recorded throughout the experimental period. The available and required environment during rearing of different instars of silkworm larvae is presented at table 1.

Table 1. Comparison of required and available environment for silkworm rearing at ED laboratory, 2005/06 – 2006/07

Larval stage	Temperature (°C)			Relative humidity (%)		
	Required	2004/05	2005/06	Required	2004/05	2005/06
First	26 – 27	21 – 25	23 – 27	85	78	77
Second	25 – 26	23 – 26	22 – 26	85	79	80
Third	24 – 25	23 – 26	21 – 24	80	81	78
Fourth	23 – 24	24 – 27	23 – 27	75	79	80
Fifth	22 – 23	26 – 29	25 – 28	70	79	79

The silkworm eggs (Disease Free Laying) were brought from Sericulture Development Section, (SDS) Khopasi, Kavre. Two races of silkworm, Chinese (C-12) and Japanese (J-12), were selected for study purposes on the basis of their popularity among sericulture farmers throughout the country. One box (about 20,000 DFLs) each of both strains were brought and placed for incubation at ED laboratory during first week of May on both years. After hatching of the eggs, the newly emerged larvae (ant worm) were brushed by a fine white feather and placed at separate rearing trays with fresh and young mulberry leaves. A total of thirty rearing trays (70 cm length, 45 cm breadth and 7 cm height) were kept separately at laboratory. In each rearing tray (replication), 100 just hatched larvae were transferred from incubation tray.

The interaction between silkworm races and mulberry varieties was placed as treatments. A total of ten treatments (five treatments with C-12 silkworm strain fed with each mulberry cultivars and another five treatments with J-12 strain fed with each mulberry cultivars) with three replications were placed for study purposes. Rearing of silkworms was carried out following methods mentioned by Thapa and Takamia (2001). The tender leaves were chopped and fed to first and second instars larvae, whereas for older larvae whole leaves were given. The last instars larvae at the time of mounting were separately

placed at mounting structures (Chandrika and Mobasu) according to the treatments. The cocoons harvested were oven dried and 50 cocoons from each replication were randomly selected and sent to SDS, Khopasi for post-cocoon evaluation tests where as the remaining cocoons were used for other study purposes.

RESULTS AND DISCUSSION

Characteristics of mulberry varieties

The bud initiation in mulberry plants started from third week of January, about 15 days after the base cut in both years. The initiation was first observed in three cultivars, Lun-40, Kanva-2 and K-22. Other two cultivars, Khumal-1 and Khumal-3 showed slower bud initiation (40 and 38 days in 2004/05; 43 and 42 days in 2005/06 respectively in Khumal-1 and Khumal-3 varieties) after base cut. Among these five cultivars, the bud initiation was found faster in Kanva-2 mulberry cultivar followed by K-22. Similarly the sprouting was also faster in Kanva-2. Lun-40 and K-22 sprouted faster than Khumal-1 and 3 cultivars. The senescence was also observed faster in Khumal cultivars compared to Lun-40, Kanva-2 and K-22. Lun-40 and Kanva-2 senescence late than K-22. This shows that the leaf availability period for silkworm rearing is longer on Kanva-2 and Lun-40 cultivars compared to other three cultivars and that of Khumal cultivars is shorter. Bongale (1990) has stated suitability of Kanva-2 and S-1 cultivars in moderate level of agricultural inputs than other tested cultivars (S-54, S-799). Similarly, the performance of Kanva-2 and Bhote local was better in non-weeded condition (Anonymous 2000) which supports the evidence of high demand of Kanva-2 variety than other available varieties.

The observation on different pest status on mulberry plants shows occurrence of aphid and thrips during initial phase of crop growth. During the same time, population of the predator lady bird beetle was also high. No adverse effects of these pests were observed on mulberry plants. Some damage by twig blight disease (more in Lun-40 and Kanva-2) was seen during the month of May. The major pest of mulberry was recorded as leaf folder (*Margaronia* sp.; Lepidoptera: Pyralidae) and hairy caterpillar (*Spilarctia* sp.; Lepidoptera: Arctiidae) which damage the mulberry leaves in all varieties (more in Kanva-2). Hairy caterpillar and Leaf folder along with stem borer are also reported from Dhading and Ilam districts as major mulberry pests (Anonymous 2002). The population of Leaf folder was observed from mid of the June while hairy caterpillar occurred from June last. The damage was found severe after mid of September.

Cocoon quality of silkworm strains

The DFLs of both silkworm strains (one each of Japanese and Chinese) were brought on first week of May in both years. These egg cards were kept at rearing room and hatched after 14 and 16 days in 2004/05 and 2005/06, respectively. The newly emerged larvae (ant worm) were brushed into rearing trays with fresh leaves of respective mulberry varieties. The larval period was found similar in both strains ranging from 29 to 30 days and 28 to 29 days during 2004/05 and 2005/06, respectively. The average days taken to complete the respective instars (first, second, third, fourth and fifth instars) were 5, 5, 6, 6, 7 to 8 days (2004/05) and 5, 5, 6, 6 to 7 (2005/06), respectively.

The fifth instars larval weight of Japanese silkworm strain was found more in comparison to larvae of Chinese strain, while not much difference was noticed in pupa weight. According to Chaluvachari and Bongale (1995), the larvae weight and molting ratio of silkworm are associated with different mulberry leaf characters as moisture content, moisture retention and lower value of sugar and protein ratios. Although the weight of female pupa was more than that of male, but no significant differences were observed in weight of male and female pupa among two strains. The weight of pupae was comparatively more in Kanva-2, Lun-40 and K-22 mulberry leaves fed silkworm strains than that of silkworm strains fed with Khumal-1 and Khumal-3 mulberry cultivars. The weight of pupa and fifth instars larvae of silkworm strains is presented in table 2.

The mounting in silkworm strains started from second week of June. Among the two strains, mounting was observed faster in Chinese strains than that of Japanese strains of silkworm. Almost all the larvae of silkworm mounted within two days and began to form the cocoon. The cocoons were harvested after

around seven days. The good cocoon recovery percent was found from 80.29 to 90.56 in Chinese strain and 82.75 to 90.74 in Japanese strains of silkworm (Table 3).

Table 2. Mean weight of pupa and 5th instars larvae (n = 25) fed with different mulberry variety at Khumaltar, 2004/05 and 2005/06

Mulberry cultivars	Chinese (C-12) strain			Japanese (J-12) strain		
	5 th instars larvae wt. (g)	Wt. of male pupa (g)	Wt. of female pupa (g)	5 th instars larvae wt. (g)	Wt. of male pupa (g)	Wt. of female pupa (g)
Lun-40	10.12±0.04	0.71±0.007	0.89±0.007	11.89±0.07	0.77±0.004	0.92 ±0.006
Kanva-2	10.74±0.07	0.76±0.004	0.98±0.004	12.18±0.05	0.76±0.003	0.96 ±0.004
K-22	10.86±0.06	0.72±0.006	0.91±0.005	11.82±0.05	0.69±0.004	0.88 ±0.005
Khumal-1	9.17±0.03	0.57±0.004	0.72±0.003	10.57±0.04	0.57±0.005	0.71 ±0.005
Khumal-3	9.44 ±0.05	0.59±0.005	0.78±0.004	11.06±0.08	0.61±0.005	0.70±0.004

Although much difference was not observed, percentage good cocoon recovery was more in the Japanese strain. In the case of both silkworm strains, the silkworm strains fed with Kanva-2 mulberry cultivar showed its superiority among other mulberry cultivars while it was found lowest in Khumal-1 and Khumal-3 leaves fed silkworm strains. Similarly the percentage of double cocoon, defective cocoon and non-neatness cocoons was found more in silkworm strains fed with Khumal-1 and Khumal-3 varieties of mulberry leaves.

Table 3. Mean cocoon characteristics of different strains of silkworm (n = 25) fed with different mulberry variety at Khumaltar, 2004/05 and 2005/06

Silkworm strains	Mulberry cultivars	Cocoon characteristics			
		% double cocoon	% defective cocoon	% non neatness cocoon	% good Cocoon
Chinese (C-12)	Lun-40	4.65 ± 0.11	6.58 ± 0.14	0.54 ± 0.004	88.23 ± 0.94
	Kanva-2	2.14 ± 0.08	6.14 ± 0.21	1.16 ± 0.008	90.56 ± 0.87
	K-22	3.85 ± 0.07	5.27 ± 0.17	1.24 ± 0.005	89.64 ± 0.81
	Khumal-1	6.54 ± 0.17	11.25 ± 0.34	1.56 ± 0.006	80.65 ± 0.62
	Khumal-3	5.13 ± 0.13	12.04 ± 0.41	2.54 ± 0.009	80.29 ± 0.97
Japanese (J-12)	Lun-40	2.36 ± 0.05	5.68 ± 0.23	1.89 ± 0.008	90.07 ± 0.54
	Kanva-2	2.10 ± 0.02	6.24 ± 0.24	0.92 ± 0.004	90.74 ± 0.68
	K-22	3.14 ± 0.05	6.54 ± 0.17	1.56 ± 0.005	88.76 ± 0.74
	Khumal-1	3.25 ± 0.06	9.28 ± 0.37	3.26 ± 0.005	84.21 ± 0.93
	Khumal-3	3.86 ± 0.06	10.35 ± 0.31	3.04 ± 0.007	82.75 ± 0.82

Table 4 shows the shell ratio and weight of 25 cocoons of Chinese and Japanese strain. Sarkar and Fujita (1993) advocated that production efficiency of cocoon shell maintained by particular races of silkworm is the final indicator in evaluating nutritive value of mulberry leaves. They also indicated that conversion efficiency of silkworm for cocoon weight, shell weight and cocoon production is high in silkworms fed with quality leaves. The weight of cocoon in both strains of silkworm showed that the silkworm strains fed with Kanva-2, Lun-40 and K-22 leaves attained comparatively higher cocoon weight as compared to Khumal-1 and Khumal-3 mulberry cultivars fed cocoons. Among these three cultivars, the Kanva-2 (26.29-g and 28.72-g in Chinese and Japanese strains respectively) leaves fed cocoon in both silkworm strains showed its superiority.

Similar result was obtained in the case of the shell ratio percent. It was found comparatively higher in the strains fed with Kanva-2 (25.97 and 26.64 in Chinese and Japanese strains respectively) cultivar of mulberry followed by Lun-40 and K-22, while the lowest shell ratio was found in the strains fed with Khumal-1 and Khumal-3 mulberry leaf. Although significant difference was not observed among the two silkworm strains in both of these characteristics, slight superiority was shown by Japanese strain of

silkworm. According to Reddy (1994), the shell ratio is one of the important characters for individual cocoon selection which is associated with high productivity of silk – higher the shell ration, usually the thicker denier. So, based on the shell ratio percentage, Kanva-2 mulberry cultivar fed to Japanese strain of silkworm was found superior than other. Similar experiment done at Entomology Division in 2001 has shown that silkworm race NG x J12 produced highest shell ratio than other races (Anonymous, 2001).

Table 4. Mean quality of cocoons produced by different strains of silkworm fed with different variety of mulberry leaves at Khumaltar, 2004/05 and 2005/06

Mulberry cultivars	Chinese strain (C-12)		Japanese strain (J-12)	
	25 cocoon-weight (g)	Shell ratio (%)	25 cocoon-weight (g)	Shell ratio (%)
Lun-40	25.67 ± 0.27	25.54 ± 0.46	28.45 ± 0.24	26.42 ± 0.28
Kanva-2	26.29 ± 0.43	25.97 ± 0.41	28.72 ± 0.35	26.64 ± 0.14
K-22	26.07 ± 0.24	25.24 ± 0.17	28.41 ± 0.17	26.13 ± 0.16
Khumal-1	23.08 ± 0.18	22.57 ± 0.19	22.09 ± 0.26	23.14 ± 0.18
Khumal-3	23.74 ± 0.31	23.04 ± 0.21	23.01 ± 0.28	22.94 ± 0.24

Post cocoon evaluation

The results regarding post cocoon characteristics of interactions between different mulberry cultivars and silkworm races are presented in table 5. The filament length (meter), average non-breakable filament length and denier were assessed. Silkworm races feeding on Kanva-2 and Lun-40 gave highest results on all post cocoon characteristics, whereas Khumal cultivars gave the lowest. Among the superior two, the silkworm feeding on Kanva-2 cultivar gave highest TFL and ANBFL closely followed by feeding on Lun-40 cultivars. The value of TFL and ANBFL was found lowest on silkworm races feeding on Khumal-1 and Khumal-3. Similar trend was observed in the case of silk filament thickness. It is found less in Khumal-3 feeding silk and was highest in Kanva-2 feeding silk. The difference between two silkworm races in post cocoon characteristics was not observed in much extent. Although the highest value of TFL and ANBFL was observed in Chinese race feeding on Kanva-2 cultivar, the Japanese race of silkworm has also shown satisfactory results. The study done at Madhi, Chitawan has shown that the silkworm race J12 x C12 gave better result as compared to K x A, Ns x N102 and N9 x N102 in post cocoon characteristics in summer and autumn rearing.

In the case of denier, Chinese race feeding on Lun-40 cultivar gave the best result, closely followed by feeding on Kanva-2 cultivar. Thicker denier silk is useful for commercial use which can be mixed with wool and other fibers. Fibers that have filament length above 1000-m and denier 2.06 are considered strong (Ghimire 2005). From the table, the overall post cocoon evaluation result has shown Chinese race fed with Kanva-2 mulberry cultivar is superior to other interactions.

Table 5. Post cocoon evaluation of interactions between different silkworm races and mulberry varieties interactions at Khumaltar, 2006

SN	Interactions (Silkworm race x mulberry cultivar)	TFL (m)	ANBFL (m)	Denier
1	Chinese x Lun-40	10145.24 ± 825.36	356.37 ± 55.34	3.68 ± 0.14
2	Japanese x Lun-40	9876.47 ± 798.54	314.17 ± 34.58	3.14 ± 0.37
3	Chinese x Kanva-2	10459.17 ± 945.12	386.86 ± 67.21	3.57 ± 0.36
4	Japanese x Kanva-2	9958.79 ± 587.24	307.52 ± 71.27	3.29 ± 0.48
5	Chinese x K-22	9568.47 ± 768.34	312.67 ± 42.35	3.37 ± 0.27
6	Japanese x K-22	9325.24 ± 479.34	329.24 ± 27.54	2.87 ± 0.54
7	Chinese x Khumal-1	6654.42 ± 753.28	245.68 ± 38.57	2.04 ± 0.79
8	Japanese x Khumal-1	7923.67 ± 534.87	214.35 ± 57.15	2.23 ± 0.47
9	Chinese x Khumal-3	7589.23 ± 769.38	289.32 ± 47.51	2.14 ± 0.46
10	Japanese x Khumal-3	7964.51 ± 432.14	292.64 ± 34.57	1.98 ± 0.61

Note: TFL indicates total filament length; ANBFL indicates average non-breakable filament length in meter

CONCLUSION

Sericulture includes the cultivation and management of mulberry plant and rearing of silkworm larvae thereby producing quality cocoon. Both of these factors are equally important for upliftment of rural farmers based on this occupation. The mulberry varieties and the silkworm races, which are introduced in Nepal from different neighboring countries, are practiced by sericulture farmers since long time, but few of these are popular. This study reflects some idea on the interaction of these both important factors for the development of sericulture in Nepal. From the study it can be concluded that Kanva-2 mulberry variety is superior in comparison to other four cultivars studied. Although this variety is prone to prevailing pests as hairy caterpillar and leaf folder, still it has other important characteristics to be considered. Among the two most cultivated races of silkworm, Japanese J-12 and Chinese C-12, distinct differences were not observed. The Chinese silkworm race mounted faster and closely followed to other parameters whereas the Japanese race was found better in terms of last instars larvae weight, cocoon weight and the shell ratio. On assessing the post-cocoon characteristics as filament length (meter), average non-breakable filament length and denier, the Chinese race was slightly better than Japanese race of silkworm. So it can be concluded that the Chinese race fed with Kanva-2 mulberry cultivar is superior to as compared to other interactions.

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Economy and Market of Baby Corn in Nepal

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ABSTRACT

Baby corn is relatively new and potentially income generating crop. In Nepal, very limited research works are accomplished on this new frontier so far. An experiment was conducted to determine the appropriate combination of baby corn and tomato cultivars in intercropping system, and to assess economics and market potentiality of baby corn. The field experiment was conducted at horticultural research farm of the Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal from February to July 2007. The market study was carried out in Kathmandu market during the experimental period. The experiment consisted of eight treatments laid out in two-factor randomized complete block design (RCBD) with three replications. Four cultivars of corn (two open pollinated: Rampur Composite and Arun-2, and two hybrids: Bioseed 9681 and JK Puja) as factor A, and two hybrid tomato cultivars (BSS-418 and Umi) as factor B formed a combination of eight treatments. Sole plots of Rampur Composite of corn and BSS-418 of tomato were maintained for economic analysis. Arun 2 had the highest stover yield (44.8 t/ha), husk and silk yield (8.18 t/ha), husked cob yield (10.75 t/ha), and dehusked cob yield (2.577 t/ha). The economic analysis revealed that baby corn had potential earning of net benefit/ha NRs 179,290 with benefit cost ratio of 1.92:1 as sole crop. Baby corn-tomato intercrop had greater (2.99:1) benefit cost ratio than maize sole system (1.44:1). The land equivalent ratio was positive (1.78) in baby corn-tomato intercrop. There was a great potentiality of baby corn supply in Nepalese market. The prerequisites for uplifting baby corn production were: canning industry; research activities, market and post-harvest; awareness creation; and regular supply. Baby corn with intercropped tomato would be an alternative of existing maize based cropping system. However, further verification is equally important for its wide dissemination.

INTRODUCTION

Baby corn (*Zea mays* L.) is an important vegetable product obtained from maize plant. The edible part is the small young ear-corn or cob or the female inflorescence (rachis or cob or style axis) of corn (maize) before pollination and fertilization (Lekagul 1994). It is a diversified product of the maize plant, which is consumed as a fresh or canned vegetable. Modern hotels and restaurants use baby corn in salads, soups, stir-fry cooking, pickle and as a more traditional side vegetables. The canning industry has added to the importance of baby corn as an industrial crop in countries like Thailand, where baby corn production technology is a success story. Baby corn is a highly nutritious commodity. In comparison to cauliflower, cabbage, tomato, eggplant and cucumber, it contained higher amount of carbohydrates (8.2 mg/100 g), fat (0.2 mg/100 g) and phosphorus (86 mg/100 g), where as it contained more or less similar amount of protein (1.9 mg/g) to these vegetables (Chatkaew and Paroda 1994). Significant quantities of by-products are produced in the cultivation of baby corn such as tassels, husks and silks, and green plant materials in field after baby corn harvest. In Nepal, baby corn is a new product. Its use as a culinary item in Nepal is a recent one and mostly confined to some hotels and restaurants. Most of the baby corns are canned products imported from abroad. The import of baby corn in Nepal is in considerable amount. But the records of baby corn import were included in sweet corn category. In 2004-05, the worth of sweet corn

categories (possibly baby corn and sweet corn) imported from China, Saudi Arabia, Singapur, Thailand, USA, and Spain were NRs. 14,826, 33,083, 11,523, 759,392, 86,606, and 183,710 respectively (TPC 2005). Similarly in 2005-06, the import worth from China PR and Thailand were NRs. 43641/- and 977,703, respectively (TPC 2006). In the past, fresh baby corn produced in Chitwan valley was introduced to markets of Kathmandu and Chitwan (Mathema 1996). But, it was no longer continued due to various reasons. According to NARC (2000), research on baby corn as an exportable commodity should be initiated.

On the other hand, tomato (*Lycopersicon esculentum* Miller) is one of the most important cash generating vegetable crops in Nepal. The population of Nepal (23 million) requires 713,575 tons of stem and fruit vegetables per year and Nepal imports 589,200 tons of vegetables per year from India (Sah et al 2004). Tomato production and supply during summer and rainy season is constrained due to high temperature and heavy rainfall. These seasons are basically for maize crop in uplands from which farmers generally get very low income. Tomato intercropping in maize plot is becoming popular but scientific research works in this aspect are very limited in Nepal.

Intercropping systems provide greater potential than monoculture for sustained production of food and income, especially in regions of limited resources (Francis 1989). For the promotion of intercropping of baby corn with tomato, there is lack of appropriate production technology with complete package of practices. Thus, the present study was conducted to determine economics, and market of baby corn in Nepal.

MATERIALS AND METHODS

The field experiment was conducted at horticulture farm of IAAS, Rampur from February 24 to July 3, 2007. Maize varieties for baby corn were planted on February 24, 2007 and completely harvested on May 10, 2007. Tomato varieties were sown in nursery on February 25, transplanted on March 16, and completely harvested on July 3, 2007. The experimental site represents the fertile uplands of inner Terai of Nepal. The previous crop was cabbage. The experiment consisted of two-factor (Baby corn cultivars as Factor A and Tomato cultivars as Factor B in randomized complete block design (RCBD) with 8 treatments (combinations of four cultivars of baby corn viz. Rampur Composite, Arun-2, Bioseed 9681 and JK Puja; and two tomato cultivars viz. BSS 418 and Umi) and 3 replications. Two additional plots for maize sole (Rampur Composite, proven as promising for baby corn production from previous studies) and tomato sole (BSS-418, a heat tolerant Indian hybrid recently adopted by farmers of Chitwan) were maintained in each replication for economic analysis. Total experimental area was 289 m² (17 m x 17 m). Space between replication and plot was 1m and 0.5m respectively. The plot size was 3 m x 2.25 m ie 6.75 m². The row-to-row distance in baby corn was 60 cm and plant-to-plant distance was 45 cm. There were 5 rows of baby corn in each plot, 5 hills of baby corn in each row, 5 seeds of baby corn were sown in each hill and 3 plants were retained by 15 days after seeding. Tomato plants were transplanted in between hills of baby corn row. Thus, there were 75 plants of baby corn and 20 plants of tomato in each plot. Raised nursery beds were prepared with the basal application of FYM @ 4 kg/m² and Urea, DAP and Potash @ 5 g/m² for both the varieties of tomato. Tomato seeds were sown thinly in shallow drills about 1.5 to 2 cm deep and 5 cm apart on February 25, 2007. The seedbed was covered with straw mulch for 5 days. The FYM @ 10 t/ha, Nitrogen, Phosphorus and Potash @ 150 kg/ha, 75 kg/ha and 40 kg/ha respectively were well mixed in each plot before seeding of baby corn. Two third portion of nitrogen was applied as side dresses at 25 and 40 days of seeding.

Observations were recorded in inner 9 hills (27 plants ie net plot) of baby corn. Similarly, in tomato, inner 5 plants were selected randomly as sample plants and outer 14 plants were maintained as border plants. A semi-structured questionnaire was developed to identify market channels, constraints, potentialities and status of baby corn in Nepalese market. Nine hotels and 8 departmental stores of Kathmandu were interviewed on marketing aspects of baby corn. The observations were recorded on yields, economy and market aspects. The data were first tabulated in Microsoft Excel and statistically analyzed by using MSTAT-C and GENSTAT Packages. Methodologies for experiment were applied as described by Gomez and Gomez (1984) and Rangaswami (2002).

RESULTS AND DISCUSSION

Baby corn crop

Stover yield: There was no significant difference in baby corn cultivars in producing stover yield (Table 1). But, a highly significant difference in cultivars was reported by Mathema (1994), where Arun-2 produced 17.45 t/ha stover yield which is very low as compared to present study (44.8 t/ha). It could be so due to different plant density in plots in case of previous experiment. According to Adhikari and Sharma (1997), cultivars did not differ in biomass ranging from 36.26 t/ha to 41.07 t/ha, where Ram-1 (37.91 t/ha) and Ram-2 (37.92 t/ha) were statistically at par. An average stover yield (27.143 t/ha) was reported by Faungtupong (1988). It was significantly varied in 10 hybrids evaluated for baby corn ranging from 29.43 t/ha to 49.25 t/ha (Almeida et al., 2005). But, intercropped tomato cultivars had no significant effect on it. In addition, no variation was in stover yield due to the combined effect of baby corn and intercropped tomato cultivars. Thavaprakash et al (2007) reported no significant effect of intercropping of baby corn with radish and coriander on stover yield.

Husk and silk yield: Bioseed 9681 of baby corn differed significantly (p 0.002) in producing husk yield (9.41 t/ha) followed by Arun-2 (8.18 t/ha) (Table 1). Rampur Composite (7.17 t/ha) and JK Puja (6.39 t/ha) were statistically at par. In a previous experiment, cultivars differed significantly and the yield ranged from 5.60 to 7.66 t/ha (Mathema 1994). Among the cultivars, Arun-2 produced lower yield than in the present study which might be due to the high plant density. Adhikari and Sharma (1997) reported that the yield ranged from 3.83 to 4.44 t/ha, where the Ram-2 had the highest yield (4.44 t/ha) among the tested varieties. The yield difference could be due to the difference in number of plants per hectare and input levels. The yield (6.237 t/ha) of husk and silk was reported by Faungtupong (1988). Yet, effect of intercropped tomato and interaction of baby corn and tomato cultivars on husk yield was statistically non-significant. However, combination of Bioseed 9681 and BSS-418 (9.78 t/ha), and Arun-2 and BSS-418 (8.98 t/ha) were promising.

Husked cob yield: Husked cob yield was varied significantly (p 0.01) in baby corn cultivars (Figure 1). Bioseed 9681 produced the highest (12.60 t/ha) yield followed by Arun-2 (10.75 t/ha). The lowest yield (9.71 t/ha) was in JK Puja. Mathema (1994) observed that the cultivars significantly varied in husked cob yield ranging from 6.284 t/ha to 9.252 t/ha, indicating that Arun-2 produced 7.869 t/ha. The higher yield of Arun-2 in the present study could be due to the consistent density of plants per plot. Lekagul et al (1978) reported the yield of checks and hybrids ranged from 4,443 to 6,425 kg/ha. The husked cob yield of ten hybrids varied significantly ranging from 2,936 kg to 6,100 kg/ha when evaluated for baby corn (Almeida et al 2005). However, effect of intercropped tomato cultivars and interaction of baby corn and tomato cultivars on husked cob yield was statistically non-significant (Table 2). The combination of Bioseed 9681 and BSS-418 (13.12 t/ha), and Arun-2 and BSS-418 (11.65) were promising. There was no significant variation in husked cob yield in intercropping with radish and coriander (Thavaprakash et al 2007). Intercropping of baby corn with amaranth and green gram had also non-significant effect on it (Thavaprakash and Velayudham 2007). Similar results were also reported by Tiwari et al (2002).

Dehusked cob yield: Baby corn cultivars had significant (p 0.004) effect on dehusked cob yield (Figure 1). The highest cob yield (3.324 t/ha) was recorded in JK Puja. But JK Puja had larger cobs than those in other cultivars so that there might be lower price due to poor quality. Thus, Bioseed 9681 (3.190 t/ha) and Arun-2 (2.577 t/ha) were promising. Among the baby corn cultivars studied, hybrids had higher yield than open-pollinated ones. Adhikari and Sharma (1997) reported that the cultivar yield ranged from 0.522 to 0.664 t/ha and Ram-2 was high yielder (0.664 t/ha). A high yield in the present study could be due to the difference in plant density and input applied. An average yield (1.362 t/ha) of dehusked cob was reported by Faungtupong (1988). Lekagul et al (1978) reported the yield of checks and hybrids ranged from 562 to 1,100 kg/ha. According to Almeida et al (2005), hybrids differed significantly in dehusked cob yield ranging from 186 to 877 kg/ha. A significant variation was observed in dehusked cob yield due to intercropped tomato cultivars while non-significant variation was due to interaction effect (Table 2). However, BSS 418 had greater effect (3.121 t/ha) than Umi (2.680t/ha). The combination of Arun-2 and BSS-418 (2.676 t/ha) and Bioseed 9681 and BSS-418 (3.340 t/ha) were potential for dehusked cob yield.

Tomato crop

Unmarketable fruit yield: The results revealed that there was no significant effect of baby corn cultivars in producing unmarketable yield of intercropped tomato (Table 1). However, tomato cultivars significantly ($p < .001$) varied in producing unmarketable yield. Tomato cultivar BSS-418 produced higher (1.403 t/ha) unmarketable fruit yield than Umi (1.004 t/ha). Tomato cultivars had 0-20 t/ha of unmarketable fruit yield when tested in summer at Chitwan (Upreti and Adhikari 1984). According to Upadhyay et al (2003), thirty-day-old seedlings of cultivar BL-410 were planted at 15 days interval from May 1 to June 15 in river basin and from May 15 to August 1 in mid hill conditions, where the highest yield was obtained from May 15 planting. However, the interaction effect of baby corn and intercropped tomato cultivars was non-significant.

Table 1. Mean values for yields of baby corn and tomato under baby corn-tomato intercrop in Chitwan (2007)

Treatments	Baby corn		Tomato parameters	
	Stover yield (t/ha)	Husk and silk yield (t/ha)	Unmarketable yield (t/ha)	Marketable yield (t/ha)
Baby corn cultivars (Fa)				
Rampur Composite	48.1	7.17 b	1.069	27.79 c
Arun-2	44.8	8.18 ab	1.094	32.47 b
Bioseed 9681	52.3	9.41 a	1.214	36.81 a
J K Puja	50.3	6.39 b	1.436	36.53 a
Mean	48.9	7.79	1.203	33.42
F-prob (p.)	0.273	0.002	0.054	<0.001
SEM±	2.69	0.463	0.0899	0.828
LSD _{0.05}	ns	1.405	ns	2.512
CV%	13.5	14.6	18.3	6.1
Tomato cultivars (Fb)				
BSS 418	50.2	8.09	1.403	47.57
Umi F1 hybrid	47.5	7.48	1.004	19.23
Mean	48.9	7.79	1.203	33.42
F-prob (p.)	0.333	0.204	<.001	<.001
SEM±	1.91	0.328	0.0636	0.586
LSD _{0.05}	ns	ns	0.1928	1.776
CV%	13.5	14.6	18.3	6.1
Baby corn cultivar x Tomato cultivar (Fa x Fb)			3.333	
Rampur Composite X BSS 418	43.5	6.51	1.296	39.61 c
Rampur Composite X Umi	52.8	7.82	0.843	15.98 e
Arun-2 X BSS 418	49.4	8.98	1.414	46.93 b
Arun-2 X Umi	40.1	7.38	0.773	18.00 e
Bioseed 9681 X BSS 418	55.9	9.78	1.331	54.01 a
Bioseed 9681 X Umi	48.8	9.05	1.097	19.60 de
J K Puja X BSS 418	52.2	7.11	1.570	49.74 ab
J K Puja X Umi	48.5	5.67	1.302	23.33 d
Mean	48.9	7.79	1.203	33.42
F-prob (p.)	0.115	0.148	0.384	0.003
SEM±	3.81	0.655	0.1271	1.171
LSD _{0.05}	ns	ns	ns	3.553
CV%	13.5	14.6	18.3	6.1

Means within the column followed by same letter are not significant at 5% level by DMRT

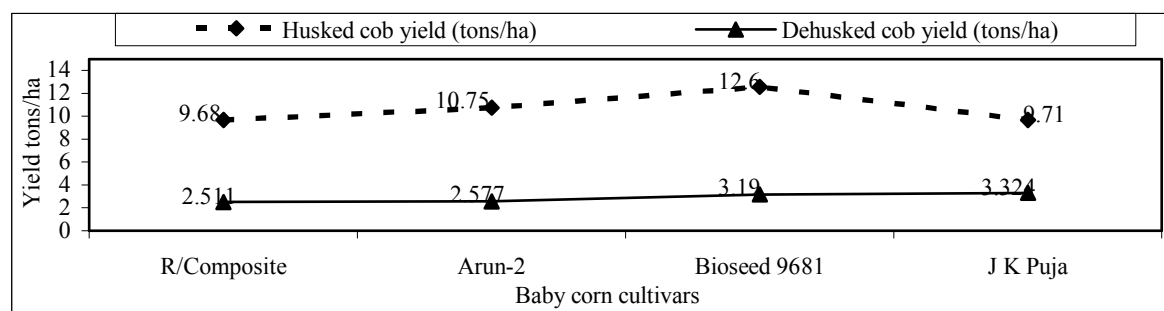


Figure 1: Husked and dehusked cob yield of baby corn under baby corn-tomato intercrop in Chitwan (2007)

Table 2. Husked and dehusked cob yield of baby corn under baby corn-tomato intercrop in Chitwan (2007)

Treatments	Husked cob yield (t/ha)	Dehusked cob yield (t/ha)
Tomato cultivars (Fb)		
BSS 418	11.22	3.121
Umi F1 hybrid	10.16	2.680
Mean	10.69	2.900
F-prob (p.)	0.091	0.013
SEM±	0.412	0.1095
LSD _{0.05}	ns	0.3321
CV%	13.4	13.1
Baby corn cultivar x Tomato cultivar (Fa X Fb)		
Rampur Composite X BSS 418	9.09	2.577
Rampur Composite X Umi	10.27	2.444
Arun-2 X BSS 418	11.65	2.676
Arun-2 X Umi	9.85	2.478
Bioseed 9681 X BSS 418	13.12	3.340
Bioseed 9681 X Umi	12.09	3.040
J K Puja X BSS 418	11.01	3.892
J K Puja X Umi	8.42	2.756
Mean	10.69	2.900
F-prob (p.)	0.171	0.124
SEM±	0.824	0.2190
LSD _{0.05}	ns	ns
CV%	13.4	13.1

ns = Not significant

Marketable fruit yield: The effect of baby corn cultivars was statistically significant ($p < 0.001$) on marketable fruit yield of intercropped tomato (Table 1). The tomato crop intercropped with Bioseed 9681 produced the highest (36.81 t/ha) yield, which was at par with JK Puja (36.51 t/ha). The tomato crop intercropped with Rampur Composite produced the lowest (27.79 t/ha) yield. The tomato cultivars significantly ($p < .001$) influenced the marketable fruit yield. BSS-418 produced higher yield (47.57 t/ha) than Umi (19.23 t/ha). The low yield of Umi might be due to heat stress. The optimum days and night temperatures for tomato growth and fruit development are considered below 30 and 23°C, respectively (Moore and Thomas 1952, Schaible 1962) while the temperatures were above the range during the fruit development in present experiment. Upreti and Adhikari (1984) reported the heat stress as a probable cause of low yield in tomato. The possible causes of low intercrop yields included low yield potential of cultivar, high plant density, inappropriate planting time, low fertility and fertilizer rate, insects and diseases, and inappropriate time of farm operations (Mwaipaya 1989). Bhurtyal et al (2007) reported that the marketable fruit yield ranged from 40.53t/ha (Bari-5) to 9.83 t/ha (CLN 1466 J) in 14 tested tomato cultivars. But, the yield potential of hybrid cultivar NSITH 162 was 150 t/ha under plastic house condition in western low hills of Nepal (Pandey and Pun, 2004). BL-410 (34.9 t/ha) and Cherry Sweet (18.67 t/ha) had the highest and lowest yield respectively in Jumla condition (Pandey and Chaudhary

2004). The marketable yield of several cultivars tested in Khumaltar condition ranged from 8.6 t/ha to 45 t/ha (Regmi et al., 2004). Some hybrids of tomato had the yield range of 2.7 t/ha (LTH-78) and 49.5 t/ha (N-162) (Paudel et al 2004). The yield potential of the 19 cultivars ranged from 3.38 to 34.90 t/ha during summer in Chitwan (Upreti and Adhikari (1984). Ojha (2006), Shakya et al (1994), and Upreti et al (1985) also observed variation in marketable fruit yield. According to Upadhyay et al (2003), thirty-day-old seedlings of cultivar BL-410 were planted at 15 days interval from May 1 to June 15 in river basin and from May 15 to August 1 in midhill conditions, where the highest yield (22.0 t/ha in river basin and 19.25 t/ha in mid hills) was obtained from May 15 planting. The interaction effect on marketable fruit yield was also statistically significant (p 0.003). BSS-418 grown under Bioseed 9681 X BSS- 418 intercropping produced the highest (54.01 t/ha) yield while the Umi intercropped under Rampur Composite X Umi had the lowest (15.98 t/ha) marketable fruit yield which was at par under Arun-2 X Umi (18.00 t/ha) intercropping.

Economics of baby corn production

Gross benefit, net benefit, and benefit cost ratio were estimated for baby corn production in one hectare. There was net benefit of Rs 179,290 and benefit cost ratio of 1.92 from baby corn crop in one hectare of land in Chitwan condition. Thus, it can be recommended as a cash-generating crop. The benefit cost ratio of 1.85:1 (variety not mentioned) was reported by Adhikari and Sharma (1997) during the evaluation of open pollinated varieties under two levels of plant densities in Chitwan condition. They also reported the net benefit NRS 57,498/ha from the study. Mathema (1996) reported the net benefit Rs. 77,600/ha (average of six open pollinated and exotic varieties) from 1.2 t/ha @ Rs. 100/kg (wholesale price).

Economics of sole and intercropping system

Benefit:cost ratio: Benefits and costs of sole crops of maize, baby corn, and tomato, and baby corn-tomato intercrops were calculated from the total costs (Table 4). The cultivar Rampur Composite of baby corn and BSS-418 of tomato were used for economic analysis. The highest benefit cost ratio (2.99:1) was estimated in baby corn-tomato intercrop. Tomato sole gave the benefit cost ratio of 2.54, however, tomato sole could not be recommended for Terai and inner Terai due to adverse environment during summer and rainy season. But, it could be recommended for intercropping where maize plant provides partial shade so that the microclimate within the canopy of corn plants could be ameliorated. The lowest (1.44:1) ratio was in maize sole, while baby corn sole gave the ratio of 1.92:1.

Land equivalent ratio

LER is the ratio of the intercrop to sole crop yields. In this case the following formula was used to determine the LER.

$$\text{LER} = \frac{\text{Yield of baby corn as intercrop}}{\text{Yield of baby corn as sole crop}} + \frac{\text{Yield of tomato as intercrop}}{\text{Yield of tomato as sole crop}}$$

$$= \frac{2259.9}{2377.8} + \frac{31680}{38132} = 0.95 + 0.83 = 1.78$$

The calculation reflected a positive LER which is greater than 1. Thus the conclusion can be drawn that the baby corn and tomato intercropping is beneficial than producing baby corn sole crops. It could be recommended that the intercropping system had higher land use efficiency than the baby corn sole.

Table 3: Economics of baby corn production in one hectare in summer at Rampur, Chitwan (2007)

Income*	Baby cobs	Biomass	Total
Yield kg/ha (Cultivar: Rampur Composite)	2,642	57,400	
Adjustable yield (10% loss due to handling and quality loss in cobs)	2,377.8	-	
Price. Rs/kg	150	0.3	
Gross Benefit. Rs/ha	356,670	17,220	373,890
Sources of Costs*	Costs (NRs.)		
1. Land preparation			
a) 5.7 hrs for 3 harrowings @ Rs 500/hr	2,850		
b) 1 hr for land leveling @400/hr	400		
2. Inputs			
a) Seed 40 kg/ha @ Rs 40/kg	1,600		
b) FYM and Fertilizers			
FYM 10 t/ha @ Rs. 500/t	5,000		
DAP 163 kg/ha @ Rs. 46/kg	7,498		
Urea 262 kg/ha @ Rs. 26/kg	6,812		
Potash 67 kg/ha @ Rs. 20/kg		1,340	
c) Presowing irrigation @ Rs 1500/irrigation/ha		1,500	
d) Farm tools: Balance, Bucket, tray, spade, sickle, polybags etc.		5,000	
3. Laborers			
Weed cleaning before planting: 17 mandays/ha @ Rs 100		1,700	
Planting: 17 mandays/ha @ Rs 100		1,700	
Fertilizer application: 17 mandays/ha @ Rs 100		1,700	
Furrow opening and covering: 17 mandays/ha @ Rs 100		1,700	
Gap filling: 15 mandays/ha @ Rs 100		1,500	
Thinning: 10 mandays/ha @ Rs 100		1,000	
Weeding 3: 190 mandays/ha @ Rs 100		19,000	
Top dressing 2: 51 mandays/ha @ Rs 100		5,100	
Irrigation with pipe 2/week: 198 mandays/ha @ Rs 100		19,800	
Detasseling: 131 mandays/ha @ Rs 100		13,100	
Harvesting: 761 mandays/ha @ Rs 100		76,100	
Cleaning: 67 mandays/ha @ Rs 100		6,700	
Stalk harvesting: 35 mandays/ha @ Rs 100		3,500	
Packing and transportation for 300 km		10,000	
Total Costs: Rs/ha*		194,600	
Net benefit: Rs/ha*		179,290	
Benefit Cost Ratio*		1.92	

*Information was collected from experimental area and converted into per hectare

Marginal rate of return (MRR)

The highest MRR (1890.91%) was observed in the shift of baby corn sole to tomato sole (Figure 2), but tomato sole should not be practical because of highly adverse climatic condition during summer and rainy season. Similarly, the same level of crop management applied in this experiment could not be expected from farmer's level. The shift from maize sole to baby corn sole had the lowest (99.174%) MRR, which indicates that there is additional total cost in baby corn production than that in maize production. Baby corn-tomato intercrop had the high marginal rate of return (451.42%), which indicated that the practice had more rate of return than baby corn sole. At this juncture, production of new maize product like baby corn would be the best alternative. In this way, shifting from maize sole to any other practice would be appropriate to modify the existing cropping system.

Table 4. Economics of cropping systems (NRs. in one hectare) at Rampur, Chitwan (2007)

Input details	Maize sole (Local)	Baby corn (Rampur Composite)	Tomato (BSS- 418)	Baby corn- tomato(Rampur Composite, BSS-418)
Seeds	1,125	1,600	11,000	12,600
Seed bed preparation	-	-	2,500	2,500
Land preparation	2,850	3,250	3,250	3,250
Presowing irrigation	-	1,500	2,500	2,500
Pit preparation	-	-	3,720	1,730
Farm tools	-	5,000	8,000	9,500
FYM	3,550	5,000	15,000	5,000
Chemical fertilizers	3,618	15,650	15,078	19,240
Fertilizer application	1,000	1,700	2,680	3,250
Weeding/debris removal	-	1,700	4,400	2,750
Furrow opening and covering	-	1,700	-	1,700
Planting	1,500	1,700	4,100	3,800
Replanting/gap filling	-	1,500	2,100	2,500
Thinning	-	1,000	-	1,000
Clipping of lower leaves	-	-	-	2,000
Weeding/ Earthing up	2,300	19,000	31,000	40,000
Top dressing	1,850	5,100	7,650	12,750
Pesticide application	-	-	9,650	12,310
Staking	-	-	9,920	-
Manual irrigation	-	19,800	24,110	20,955
Harvesting	2,250	76,100	25,378	61,478
Detasseling	-	13,100	-	13,100
Cleaning	-	6,700	-	-
Stalk harvesting	1,000	3,500	-	-
Packing/transport/sell	1,500	10,000	19,500	23,500
Threshing/drying/ storage	2,350	-	-	-
Total cost	24,893	194,600	201,536	277,413
Total yield kg/ha	Grain: 2,532 Biomass 17,000	Cobs: 2,642 Biomass 57,400	42,665	Cobs: 2,511, Biomass: 54,520 Fruits: 39,600
Adjusted yield:	Grain: 2,278.8	Cobs: 2,377.8	34,132	Fruit 31,680, Cob
Loss of Cobs 10%, tomato fruit: 20%	Biomass 17,000	Biomass 57,400		2,259.9 Biomass 54,520
Farm gate price (Rs/kg)	Grain: 15, Biomass: 0.1	Cobs: 150, Biomass: 0.3	15	Cobs: 150 Fruit: 15 Biomass 0.3
Gross benefit	Grain: 34,182 Biomass 1,700 Total: 35,882	Cobs: 356,670 Biomass 17,220 Total: 373,890	511,980	Cobs: 338,985, Biomass 16,356 Fruits: 475,200 Total: 830,541
Net benefit	10,989	179,290	310,444	553,128
Benefit cost ratio	1.44	1.92	2.54	2.99

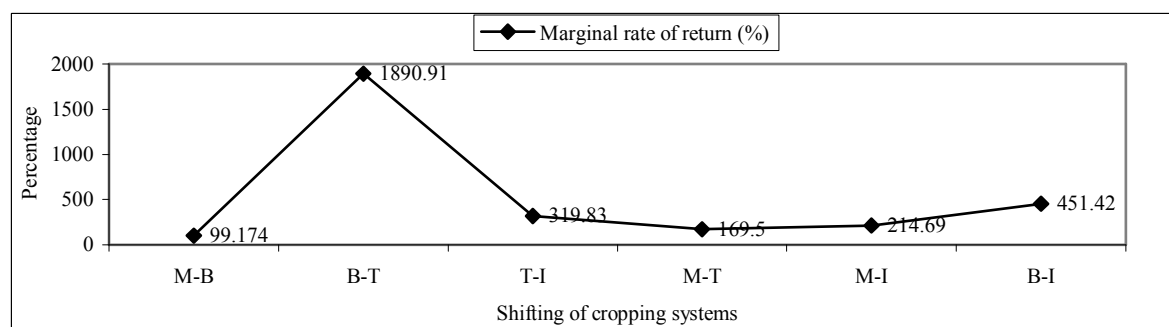


Figure 2: Marginal rate of return (%) from shifting of cropping systems, where M = Maize sole, B = Baby corn sole, T = Tomato sole and I = Baby corn-tomato intercrop.

Market assessment of baby corn

Information was collected from representative hotels and departmental stores of Kathmandu valley (Table 5). Separate questionnaires were prepared and the representatives of hotels and stores were interviewed.

Information from departmental stores

Information was collected from 8 top-level supermarkets/ departmental stores and the respondents were the persons involved in sale/store/market/account, who really knew the status of baby corn products in the market.

Average consumption per day

The variation in consumption amount per day was observed. The highest amount (50 cans per day) of sale was recorded by the Bhatbhateni departmental store, whereas the lowest (2-4 cans per day) was given by Vijay store, Kupandole. According to the representatives interviewed, the consumption had increasing trend for the last 2-3 years.

Major consumers

All stores realized that the major consumers were foreigners who stayed at hotels and standard restaurants. Thus, the star hotels used to purchase this item to serve the foreigners. Nowadays, a trend has been developed in Kathmandu city, where the people use baby corn in mixed vegetables and soup preparations in get-togethers, parties and festivals.

Producers

Limited quantity was produced in Nepal. However, major production reached directly to hotels without canning. A small quantity was canned by Rijal Tashi Industry, Itahari; however, its major focus was on sweet corn. Departmental stores had foreign canned product.

Role of middlemen

There was a very important role of middlemen to supply baby corn from abroad. But, Nepalese farmers contacted the hotels and directly supplied it.

Marketing pathway

Three pathways were in Nepalese market. In the first, the foreign product entered the country from producers via importers and reached the consumers through distributors and wholesalers. In the second, the Nepalese farmers produced fresh baby corn and directly supplied to hotels and restaurants. In third, the canned product of Nepal was supplied to consumers through departmental stores.

Import

The major countries exporting baby corn were Thailand, China, Malaysia, Singapur and Dubai. Among them Thailand was the leading country to supply baby corn followed by China, Malaysia and Dubai.

Market of Nepalese product

All departmental stores agreed to purchase Nepalese canned products only (not fresh). They also agreed to buy 1-3 case per week (12 cans per case). They would purchase Nepalese product @ NRs. 40-55 per can. The existing price of foreign canned product was NRs. 45-75 per can.

According to interviewees, there is great potential of canned product in Nepalese market. They also focused on the exportability of baby corn to India and European countries. They suggested following points for the promotion of baby corn production in Nepal:

- Create awareness to farming community and consumers level
- Research on production practices, post harvest and market aspects
- Mass production and regular supply to meet the market demand
- Cost effective canning to down the import, and
- Quality canning and tasty products.

Information from hotels and restaurants

Information was collected from 9 hotels and restaurants, where the tourists came frequently and preferred the baby corn included food items. Most of the hotels were five stars. The respondents were primarily the chief of the working group in kitchen, or the person involved in marketing/purchase of the baby corn (Table 6).

Baby corn as food item

Hotels included baby corn as one of the food items in their menu. Mostly canned baby corn was used as mixed vegetables and salad. They served baby corn either once a day or alternate day.

Market related information

Major amount of the baby corn consumed in hotels was imported from Thailand, Singapur, Malaysia, and China. The price they paid for baby corn ranged from NRs. 45-65/can (450 g). Since the canned product weighed 450 g with the preservative solution, the actual weight of baby corn ranged from 120 g to 180 g depending upon the size of cobs. Importers and suppliers had the major role in distributing the products to the hotels and restaurants. The main suppliers are Nepalese importers, sub-distributors, distributors, and wholesalers. Hotels and restaurant personnel were not familiar about the varieties of baby corn. Per day consumption amount ranged from 4 to 7 cans.

There were some causes of serving baby corn instead of other substitutes as mentioned below

1. Consumers' preference: Most of the consumers Indian and Europeans, they prefer it.
2. One of the most important ingredients of some food items like salad, vegetable curry, soup, and mixed vegetables.
3. Adds taste and color in the food item.

The hotels and restaurants had willingness to use Nepalese product of 3-6 cans per day and if fresh, 2-3 kg per day. The price of fresh baby corn was @ NRs. 225 per kg, which was expensive in the hotel's experience. Now they could purchase fresh baby corn @ NRs 150-175/kg. The most preferred items of consumers were salad, Chinese mixed vegetable, soup and curry. The hotels gave similar suggestions as the departmental stores.

Table 5. Status of baby corn in Kathmandu market

Shop and respondent	Sale (Cans/day)	Main consumers	Brands	Major supplier	Price (Rs./can)	Price of local supply Rs/can
Bhatbhateni Supermarket and Departmental Store: Kailash Khadka	50	Foreigner, restaurant, hotels, upgraded family	Great, Hoseng, King bell	Thailand	55-60	50
Namaste Super Market, Pulchowk, Lalitpur: Sahana Chitrakar	4-6	Parties, foreigners, hotels, higher families	Golden Kingbell, UFC, Monty Great,	Thailand	40-75	45
Saleways department store, Pulchok, Lalitpur: Abhijit Baidya	12	Star hotels, foreigner, upper class families	King bell, Hosen, UFC, Red & White	Malaysia, Thailand	53	44
Kumari Convenience Centre, Kupandole: Yuba Raj Bhattarai	3-4	Restaurants, foreigner	Scof, Nepali	-	58-65	30
Vijaya Store, Kupandole: Digvijaya Lal	2-4	Foreigners, upper classes	Sunlee, Great	China, Thailand	45	45
Gemini Super Market, Baudha, Kathmandu: Jagdish Maskey	10-12	Restaurants, Hotels, Parties	Great	Thailand	55	30
Blue Bird Departmental Store, Lazimpat, Kathmandu: Prabesh Shapit	4	Tourists, Hotels	King bell, Hosen, Great and others	Thailand, Dubai	60-65	30
Kashthamandap Supermarket, Darbarmarg: Mani K. Manandhar	6	Foreigners, Hotels	King bell, Hosen, UFC	Thailand, Singapore	45-68	40-44

Table 6. Status of baby corn in Hotels/ Restaurants of Kathmandu

Hotel/ Respondent	Established	Status	Form	Items	Serving	Source	Suppliers	Price NRs.	Used cans/day	Preferred item	Internal purchase
Everest Casino, New Kathmandu: Baneshor, Keshav Prasad	1993	5 star	Fresh, Can	Salad, Vegetables	1/day	In-country, Import	Supermarkets and middlemen	45-65/can 175-225/kg	4-7	Salad, Chinese veg.	3 cans @ 40, 3 kg @ 150-175
Downtown restaurant, Harihar Bhawan: Raju Dhakhwa	1989	-	Can	Vegetable	Everyday	Import	Retailers	52/can	2	Chinese curry	2 cans @ 52
Royal Disco bakery Caf�, Baneshor: Dharma Raj Karki	-	-	Can	Salad, soup, veg.	Every day	Import	Retailers	48/can	1-2	Mixed veg. curry	2 cans @ 45
Everest Hotel, New Baneshor: Mashor Alam	1981	5 star	Fresh, Can	Salad, Vegetables	1/day	In-country, Import	Supermarkets and middlemen	45-65/can 175-225/kg	4-7	Salad, Chinese veg.	3 cans @ 40, 3 kg @ 150-175
Casino Rad, Lazimpat: Sher Bdr	2003	5 star	Canned	Salad, soup, veg, curry	Alternate day	Import	Supermarkets	52/can	6	Salad, veg @150	5 cans @ 40, 2 kg @150
Soaltee Crown Plaza, Tahachal: Rajeev Shrestha	1965	5 star	Fresh Can	Salad, Vegetables	Every day	Import	Supermarkets	45-52/can	6-8	Chinese veg	6 cans @ 45, Fresh 3 kg @ 165
Yak and Yeti, Darbar Marg: Mohan Sijapati	-	5 star	Can	Salad, Vegetables	2/day	Import	Supermarkets	55/can	6-7	Boiled mixed veg Chinese	6 cans @ 45, Fresh 2.5 kg @ 155
Annapurna, Darbarmarg: Bashu Giri	-	5 star	Can	Salad, Vegetables	2/day	Import	Supermarkets	50/can	5-7	Mixed veg. salad	4 cans @ 40, Fresh 2 kg @ 150
Hayatte Regency, Baudha: Bikram Kanpure	1976	7 star	Can	Salad, Vegetables	Every day	Import	Supermarkets	52/can	6-10	Chinese veg.	7-8 cans @45, 2-3 kg @ 160

CONCLUSION

Baby corn is relatively a new crop in Nepal. Technology generation on various aspects of baby corn has become urgent to promote it as a cash-generating commodity. Among the technologies, variety, economics, market and appropriate cropping system are very important. The interaction of Arun-2 and BSS 418 and Bioseed 9681 and BSS 418 were promising for optimum yield and economy of both crops. The economic analysis revealed that baby corn production had potential of earning net benefit NRs 179,290 with benefit cost ratio of 1.92:1 in one hectare as a sole crop. In intercropping, baby corn-tomato intercrop had greater (2.99:1) benefit cost ratio than existing maize sole system (1.44:1). The land equivalent ratio was positive (1.78) in case of baby corn-tomato intercrop. Thus baby corn-tomato intercrop was more profitable. The market study showed a great potentiality of baby corn supply in Nepalese hotels, restaurants, departmental stores and upgraded families. The prerequisites for uplifting baby corn production are: establishing canning industry, conducting research on various aspects of production, market and post-harvest, creating awareness on value of the product, and regulating the supply of baby corn as per the market demand. Since it is served every day in most of the star hotels and top-level restaurants as a food component, it demands for huge amount of canned and fresh products with competitive cost and quality.

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Study on Adoption of Major Grain Legumes Technologies in Chitwan District

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ABSTRACT

Study on adoption of major grain legumes technologies at the outreach sites of the National Grain Legume Research Program in Chitwan district was conducted in December 2007. Tharu was the dominant caste of the surveyed site. Lentil, pea, soybean, pidgeonpea, cowpea, bean and rajma were the legumes included in their cropping pattern. The average yield of lentil was 1.35 ton per hectare. Weed was the major problem in lentil causing high labour cost. Another serious problem was botrytis gray mold disease of lentil. Rajma bean is replacing the lentil area because farmers view rajma bean could be a lucrative crop in comparison to lentil. Farmers' preference on legume crops and their varieties varied for biological and socio-economic characters.

Keywords: Adoption, grain legumes, production technology

INTRODUCTION

Grain legumes rank fourth place both in terms of area and production after rice, maize, and wheat. Researches on legumes have resulted in the recommendation of several varieties of grain legumes, which includes 8 of lentil (Sital, Sikhar, Simrik, Khajura-1, Khajura-2, Simal, Sisir, Sindhur), 6 of chickpea (Sita, Dhanush, Koseli, Kalika, Radha, Trisul), 3 of cowpea (Aakash, Prakash, Surya), and 2 of pigeonpea (Rampur Rahar-1, Bageshowri) (Annual report 2005/06).

Research results indicated that though the yield potential of recommended technologies is about 3.0 t/ha yield obtained at the farmers field under well managed conditions is only 1.5 t/ha. This could be due to poor adoption of recommended technologies and a number of biotic, abiotic, socio-economic and technological constraints (NGLRP 2004).

Per capita consumption of grain legumes in Nepal is around 10.0 kg/annum which are very low as compared to the standard FAO recommendation of 18.0 kg/capita/annum or 50.0 gm protein/capita/day (NGLRP, 1998/99). The importance of grain legumes as an exportable commodity has been realized in recent years. Lentil is the single commodity among legumes exported to overseas. The demand for orange or red cotyledons lentil is ever high in the international market. Lentil was exported from Nepal to Bangladesh as quantity of 4680.0 mt equivalents of NRs. 191.7 million (US\$. 2995.4 thousand) (TAEPC 2005/06).

The objectives of this study were: to assess the adoption of various grain legume technologies in farmers' fields, to find out the factors for the poor adoption of grain legume technologies, and to recommend measures for policy intervention for the wider dissemination of grain legume technologies.

GENERAL METHODOLOGY

Checklist and structured questionnaire were developed for the study. Eight VDCs of Chitwan, including Sukranagar, Khairahani, Surtani, Chainpur, Pathiyani, Jagatpur, Parbatipur, Gitanagar were selected. The study was conducted in December 2007. Random sample method was followed to select the households.

Structured questionnaire was administered for data collection and in total 40 households were surveyed by a multidisciplinary team. Group discussion was held with farmers. Primary and secondary data were also collected from different institutions. Data analysis was done using SPS package.

RESULTS AND DISSCUSSION

The total area under legume crops of the 40 households was 33.31 ha, of which 28.34 ha was khet land and the remaining 4.97 was bari land (Table 1). In 33.31 ha of land the total legume production was 52.24. The yield was 1.57 kg/ha. The crop-wise details are given in Table 2. The crops included lentil, bean, pigeon pea, soybean, cowpea and rajma. According to the farmers, rajma is getting more popular and also replacing lentil. It is because farmers like to eat rajma with rice and also with roti (bread) and it has more market value than lentil.

Table 1 Area under legume cultivation by 40 households in the surveyed VDCs of Chitwan district, 2007

Name of VDC	No. of households	Area of khet land, ha	Area of bari land, ha	Total area, ha	Total production, mt
Sukranager	14	10.09	0.99	11.8	19.62
Khairahani	5	3.46	1.05	4.51	7.43
Surtani	1	0.27	0.14	0.41	0.65
Chainpur	1	0.51	0	0.51	0.95
Pathiyani	5	4.81	0.85	5.66	9.00
Jagatpur	1	0.27	0	0.27	0.51
Parbatipur	4	5.22	1.32	6.54	7.60
Gitanagar	9	3.73	0.68	4.41	6.48
Total	40	28.34	4.97	33.31	52.24

Table 2. Area and production of different legume crops in surveyed VDCs of Chitwan district, 2007

VDC	Sukranager (HH- 14)		Khairahani (HH - 5)		Surtani (H - 1)		Chainpur (HH - 1)		Pathiyani (HH - 5)		Jagatpur (HH -1)		Parbatipur (HH - 4)		Gitanagar (HH - 9)	
Variety	TA, ha	TP, mt	TA, ha	TP, mt	TA, ha	TP, mt	TA, ha	TP, mt	TA, ha	TP, mt	TA, ha	TP, mt	TA, ha	TP, mt	TA, ha	TP, mt
Lentil	9.2	14.7	2.9	3.91	0.41	0.65	0.24	0.40	4.17	6.26	0.27	0.51	1.41	2.10	3.47	5.10
Bean	-	-	0.17	0.37	-	-	0.27	0.55	-	-	-	-	-	-	0.13	0.31
Pea	-	-	-	-	-	-	-	-	-	-	-	-	0.12	0.09	-	-
Pigeonpea	-	-	-	-	-	-	-	-	-	-	-	-	3.23	2.5	-	-
Soyabean	0.2	0.44	0.37	0.9	-	-	-	-	0.32	0.61	-	-	0.33	0.66	0.14	0.36
Cowpea	0.4	1.08	0.54	1.35	-	-	-	-	0.14	0.38	-	-	0.13	0.36	-	-
Rajma	2.0	3.4	0.53	0.90	-	-	-	-	1.03	1.75	-	-	1.32	2.24	0.42	0.71
	19.6															
Total	11.8	2	4.51	7.43	0.41	0.65	0.51	0.95	5.66	9.0	0.27	0.51	6.54	7.60	4.16	6.48

TA – Total area; TP- Total production

The variety-wise details of each legume crop are given in Table 3. Thirty-three households cultivated improved and local lentil varieties in surveyed area. Improved varieties, Simal and Sidhur of lentil were the higher yielder (2.0 mt/ha) compared with other varieties. However, 22 households were cultivating local varieties of lentil as they had not received the improved varieties yet. services. In case of soybean, majority of farmers (35) found cultivating improved varieties, while only 3 farmers used local varieties. However, the yield of one of the improved varieties (PK416) was found low when compared even with the local variety (Local small). Of 27 rajma growing households, 22 cultivated variety PDR14 with the yield of 2.4 t/ha. Yield of other rajma varieties grown in the area was low (1-1.5 t/ha).

Table 3. Legume varieties (with yield) adopted by farmers in surveyed VDCs of Chitwan district, 2007

Lentil		Pea		Soybean		Pegionpea		Cowpea		Rajma	
Variety	HH, no.	Variety	HH, no.	Variety	HH, no.	Variety	HH, no.	Variety	HH, no.	Variety	HH, no.
Bikashi (1.5 t/ha)	1	Hybrid (3.4 t/ha)	1	PK416 (1.4 ha)	25	Local (0.3 t/ha)	2	Green pods (2.5 t/ha)	4	Hetuada (1.2 t/ha)	3
Local (0.75 t/ha)	22	Local (Mahili) (1.0 t/ha)	6	PK327 (3.0 t/ha)	10	-	-	Makwanpure (2.5 t/ha)	1	Local (1 t/ha)	1
ILL7164 (1.4 t/ha)	1	Local (Kanchi) (1.0 t/ha)	5	Local small (2.8 t/ha)	1	-	-	Prakash (1.6 t/ha)	3	PDR14 (2.4 t/ha)	22
Simal (2.0 t/ha)	4	-	-	Local White (1.6 t/ha)	2	-	-	Surya (1.3 t/ha)	1	-	-
Sindur (2.0 t/ha)	3	-	-	-	-	-	-	-	-	Mixed (1.5 t/ha)	1
Improved Simrik (1.7 t/ha)	2	-	-	-	-	-	-	-	-	-	-

HH no. – Number of households

Farmers' preferences for legumes over different characters

Table 4 shows farmers' preferences for different legumes over different characters in terms of percent adoption and non-adoption. For lentil, farmers preferred high yielding (92.0%), early maturity (79%), less management requirement (69%), fit in cropping pattern (98%), cooking quality (81%), nutrition value (72%), easy threshing (69%), cold tolerance (73%), biomass (83%) and reasonable price (64%). However, only 7 and 6 percent of the farmers preferred disease resistant and insect resistant varieties. This is because the farmers were not aware of the disease and insect problems.

Table 4. Preferences of legume varieties for different biological and socio-economics characters by farmers (%) in surveyed VDCs of Chitwan district, 2007

Characters	Lentil	Soybean	Pigeon pea	Cowpea	Rajma	Pea (big)	Pea (Small)
Bold grain	37	74	23	89	72	33	11
High yielding	92	87	21	75	73	71	66
Early maturity	79	91	73	79	19	79	28
Require less mangt.	69	84	17	69	67	34	68
Fit in cropping pattern	98	97	98	100	99	100	100
Traditional crop	3	96	2	100	98	100	100
Lodging resistance	77	87	72	67	29	14	23
Disease resistance	7	73	13	65	35	7	62
Insect resistance	6	69	8	59	33	66	59
Biomass	83	71	71	77	69	29	72
Better cooking quality	81	76	72	72	59	28	63
High nutrition value	72	63	82	67	69	82	73
Easy threshing	69	67	68	70	72	31	71
Cold tolerance	73	59	65	65	17	61	67
Reasonable price	64	69	63	66	72	66	65

Lentil: ILL3490, RL-7164, RL-27, RL-93; Soybean: PK327, Puja; Pigeonpea: Rampur -1, Maghi, RR-1; Cowpea: Prakash, Akash; Rajma: PDR-14, ILL7164; Pea –Big; Pea – Small.

Legume crops after harvest are made available in market through different channels. Prices are generally determined by cost of production. Actually, there are three types of prices: farm gate price, whole sale price and retail price. Pigeonpea and lentil were sold in the market in high retail price Rs. 80.0/kg and 74.0/kg, respectively compared with other legumes (Table 5).

Table 5. Farm gate price to market price (NRs./kg) for different legume crops in surveyed VDCs of Chitwan district, 2007

Legumes Crop	Farm gate price	Wholesale price	Retail Price	Price difference between farm gate price and retail price
Lentil	35	71	74	39
Pea (big)	40	51	53	13
Pea (Small)	30	40	48	18
Rajma	40	37	45	15
Soyabean	30	45	52	22
Cowpea	40	60	70	30
Pigeonpea	38	75	80	58

Note: Transportation cost, NRs. 2/kg, from farmers' field to Naranghat bazaar, Chitwan

The reasons for non-adoption of improved packages of practices by farmers included unavailability of seeds of improved varieties in time, inadequate extension services, inadequate number of varieties/packages of practices for cultivation for varied agro-climate conditions. Also, a number of biotic, abiotic and socio-economic constraints were found, causing wide yield gaps between research stations and farmers' fields. The biotic constraints were wilt, stemphyllum blight, botrytis gray mold (BGM), pod borer and yellow mosaic virus in lentil, chickpea, pigeon pea and cowpea. The exact statistics, adoption trends and study on adoption of improvised varieties of legumes are not available. The contribution of grain legumes in the rural farmers for food security, additional income and poverty reduction hasn't been properly reported yet in the above-mentioned areas.

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