ISSN 1029-533X

NEPAL AGRICULTURE RESEARCH JOURNAL

Volume 7, 2006

Nepal Agricultural
Research Council (NARC)

Society of Agricultural
Scientists Nepal (SAS-N)

Nepal Agriculture Research Journal

Published annually by the Society of Agricultural Scientists Nepal (SAS-N) and Nepal Agricultural Research Council (NARC) since 1997. It could not be published in 2001, 2002 and 2003. **Subscription rates per copy is Rs200 for individual, Rs500 for institution, $15 for SAARC countries and $25 for overseas. Publication charge per article is Rs500 for non-member ($25.00 for foreigner).** SAS-N member can publish their articles free of cost. In case of articles with many authors, one of the authors must be the member of the Society for free publication in the journal.

Original (not published or submitted for publication elsewhere) research, review and feature articles written in English from members of the Society of Agricultural Scientists Nepal (SAS-N) and other interested scientists or technicians in all aspects of agricultural research particularly in the field of agriculture, animal science, agro-forestry, post harvest technology and several other topics related to agriculture will be accepted. Research note may also be published in the journal.

Editorial Board

CORRESPONDING ADDRESS
SAS-N
Bal K. Joshi
Biotechnology Unit-NARC, Khumaltar
PO Box 1135 Kathmandu, Nepal
Tel: 977-01-5521615
Fax: 977-01-5545485

The Society of Agricultural Scientists, Nepal (SAS-N) is a professional organization that serves as a common forum for the agricultural scientists and researchers. SAS-N got officially registered in District Administration Office, Lalitpur on 5 June 1995 with registration no. 490/051/52.

Nepal Agricultural Research Council (NARC), established in 1991, is an apex body for agricultural research in the country.

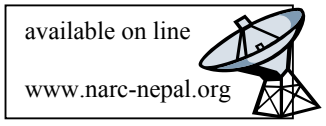
The views expressed in this journal are those of the author/s.

REVIEWERS OF THIS VOLUME

Bedanand Chaudhary	NARC, Hardinath
Gyan K Shrestha	IAAS, Rampur
Hari K Upreti	NARC, Khumaltar
Madhav Joshi	NARC, Khumaltar
Shambhu P Dhital	NARC, Khumaltar
Sunder K Shrestha	NARC, Khumaltar
Tara Lama	DoA, Khumaltar
Thakur P Tiwari	CIMMYT, Kathmandu
Thaneswor P Pokharel	NARC, Khumaltar

INSTRUCTIONS TO AUTHORS

Please see Volume 6, 2005.



Nepal Agriculture Research Journal **Vol. 7, 2006**

Contents

Wheat Genetic Resources in Nepal

Bal K. Joshi*, Ashok Mudwari and Madan R. Bhatta

NARC, PO Box 1135 Kathmandu, Nepal

ABSTRACT

Genetic diversity must be maintained and utilized for sustainable agriculture development. The amount of genetic diversity in the country depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool, wild relatives and existing landraces. The objective of this research was to study the diversity of wheat gene pool present in the Nepalese bread wheat cultivars and landraces that could help for developing conservation and utilization strategy effectively. We examined the pedigrees of 35 Nepalese wheat cultivars and surveyed the literature for distribution of landraces and wild relatives of wheat. Cultivated landraces of spring and winter type, wild landraces and diploid species of wheat are found in Nepal. There are 35 improved wheat cultivars, 540 landraces and 10 wild relatives of wheat. Crosses between winter and spring wheat gene pools are far more common and offer a new source of diversity. Mexico, India and Nepal are the origin countries for 35 cultivars. In Nepal four cultivars were bred and developed using foreign landraces and maximum number of cultivars was developed in Mexico. Lerma 52, first improved cereal variety to be released in the history of cereal breeding in Nepal was released in 1960. A total of 89 ancestors originated in 22 different countries were used to develop these cultivars. Highest number of ancestors was from India. Ancestors of both *aestivum* and *durum* species having winter, spring and intermediate growth habit indicated the collection of wide gene pool. Most of the ancestors were *aestivum* (76.40%) and spring growth habit (57.31%). Modern varieties are replacing the landraces and improved old varieties resulted in the genetic erosion. Therefore, *in situ*, on farm and *ex situ* conservations are necessary for maintaining these genetic variations. Unutilization of local landraces in breeding program may be the major factor that causes to accelerate the genetic erosion. Gene pool from these landraces along with international gene pool could make towards success in developing high yielding cultivars with wide adaptability. In this study, cultivars and landraces surveyed represent a wide range of variation for different areas of origin and adaptation.

Key words: Ancestor, landrace, origin, wheat gene pool

INTRODUCTION

Wheat has been growing since time immemorial particularly in Far and Mid Western hills of Nepal. Mudwari (1999) reported many landraces and 10 wild relatives of wheat in Nepal. It is the third most important crop after rice and maize in Nepal. During mid 1960s the yield potential of dwarf high yielding varieties initiated a scope for raising wheat production in the country. Several exotic varieties were obtained through CIMMYT and USAID (NARC 1997). National Wheat Development Programme was established in 1972 to organize the research and development works on wheat as a commodity crop. Since then, there have been great achievement brought out by the consolidated efforts of wheat researchers, extension workers and farmers. So far there are 35 improved wheat cultivars and 90% of the wheat area is covered by modern wheat cultivars in Nepal (Bhatta et al 2000). Currently wheat is mainly used for bread and biscuits and is becoming more important in Nepalese economy.

Genetic diversity is necessary to derive different transgenic segregants suitable for different agro-ecology to meet the needs of farmers. Both the potential for long term genetic gain and the reduction of genetic vulnerability may depend on the genetic diversity present in the genetic base. The amount of

genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool and existing landraces. The level of genetic variation present in gene pools of most important crops has been analyzed by studying the pedigree relationship between cultivars. Kinship coefficients estimation of cultivars of oat (Souza and Sorrells 1989), soybean (Cox et al 1985a), winter wheat (Cox et al 1985b), rice (Dilday 1990) and barley (Martin et al 1991) has shown that a restricted number of ancestral genotypes account for a large proportion of the variation present in released cultivars. However Nepalese wheat cultivars possess great diversity because of using many ancestral genotypes to develop them (Joshi et al 2004). Richness on wheat taking into account the ancestors of cultivars and landraces should be assessed for effective conservation and utilization of wheat gene pools. Therefore we have focused here on landraces and its distribution in Nepal and countries from where genes were introduced through improved lines in Nepal.

METHODOLOGY

Literature related to wheat exploration, improved cultivars and Nepalese landraces were reviewed. Two sites, National Wheat Research Program (NWRP), Bhairawa and Plant Genetic Resources (PGR) Unit, Khumaltar were visited. PGR Unit has collected many wheat landraces from different parts of Nepal. Based on collection data landraces distribution were indicated in Nepal map. Frequency of wheat accessions collected from different districts and conserved in PGR Unit were computed. We examined the pedigrees of all 35 cultivars. Altogether 35 cultivars had been released in Nepal from 1960 to 2001. Most of the cultivars were introduced either from CIMMYT, Mexico or India. The pedigrees of all bread wheat cultivars were traced back to their ancestors that had no known relationship each other. The source of pedigrees and release dates for cultivars were Jain (1994), NARC (1997), Bland (2001), Skovmand et al (1997) and Skovmand et al (2000). Countries from where the genes introduced through the improved lines in Nepal were located in world map.

RESULTS AND DISCUSSION

The land in Nepal has the largest variations in altitude in the world. It lies between 26^{o} 22'N to 30^{o} 27'N and 80^{o} 4'E to 88^{o} 12'E. Elevation ranges from 60 to 8848m. Three types of land *Bari* (upland), *Khet* (lowland) and flat and fertile with good soil depths produce wheat indicating the diverse wheat genotypes adapted to different production environments. Wheat is grown as winter crop sown in October or November and harvested in March or April. It is also grown as a summer crop sown in April or May coming to fruition in September or October. Due to the varied agro-ecological diversity of the country, it is possible to plant same cultivar in both winter and summer season. Nepal is not original home for wheat but under the CGIAR system Nepal received a lot of wheat genotypes. In 1965, the Department of Agriculture launched a Grow more wheat campaign with the introduction of Mexican semi dwarf wheat resulted in a rapid expansion in wheat area and production.

Nepal is politically divided into five regions (Eastern, Central, Western, Mid Western and Far Western). Only two exploration missions have targeted wheat species in Western Nepal. Eighteen exploration programs were carried out in different parts of Nepal to collect different crops species. There are 63 landraces, which are differed by name and conserved in ABD (Table 1). These are collected from different altitude ranging from 720 to 3353 m. Farmer unit of description (FUD) is generally related to their phenotype and use value. FUD also indicates the level of diversity present in wheat gene pool. There may be many landraces that are genetically same but differed only by name or vise versa. These need to verify. ABD has 390 accessions of wheat landraces collected from all over the Nepal. These are conserved *ex situ* at medium term storage facility in Khumaltar, Kathmandu. Due to agro ecological differences Nepalese genotypes may contain unique genes. Dutch scientists who collected in around 1981, wheat in remote part of the Himalayan in Nepal has found material that is new and considerably

different from germplasm already in gene bank anywhere in the world (Hawkes 1981). These genes if conserved properly could be enough to fulfill wheat diversity demand for developing wheat cultivars for next century.

Table 1. Different Nepalese wheat landraces and their cultivating area

SN	Landrace	District	Location	Altitude, m
1	Badi gahun	Bajura	Gadukhati-9	1768
2	Bangali gahun	Kalikot	Jubitha-7, Jubitha	1792
3	Bartole gahun	Baitadi	Patan	1372
4	Bhabri gahun	Mugu	Srinagar-5, Chaina	1960
5	Bhagere gahun	Baglung	Bhimpokhara	1565
6	Bhartole gahun	Baitadi	Gokuleswor-1, Kalchunde	720
7	Bhote gahun	Solukhumbu	Salleri	2408
8	Bhugari gahu	Bajura	Atichaul-1	1981
9	Bikase gahun	Darchula	Gokuleswor-3, Gokuleswor	750
10	Bikasi seto gahun	Sallyan	Dandagaon	1200
11	Bugoti	Bajura	Dogdi-6	1829
12	Bungoli	Bajhang	Kalukheti-8	1737
13	Chamdi gahun	Bajura	Gadukhati-9	1768
14	Dabde gahun	Jumla	Patrasi-7, Shelagarhigaon	2713
15	Dabdi gahun	Dandeldhura	Joishina	1585
16	Dabdikhane gahun	Dandeldhura	Matar gaon	
17	Dalkhane gahun	Kalikot	Mahadev-7, Sarkivada	1980
18	Dapche gahun	Dandeldhura	Bhel	1585
19	Daudi	Baitadi	Patan	1372
20	Daudi gahun	Baitadi	Shidheswor-8, Amarkholi	2070
21	Dhaule gahun	Baitadi	Gokuleswor-1, Kalchunde	720
22	Dho	Mustang	Kagbeni	2697
23	Dho/gahun	Mustang	Jharkot	3353
24	Dhu	Mustang	Khinga	3216
25	Dolkhe gahun	Khotang	Khalde	1402
26	Dudhe murilo	Rukum	Vulma	823
27	Gahun	Baglung	Dobira	1010
28	Gaile gahun	Bajura	Gadukhati-9	1768
29	Geru gahun	Mugu	Pina-5, Balagaon	2035
30	Gharelu gahun	Dandeldhura	Manara	1158
31	Hansa gahun	Myagdi	Benibagar	792
32	Jhirke	Bajhang	Majhigaon-8	1585
33	Jhuse gahun	Sallyan	Dandagaon	1100
34	Jhuse rato gahun	Kalikot	Mahadev-7, Sarkivada	1980
35	Keuma gahun	Solukhumbu	Chhulembu	2195
36	Lal gahun	Kanchanpur	Mahendra nagar-19	
37	Lalitpur local			
38	Lera rato gahun	Sallyan	Dandagaon	1200
39	Lere seto gahun	Sallyan	Tharmare	1160
40	Thaniya gahun	Jumla	Birat-9, Ludku	2390

SN	Landrace	District	Location	Altitude, m
41	Lunthung gahun	Taplejung	Lelep-5, Lunthum	1800
42	Mude gahun	Dandeldhura	Bhandare	1530
43	Mudlo gahun	Baglung	Gitapatha	1094
44	Mudule gahun	Arghakhanchi	Dhikura-2, Gairakot	1200
45	Mudulo gahun	Myagdi	Dhode	747
46	Murala gahun	Rolpa	Khumil	1500
47	Murulo rato gahun	Jajarkot	Gagane khola	2775
48	Nano gahun	Dandeldhura	Ghatal	1768
49	Paude gahun	Baitadi	Vasling-3, Gwane	2040
50	Pawai	Bajura	Kolti	2000
51	Peta gahun	Solukhumbu	Chhulembu	2195
52	Rani gahu	Bajhang	Majhigaon-8	1585
53	Rato gahun	Jajarkot	Risang	2850
54	Ratonal	Baitadi	Patan	1372
55	Ratonale	Baitadi	Patan-1	1372
56	Rupali gahun	Dandeldhura	Amargadhi-2, Dotighatal	1750
57	Sano gahun		Suda	
58	Sate gahun	Taplejung	Nankholyang-5, Myakha	900
59	Seto gahun	Rukum	Khara	
60	Talak gahu		Mahendra nagar	
61	Tari gaire	Bajura	Gadukhati-9	1768
62	Those gahun	Bajura	Gadukhati-9	1768
63	Thulo ghumche	Jajarkot	Danda gaon	2750

Source: Gupta et al 2000.

Nepal has many locally adapted wheat but any one has not been used or improved for developing Nepalese wheat cultivars. Such trends lead to genetic erosion. NWRP has maintained 150 landraces and ABD has 390 accessions of wheat. There may be duplicate accessions in these two places. Removing duplicate accessions and adding new one should be made continuously. Characterization, evaluation and utilization of these landraces in breeding program by NWRP and ABD could certainly enhance the wheat genes pool conservation. Landraces are mostly found in Western regions and only few locations of Central and Eastern regions (Figure 1) in Nepal. It is still unanswered why these landraces get popularized in remote areas e.g. Western Nepal. There are many important landraces in Western region. *Dabad Khani* is most popular local wheat suited to maize based cropping pattern in Western region. This distribution pattern could help to locate diverse wheat areas and to implement *in situ*, on farm conservation and exploration program. This pattern suggests that there are diverse wheat landraces adapted to different environments.

ABD has representative wheat landraces from 29 out of total 75 districts of Nepal (Table 2). Highest number of wheat accessions was collected from Dandeldhura (3.59% of total accessions) followed by Baitadi (3.33%), Bajura and Baglung. Dandeldhura, Baitadi, Bajura, Baglung and Achham may be the focal area in term of wheat landraces diversity. Due to the expansion of modern varieties these landraces are under threats of extinction. Extensive survey and duplication study of accessions could help to control genetic erosions and conservation cost. Many of these landraces are still grown by farmers and are the mixtures of white and brown coloured spike, amber and red coloured kernels, awned and awnless characters. These landraces have a wide range of natural adaptation to withstand varied abiotic and biotic conditions. In addition, these landraces have high tillering ability, withstand severe drought stress, have high protein content and longer seed dormancy. These are pure spring bread wheat types.

Some landraces with winter growth type have been reported in the northern high mountain area bordering Tibet, China. In addition to these, some diploid species have also been reported in the northern high mountains. Since these landraces are adapted to a small confined area, and wheat was considered a minor cereal until the middle of 20th century, there was no attempt to improve these landraces or the production practices. These landraces are generally grown under marginal lands under rainfed and low fertility conditions.

Table 2. Frequency and total accessions of wheat landraces collected from different districts of Nepal and conserved in Agriculture Botany Division Khumaltar

SN	District	Accession, n	Frequency, %	SN	District	Accession, n	Frequency, %
1	Achham	11	2.82	17	Khotang	3	0.77
2	Arghakhanchi	1	0.26	18	Manang	5	1.28
3	Baglung	12	3.08	19	Mugu	5	1.28
4	Baitadi	13	3.33	20	Mustang	9	2.31
5	Bajhang	6	1.54	21	Myagdi	6	1.54
6	Bajura	12	3.08	22	Nawalparasi	1	0.26
7	Dandeldhura	14	3.59	23	Panchthar	1	0.26
8	Darchula	4	1.03	24	Pyuthan	2	0.51
9	Doti	6	1.54	25	Rolpa	2	0.51
10	Gorkha	1	0.26	26	Rukum	6	1.54
11	Gulmi	2	0.51	27	Sallyan	5	1.28
12	Jajarkot	5	1.28	28	Solukhumbu	7	1.79
13	Jumla	6	1.54	29	Taplejung	2	0.51
14	Kalikot	5	1.28	30	Unknown	236	60.51
15	Kanchanpur	1	0.26				
16	Kaski	1	0.26		Total	390	

Thirty-five improved bread wheat varieties suitable to hills, plains and Western regions of Nepal are real efforts of researchers to be released during the period from 1960 to 2001. More numbers of crosses involving many parental lines in cultivars like Annapurna 2, Annapurna 4, Bhrikuti, LR64, RR21, NP884 and NP809 indicate the effort of scientists to collect value genes in single genotype. Four cultivars were released in 1997, which is the year of releasing highest number of cultivars. These cultivars were Achyut, Kanti, Pasang Lhamu and Rohini. Lerma 52, first improved cereal variety to be released in the history of cereal breeding in Nepal (Bland 2001) was released in 1960.

A total of 89 ancestors originated in 22 different countries were used to develop 35 cultivars (Table 4). Mexico, India and Nepal are the origin countries for 35 cultivars. In Nepal four cultivars had been originated and maximum number of cultivars was originated in Mexico. Ancestors of both *aestivum* and *durum* species having winter, spring and intermediate growth habit indicated the collection of wide gene pool.

Table 3. Improved bread wheat varieties released from 1960 to 2001 in Nepal

SN	Variety	Abbr†	Pedigree	Origin	Year released	Area of adaptation
1.	Achyut	ACH	CPAN168/HD2204	India	1997	Plains
2.	Annapurna1	ANNA1	KVZ/BUHO//KAL/BB	Mexico	1988	Hills
3.	Annapurna2	ANNA2	NAPO/TOB//8156/3/KAL/BB	India	1988	Hills
4.	Annapurna3	ANNA3	KVZ/BUHO//KAL/BB	Mexico	1991	Hills
5.	Annapurna4	ANNA4	KVZ/3/CC/INIA//CNO/ELGAU/4/SN64	Mexico	1994	Hills
6.	Bhrikuti	BK	CMT/COC75/3/PLO//FURY/ANA	Mexico	1994	Plains
7.	Bhairahawa Line1022	BL1022	PVN/ALD	Nepal	1991	Western Terai
8.	Bhairahawa Line1135	BL1135	QTZ/TAN	Nepal	1994	Plains
9.	Bhairahawa Line1473	BL1473	NL297/NL352	Nepal	1999	Plain & Hills
10.	Hybrid Delhi1982	HD1982	E5557/HD845	India	1975	Western Plains
11.	Kalyansona	KAL	PJ/GB55	Mexico	1968	Plains
12.	Kanti	KANTI	LIRA/FFN//VEE	Mexico	1997	Hills
13.	Kenya291	K291	NA‡	Kenya	1962	Hills
14.	Lerma52	L52	MTA/K324	Mexico	1960	Hills
15.	Lerma Rojo64	LR64	Y50/N10B//L52/3/2*LR	Mexico	1967	Hills
16.	Lumbini	LUM	E4871/PJ	India	1981	Plains
17.	Nepal Line251	NL251	WH147/HD2160//2*WH147	India	1988	Plains
18.	Nepal Line297	NL297	HD2137/HD2186//HD2160	India	1985	Plains
19.	Nepal Line30	NL30	HD832/BB	India	1975	Western Plains
20.	New Pusa799	NP799	NP 792	India	1962	Hills
21.	New Pusa809	NP809	DO/C518//SPP/NP114/3/WIS245	India	1962	Hills
22.	New Pusa835	NP835	NP760/RN	India	1962	Plains
23.	New Pusa852	NP852	KF/2*NP761	India	1962	Plains
24.	New Pusa884	NP884	KC6042/GUL//PLT/3/K58/N/4/NP755	India	NA†	Plains
25.	Pasang Lhamu	PAL	PGO/SERI	Mexico	1997	Hills
26.	Pitic62	PI	YT54/N10B 26.1C	Mexico	1967	Hills
27.	Rohini	ROH	PRL/TONI//CHIL	Nepal	1997	Plains
28.	Rust Resistant21	RR21	II53.388/AN/3/YT54/N10B/3/LR/4/B4946.A.4.18.2.IY/Y53//3*Y50	Mexico	1971	Hills & Plains
29.	S331	S331	LR64/HUAR	Mexico	1971	Hills & Plains
30.	Siddhartha	SID	HD2092/HD1962//E4870/3/K65	India	1983	Plains
31.	Sonora64	SN64	YT54/N10B//2*Y54	Mexico	1967	Hills
32.	Triveni	TRI	HD1963/HD1931	India	1982	Plains
33.	Uttar Pradesh262	UP262	S 308/BAJIO 66	India	1978	Plains
34.	Vaskar	VKR	TZPP/PL//7C	Mexico	1983	Mid-western Plains
35.	Vinayak	VIN	LC55	India	1983	Plains

† Abbr, Abbreviation. ‡ NA, Not available.
Source: NARC 1997.

Wheat genes from all regions of the world were introduced in Nepal through improved cultivars (Figure 2). Maximum ancestors were from India followed by USA and Kenya. Thanks to CGIAR, India, USA, Kenya, Australia and Argentina. Involvement of ancestors from 22 countries indicates the introduction of genes adapted to different geographic locations. Even though contributions of Nepalese wheat landraces in the world is not known, world contribution is recognized in wheat development in Nepal. A single landrace of each of eight countries have been used in developing wheat cultivars probably because of having value genes with them. It can be concluded that breeders can develop best varieties by reshuffling the genes from these wide collections.

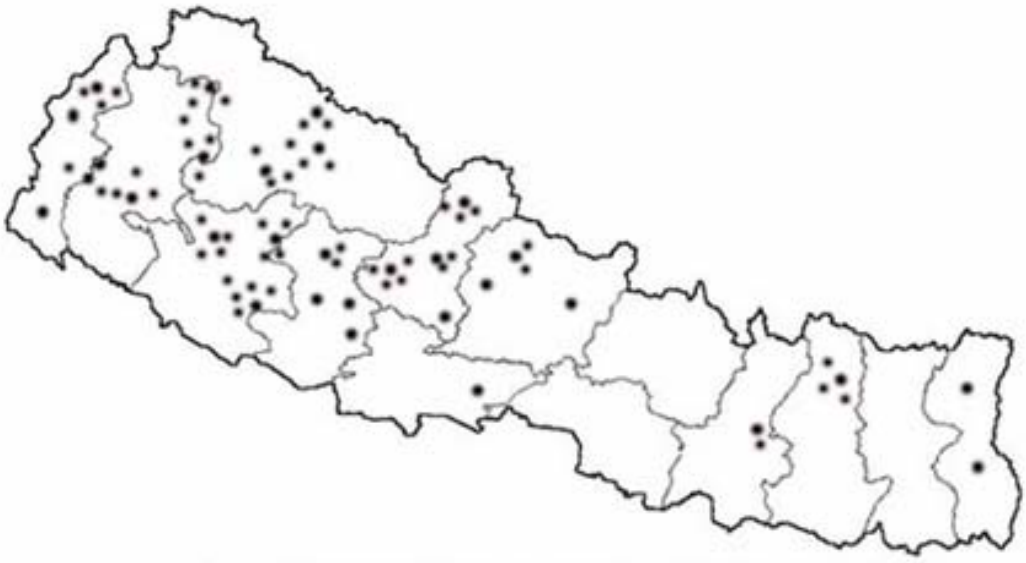


Fig. 1. Distribution of Nepalese wheat landraces in different parts of Nepal (dot indicates landraces distribution).

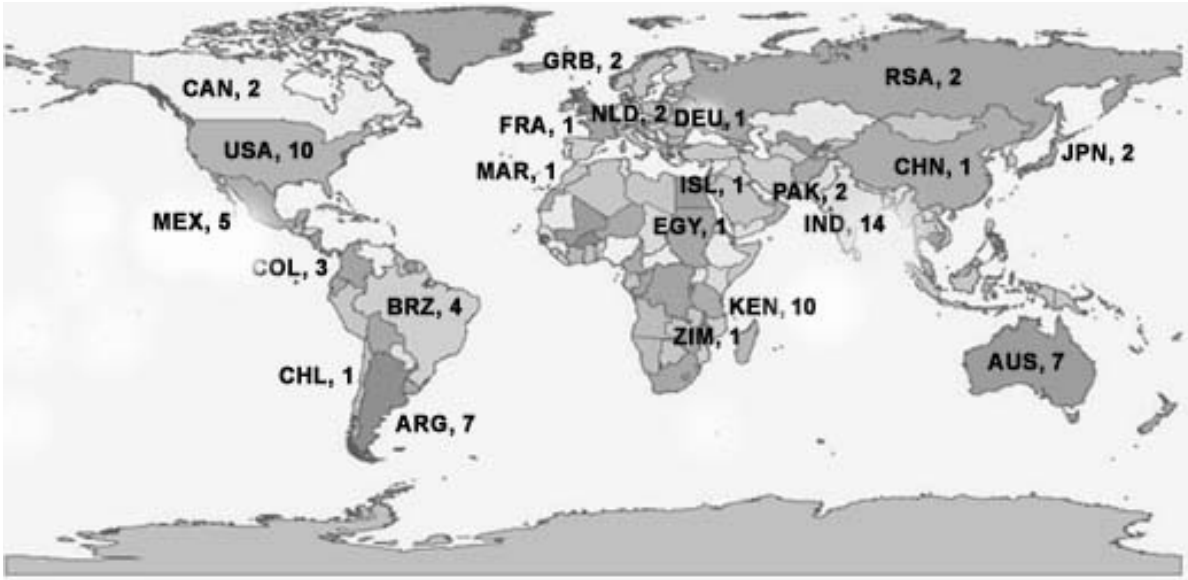


Fig. 2. Countries where the ancestors of Nepalese improved wheat cultivars were originated. Wheat genes of these countries are playing in Nepal (See table 5 for country code description, value after country code indicates total ancestors, origin of 9 ancestors are unknown).

Table 4. Ancestors of 35 Nepalese wheat cultivars and their origin

SN	Name	Abb†	Origin		Growth habit	Species
			Name	Abb		
1.	21931	21931	ISREAL	ISL	?	AESTIVUM
2.	36896	36896	ARGENTINA	ARG	?	AESTIVUM
3.	8A	8A	INDIA	IND	?	AESTIVUM
4.	8B	8B	INDIA	IND	?	?
5.	9D	9D	INDIA	IND	?	AESTIVUM
6.	AKAGOMUGHI	AGM	JAPAN	JPN	WINTER	AESTIVUM
7.	ALFREDO CHAVES 6.21	AC	BRAZIL	BRA	SPRING	AESTIVUM
8.	B4946.A.4.18.2.IY	B4946	?	?	?	?
9.	BONZA	BZA	COLOMBIA	COL	SPRING	AESTIVUM
10.	BREVOR	BVR	USA	USA	WINTER	AESTIVUM
11.	BUNGE NO 2	BN2	?	?	?	?
12.	BUTTON	BUTTON	?	?	?	AESTIVUM
13.	C13	C13	INDIA	IND	SPRING	AESTIVUM
14.	C209	C209	INDIA	IND	SPRING	AESTIVUM
15.	CARIANCA422	CAR422	CHILE	CHL	WINTER	AESTIVUM
16.	CENTENARIO	CTR	BRAZIL	BRA	SPRING	AESTIVUM
17.	CHRIS	CHR	USA	USA	SPRING	AESTIVUM
18.	CLEMENT	CMT	NETHERLANDS	NLD	WINTER	AESTIVUM
19.	CPAN1687	CPAN1687	INDIA	IND	SPRING	AESTIVUM
20.	DAVIS6301	D6301	USA	USA	?	AESTIVUM
21.	DEMOCRATE	DO	USA	USA	?	AESTIVUM
22.	EL GAUCHO	ELGAU	ARGENTINA	ARG	SPRING	AESTIVUM
23.	FEDERATION	FR	AUSTRALIA	AUS	SPRING	AESTIVUM
24.	FLORENCE	FLO	?	?	?	?
25.	FROCOR	FCR	BRAZIL	BRA	SPRING	AESTIVUM
26.	FUFAN17	FFN	CHINA	CHN	SPRING	AESTIVUM
27.	FURY	FURY	KENYA	KEN	SPRING	AESTIVUM
28.	GABO-AUS	GB	AUSTRALIA	AUS	SPRING	AESTIVUM
29.	GAZA	GAZA	EGYPT	EGY	SPRING	DURUM
30.	GENERAL URQUIZA	GU	ARGENTINA	ARG	SPRING	AESTIVUM
31.	HARD FEDERATION	HF	AUSTRALIA	AUS	SPRING	AESTIVUM
32.	HARDRED CALCATTA	HRC	INDIA	IND	SPRING	AESTIVUM
33.	HOPE	H44	USA	USA	?	AESTIVUM
34.	HYBRID DELHI845	HD845	INDIA	IND	SPRING	AESTIVUM
35.	IUMILLO	IU	USA	USA	SPRING	DURUM
36.	KANRED	KR	USA	USA	WINTER	AESTIVUM
37.	KAVKAZ	KVZ	RUSSIA	RSA	WINTER	AESTIVUM
38.	KENTANA48	KT48	MEXICO	MEX	SPRING	AESTIVUM
39.	KENYA C6042	KC6042	KENYA	KEN	?	?
40.	KENYA GOVERNER	KGV	KENYA	KEN	SPRING	AESTIVUM
41.	KENYA STANDARD	KS	KENYA	KEN	SPRING	?
42.	KENYA117A	K117A	KENYA	KEN	SPRING	AESTIVUM
43.	KENYA256	K256	KENYA	KEN	SPRING	?
44.	KENYA291	K291	KENYA	KEN	SPRING	AESTIVUM
45.	KENYA324	K324	KENYA	KEN	SPRING	?
46.	KENYA350-A-D9-C-2	KAD	KENYA	KEN	SPRING	?
47.	KENYA58	K58	KENYA	KEN	SPRING	AESTIVUM
48.	KHAPLI	KHP	INDIA	IND	SPRING	DURUM
49.	KLEIN ATLAS	KLAT	ARGENTINA	ARG	SPRING	AESTIVUM
50.	KLEIN RENDIDOR	KLRE	ARGENTINA	ARG	SPRING	AESTIVUM
51.	LA ESTANZUELA2787C	LAEST	**?**	?	?	?
52.	LC55	LC55	INDIA	IND	?	?
53.	LERMA ROJO	LR	MEXICO	MEX	SPRING	AESTIVUM
54.	MARNE DESPREZ	MD	FRANCE	FRA	WINTER	AESTIVUM
55.	MARROQUI	MRQ	MOROCCO	MAR	SPRING	AESTIVUM

SN	Name	Abb†	Origin		Growth habit	Species
			Name	Abb		
56.	MARSALL'S NO 3	MS-A	AUSTRALIA	AUS	?	AESTIVUM
57.	MCMURACHY	MCM	CANADA	CAN	SPRING	AESTIVUM
58.	MIDA-U	MIDA	USA	USA	SPRING	AESTIVUM
59.	MUNDIA	MUNDIA	INDIA	IND	?	?
60.	NAINARI60	NAI60	MEXICO	MEX	?	AESTIVUM
61.	NAPO	NAPO	COLOMBIA	COL	SPRING	AESTIVUM
62.	NARINO59	NAR59	COLOMBIA	COL	SPRING	AESTIVUM
63.	NEW PUSA773	NP773	INDIA	IND	SPRING	AESTIVUM
64.	NORIN10	N10	JAPAN	JPN	WINTER	AESTIVUM
65.	NP114	NP114	INDIA	IND	?	AESTIVUM
66.	OLESEN'S DWARF	ON	ZIMBABWE	ZIM	SPRING	AESTIVUM
67.	P4160E	P4160E	MEXICO	MEX	SPRING	AESTIVUM
68.	POLYSSU	PSSU	BRAZIL	BRA	SPRING	AESTIVUM
69.	QUINTZEL	QTZ	?	?	?	?
70.	RED FIFE	RF	CANADA	CAN	SPRING	AESTIVUM
71.	RED MACE	RM	GREAT BRITAIN	GBR	WINTER	AESTIVUM
72.	REITI	REITI	?	?	?	?
73.	S339	S339	INDIA	IND	SPRING	AESTIVUM
74.	SANTA ELENA	SE	USA	USA	SPRING	AESTIVUM
75.	SINVALOCHO MA	SCHOMA	ARGENTINA	ARG	SPRING	AESTIVUM
76.	SPALDING PROLIFIQUE	SPP	GREAT BRITIAN	GBR	?	AESTIVUM
77.	STEINWEDEL	SWD	AUSTRALIA	AUS	SPRING	AESTIVUM
78.	TEZANOS PINTOS RECOZ	TZPP	ARGENTINA	ARG	SPRING	AESTIVUM
79.	THEW	THEW	AUSTRALIA	AUS	WINTER	AESTIVUM
80.	TIMESTEIN	T	AUSTRALIA	AUS	SPRING	AESTIVUM
81.	TYPE1	TYPE1	PAKISTAN	PAK	?	DURUM
82.	TYPE9	TYPE9	PAKISTAN	PAK	?	AESTIVUM
83.	VERNAL EMMER	VN	RUSSIA	RSA	SPRING	DURUM
84.	WAGGA13	WG13	?	?	?	?
85.	WEIQUE	W	DEUTSCHLAND	DEU	WINTER	AESTIVUM
86.	WILHELMINE	WHM	NETHERLANDS	NLD	WINTER	AESTIVUM
87.	WILLET ERONO	WTE	USA	USA	SPRING	AESTIVUM
88.	WIS 245	WIS 245	?	?	?	?
89.	YAKTANA54	YT54	MEXICO	MEX	SPRING	AESTIVUM

† Abb, Abbreviation. ? Not known.

Use of 89 ancestors from 22 different countries represent the great diversity in built in 35 Nepalese wheat cultivars. Ancestors were with different growth habit eg spring (57.31%) and winter (13.48%). There were 76.40% *aestivum* and 5.62% *durum* ancestors species. Such diversity in species, origin and growth habit in ancestors have certainly enriched Nepalese wheat biodiversity.

Despite high yielding attributes of improved cultivars compared to those of local types improved varieties were found to be susceptible to diseases and lodging (Shrestha 1976). There are many examples of improved varieties gaining popularity within a short period of time but later become susceptible to biotic stresses. Such trend was not reported in landraces. In this study, cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity may be useful for further wheat improvement. The results of this study may help in the selection of the most diverse cultivars and greatly expand genetic variation for wheat improvement. Measurers of genetic diversity can be used to maximize the level of variation in segregating populations by intermating cultivars with greater genetic distance. Modern varieties are replacing the landraces and improved old varieties resulted in the genetic erosion. Therefore, *in situ*, on farm and *ex situ* conservations are necessary for maintaining the genetic variation in Nepalese wheat. Government, semi governmental and private agencies should take action to conserve and utilize wheat genetic variations present in Nepal.

Nepal being proximal to the secondary source of origin of wheat, might harbor the wheat relatives in addition to the so far recorded one species of *Aegiolopes* and nine species of *Agropyron*. Since wild germplasm is a valuable source for improving bread wheat productivity and durability, explorations on those wild relatives are suggested followed by their proper characterization and utilization in the breeding program. Gene pool from cultivated landraces of spring and winter type, wild landraces and diploid species of wheat along with international gene pool could make to success in developing high yielding cultivars with wide adaptability.

ACKNOWLEDGEMENTS

Sincere thanks go to GO Ferrera and HB KC for providing literatures. S Rai provided e-maps and TP Pokhrel suggested for improving this paper.

REFERENCES

Bhatta MR, GO Ferrera, B Gurung, TP Pokharel, NR Gautum, P Gurung and RB Neupane. 2000. Present status of participatory plant breeding research on wheat at the National Wheat Research Programme, Nepal. **In:** *An exchange and experiences from South and South East Asia: Proceedings of the International Symposium on PPB and PGR enhancement*, Pokhara, Nepal, 1-5 May 2000. PRGA, IDRC, DFID, DDS, LIBIRD, IPGRI and ICARDA. Pp. 391-398.

Bland B. 2001. Nepalese wheat pool. **In:** *The world wheat book: A history of wheat breeding*. (AP Bonjean and WJ Angus, eds). Intercept, TEC and DOC, LAVOISIER, New York. Pp. 817-830.

Cox TS, YT Kiang, MB Gorman and DM Rogers. 1985a. Relationship between coefficient of parentage and genetic similarity indices in the soybean. *Crop Sci.* 25:529-532.

Cox T, GL Lokhart, DE Walker, LG Harrell, LD Albers and DM Rogers. 1985b. Genetic relationships among hard red winter wheat cultivars as evaluated by pedigree analysis and gliadin polyacrylamide gel electrophoretic patterns. *Crop Sci.* 25:1058-1062.

Dilday RH. 1990. Contribution of ancestral lines in the development of new cultivars of rice. *Crop Sci.* 30:905-911.

Gupta SR, MP Upadhyay and DM Dongol (eds). 2000. *Nepalese germplasm catalogue - 2000*. Agriculture Botany Division, NARC, Khumaltar.

Hawkes J. 1981. Germplasm collection, preservation and use. **In:** Plant Breeding II (Frey KJ, ed.). The Iowa State University Press/ Ames.

Jain KBL. 1994. Wheat cultivars in India: Names, pedigrees, origins, and adaptations. *Research Bulletin No. 2*. Directorate of Wheat Research, Karnal. India. 72 pp.

Joshi BK, A Mudwari, MR Bhatta and GO Ferrera. 2004. Genetic diversity in Nepalese wheat cultivars based on agro-morphological traits and coefficients of parentage. *Nepal Agric. Res. J.* 5:7-18

Martin JM, TK Balke and EA Hockett. 1991. Diversity among North American spring barley cultivars based on coefficients of parentage. *Crop Sci.* 31:1131-1137.

Mudwari A. 1999. Wild relatives of wheat and its status in Nepal. **In:** *Wild relatives of cultivated plants in Nepal* (R Shrestha and B Shrestha, eds). Proceedings of National conference, 2-4 June 1999 Kathmandu, GEM-Nepal. Pp.83-89

NARC. 1997. *25 years of wheat research in Nepal (1992-1997)*. NARC, NWRP, Nepal.

Shrestha RB. 1976. Wheat production technology in Nepal. *Nepalese Journal of Agriculture* 6:18-24.

Skovmand B, MC Mackary, C Lopez and A McNab (eds). 2000. *Tools for the millennium.* On compact disk, Mexico, D.F.: CIMMYT.

Skovmand B, R Vilereal, M Van Ginkel, S Rajaram and GO Ferrera. 1997. *Semi dwarf bread wheats: Names, parentages, pedigrees and origins*. Mexico. D.F.: CIMMYT.

Souza, E and ME Sorrells. 1989. Pedigree analysis of North American oat cultivars released from 1951 to 1985. *Crop Sci.* 29:595-601.

Participatory Varietal Evaluation of Rainy Season Tomato under Plastic House Condition

Yama R. Pandey*, Amar B. Pun and Kalika P. Upadhyay

Regional Agricultural Research Station-NARC Lumle, PO Box 1, Kaski, Nepal

ABSTRACT

Four tomato varieties namely LTH-61, Avinash-2, NSITH-162 and BL-410 were evaluated in farmer's field with farmers participation under plastic house condition for yield potential and other yield characters at Hemja, Kaski (920 masl) during rainy seasons of two consecutive years 2002 and 2003. The experiment was arranged in randomized complete block design with 5 replications, farmer as a replication. NSITH-162 took the shortest period of days to flowering and first harvest with an average of 36 and 66 days after transplanting respectively. Fruit set after flowering was highest in NSITH-162 (93.9%) and the lowest in Avinash-2 (83.1%). NSITH-162 produced the highest marketable fruit yield (89.05 t/ha) and Avinash-2 produced the lowest (51.98 t/ha). The results of the experiment revealed that the hybrid varieties NSITH-162 and LTH-61 have more yield potentiality than open pollinated variety BL-410 and Avinash-2 an Indian hybrid variety and therefore NSITH-162 variety could be recommended for commercial production under plastic house condition.

Key words: Participatory, plastic house, rainy season, tomato

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the major commercial vegetable crops and widely grown both in the plains and hills of Nepal. In the hills, tomato can be produced successfully in two growing seasons, spring and rainy. Rainy season tomato is quite remunerative enterprise to the hill farmers as the supply from Tarai is constrained by high temperature, low fruit set, flowering, bacterial wilt etc. Tomato production during rainy season in open field condition is very difficult and the production during the season is very low. Tomato production inside plastic house during rainy season is a new and modest technology to farmers in the western hills of Nepal. The varieties recommended for spring season cultivation are Pusa Ruby, Roma, Monprecos and Money Maker (Bhattarai and Subedi 1996). Heat, blight and bacterial wilt susceptible varieties cannot be cultivated during rainy season. In addition to blight and wilt diseases, reduced fruit set due to high ambient temperature is also one of the important problems directly related to yield. Maximum day and minimum night temperature above 32^0C and 21^0C respectively are known to limit fruit set due to an impaired physiological process in flower and fruit setting and or abscission (Bhattarai and Subedi 1996). Though tomato is best suited to the Tarai, low and mid hills, it is becoming increasingly attractive for cash generation in the high hills also (Pandey and Chaudhary 2004). Problems of poor fruit set due to low temperature, high rainfall during flowering and blight disease in the mid to high hills and high temperature, rainfall, bacterial wilt, stem rot and viral diseases in the low hills are the most important factors limiting tomato cultivation on a commercial scale. However, tomato production inside the plastic house during rainy season has become very popular and profitable where there is market access. Since tomato is very expensive during rainy season, farmers could fetch good price besides its high initial investment cost. Jaiswal et al (1997) reported that BL-410 variety was found the most suitable in terms of good yield, attractive fruit shape and size and comparatively free from insect/pest and disease damage.

There are two main approaches of producing rainy season tomato 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. Off-season vegetables could be produced with the introduction of heat and rain tolerant hybrids or open pollinated varieties especially for rainy season production (Pandey 2004). Though there are many reports on varietal selection, appropriate time of planting and pest and disease control measures for rainy season tomato, these constraints still prevail in the farmer's field. To develop rainy season tomato production as a remunerative enterprise, plastic house technology was found highly successful in the western hills where there is market access. Though the technology is highly successful, seed availability and varietal option has became major constraints in hills. Majority of tomato hybrid seed is imported from India and other countries and there is no certainty and varietal sustainability in the seed market. To provide alternative option of varieties and selection of suitable varieties, the experiment was conducted to evaluate different type of varieties in farmer's field under plastic house condition.

MATERIALS AND METHODS

The experiment was conducted at Outreach Research Site Hemja, Kaski (920 masl) of Regional Agricultural Research Station, Lumle during rainy seasons of two consecutive years 2002 and 2003. The experiment was arranged in a randomized complete block design (RCBD) with 5 replications, farmer as replication. Four popular, yet easily available varieties were included in the experiment. Among these varieties, LTH-61 and NSITH-162 were F1 hybrids developed in Nepal, Avinash-2 an Indian hybrid and BL-410 an open pollinated variety recommended by Regional Agricultural Research Station, Lumle in its research command area for rainy season production. The individual plot size was 12.6 m^2 (2.1- × 6-m) with one bed per plot, 6 rows in 90 cm apart in a bed and 7 plants per row, counting a total of 42 plants per plot. The size of plastic house was 5 m wide and 12 m long with 3 m height at the center. The experimental plot was equally divided into two plots longitudinally with 80 cm space at the center maintaining 2.1 m width of the experimental plot. All these varieties were seeded in the nursery on 30 May 2002 and 31 May 2003 and three weeks old seedlings were transplanted in the experimental plots on 21 June 2002 and 23 June 2003. Compost 40 tons and NPK 50:60:60 kg/ha was applied as basal dose during field preparation and additional dose of nitrogen 100 kg/ha was applied as top dressing in two equal splits at 30 and 50 days after transplanting. In addition, pensibao 3rd generation, a micronutrient was applied at 25, 45 and 75 days after transplanting. Irrigation was applied as and when necessary. The observations on days to flowering, days to first fruit harvest, number of clusters/plant, number of fruits/cluster, fruit set %, marketable fruit yield, non-marketable fruit yield and plant stand (survivability) at harvest were collected and statistically analyzed using Genstat computer software.

RESULTS AND DISCUSSION

Days to flowering from transplanting

The major objective of this observation was to study the earliness character of the variety. The difference among the varieties on days to flowering from transplanting was highly significant (Table 1). NSITH-162 took the shortest period 35 days in 2002 and 36 days in 2003 whereas other two varieties LTH-61 and BL-410 took 39 days from transplanting to flowering. Avinash-2 took the longest period 40 days. However, there was only four days difference among the varieties on days to flowering from transplanting. Bhattarai and Subedi (1996) reported the flowering days of different varieties ranged from 53 to 74 days after transplanting in open field condition. Earlier flowering in this experiment might be due to the congenial growing environment in plastic house as compared to open field condition.

Days to first harvest from transplanting

The major objective was to study the earliness character of the variety. The difference among the varieties on days to first harvest from transplanting was highly significant (Table 1). NSITH-162 took the shortest period 66 days from transplanting to first harvest whereas Avinash-2 and BL-410 took the longest period 71 days. However, there was only five days difference among the varieties on days to first harvest from transplanting. Earliness plays important role on fetching higher market price and more income. Even a single day is important for market price and total income from the product. Therefore early varieties are generally preferred for cultivation on commercial scale. The result of the varietal experiment conducted at Yampaphant (430 masl) in open field condition showed that days to first harvest from transplanting ranged from 93 to 115 days (Bhattarai and Subedi 1996). The earliness in this experiment might be due to the variety and congenial growing environment in plastic house as compared to open field condition.

Table 1. Performance of tomato varieties on flowering days, first harvest days and fruit set under plastic house condition at Hemja, Kaski during 2002 and 2003 rainy seasons

Variety	Days to flowering from transplanting			Days to first harvest from transplanting			Fruit set, %		
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
Avinash-2	39	40	40	72	71	71	83.0	83.2	83.1
NSITH-162	35	36	36	67	66	66	93.0	94.8	93.9
LTH-61	39	39	39	70	70	70	90.0	91.6	90.8
BL-410	39	39	39	72	70	71	89.0	91.0	90.0
Mean	38	39	38	70	69	70	88.8	90.2	89.5
P value	< .001	< .001	< .001	0.001	< .001	< .001	< .001	< .001	< .001
LSD (0.05)	0.78	0.71	0.57	0.53	0.88	0.69	1.16	1.01	1.10
CV, %	1.5	1.3	1.6	0.6	0.9	1.1	0.9	0.8	1.4

Fruit set

Fruit set percent on tomato varieties is one of the important parameters for summer and rainy season tomato production, which determines the resistance and tolerance of a variety to a particular temperature and environment. The fruit set percent was highly affected by the varieties (Table 1). The highest fruit set (93.9%) was observed in NSITH-162 whereas, the lowest fruit set (83.1%) was observed in Avinash-2. It might be due to the adaptability of NSITH-162 in the local environment and tolerance to high temperature. The result revealed that higher the fruit set percentage more fruit yield is obtained. Fruit set percent is directly related to the fruit yield. In a varietal experiment Bhattarai and Subedi (1996) reported the fruit set percent ranging from 1 to 55%. The difference in fruit set in different experiments might be due to the varietal character and growing environment.

Plant stand or survivability at harvest

Plant stand at harvest of the crop varieties is one of the important parameters for rainy and off-season production of vegetables, which determines the resistance and tolerance of a variety to a particular environment and incidence of pests and diseases. The survivability percent among the varieties was found significantly different (Table 2). The highest percentage of survivability at harvest (99.6%) was observed in LTH-61 and BL-410 whereas the lowest percentage (77.2%) was observed in Avinash-2. The survivability was 99.3% in NSITH-162. The low survivability in Avinash-2 was due to the incidence of bacterial wilt disease. Bacterial wilt disease is one of the major threats for rainy season tomato production. Plant stand at harvest or survivability depends on the varietal character, growing environment, disease and pest incidence, suitable to the existing environment etc.

Number of clusters per plant

The objective of this observation was to evaluate the varieties for fruiting character and the relation of clusters to the yield. The difference among the varieties on number of clusters/plant was highly significant (Table 2). The highest number of cluster (38.4) was produced by NSITH-162 whereas the lowest number of cluster (14.8) was produced by Avinash-2. Number of cluster per plant in LTH-61 was 28.5 and 19.6 in BL-410. It is one of the major criteria to select better variety for its higher yield

and preferable fruit size. The number of clusters directly influenced the fruit yield. However, fruit size and fruit number per cluster are also determinant factors.

Table 2. Performances of tomato varieties on plant stand at harvest, fruit clusters/plant and fruits/cluster under plastic house condition at Hemja, Kaski during 2002 and 2003 rainy seasons

Variety	Plant stand at harvest, %			Number of cluster/plant			Number of fruits/cluster		
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
Avinash-2	78.3	76.1	77.2	14.2	15.4	14.8	5.6	5.8	5.7
NSITH-162	99.0	99.7	99.3	37.2	39.5	38.4	6.6	6.9	6.8
LTH-61	99.5	99.6	99.6	27.4	29.6	28.5	5.4	5.7	5.6
BL-410	99.5	99.7	99.6	18.8	20.4	19.6	5.2	5.8	5.5
Mean	94.1	93.8	93.9	24.4	26.2	25.3	5.7	6.1	5.9
P value	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001
LSD (0.05)	6.22	0.61	2.79	0.43	0.73	1.03	0.28	0.20	0.25
CV, %	4.8	0.5	3.3	1.3	2.0	4.5	3.6	2.5	4.7

Number of fruits per cluster

The objective of this observation was to evaluate the varieties for fruiting character and effect of the fruit size and number to the yield. The difference among the varieties on number of fruits/cluster was significant (Table 2). The highest number of fruits (6.8) was produced by NSITH-162 whereas the lowest number of fruits (5.5) was produced by BL-410. However the fruits/cluster was at par in Avinash-2, LTH-61 and BL-410. It is one of the major criteria to select better variety for its higher yield and preferable fruit size. In general, higher the number of fruits/cluster more fruit yield is obtained but fruit size is also determining factor for yield estimation.

Marketable fruit yield

Marketable fruit yield is the major determinant variable for selecting a particular variety for its commercialization and income generation capability. The difference among the varieties on marketable fruit yield was highly significant (Table 3). NSITH-162 produced the highest marketable fruit yield (87.53 t/ha in 2002 and 90.56 t/ha in 2003 with combined yield 89.05 t/ha. Similarly, LTH-61 produced 76.33 t/ha in 2002 and 77.47 t/ha in 2003 with combined yield 76.90 t/ha. BL-410 open pollinated variety produced 70.13 t/ha in 2002 and 72.86t/ha in 2003 with combined yield 71.50 t/ha. The lowest yield 51.02 t/ha in 2002 and 52.93 t/ha in 2003 with combined yield 51.98 t/ha was produced by Avinash-2. In a varietal experiment conducted by Bhattarai and Subedi (1996) reported that the marketable fruit yield of open pollinated tomato varieties grown in open field condition ranged from 0.1 to 12 t/ha. Many folds increase in fruit yield might be due to the variety and growing condition in plastic house.

Table 3. Performances of tomato varieties on marketable and non-marketable fruit yield under plastic house condition at Hemja, Kaski during 2002 and 2003 rainy seasons

Variety	Marketable fruit yield, t/ha			Non-marketable fruit yield, t/ha		
	2002	2003	Mean	2002	2003	Mean
Avinash-2	51.02	52.93	51.98	2.49	2.41	2.45
NSITH-162	87.53	90.56	89.05	6.50	5.21	5.86
LTH-61	76.33	77.47	76.90	4.96	4.06	4.51
BL-410	70.13	72.86	71.50	4.92	4.26	4.59
Mean	71.25	73.46	72.35	4.72	3.99	4.35
P value	< .001	< .001	< .001	< .001	< .001	< .001
LSD (0.05)	0.94	1.13	1.35	0.24	0.23	0.46
CV, %	1.0	1.1	2.1	3.7	4.2	11.7

Non-marketable fruit yield

Non-marketable fruit yield is one of the major variables for selecting a particular variety for its economic yield potential and varietal character. The difference among the varieties on non-marketable

fruit yield was highly significant (Table 3). NSITH-162 yielded the highest non-marketable fruit yield 5.86 t/ha. Similarly, BL-410 produced 4.59 t/ha and LTH-61 4.51 t/ha non-marketable fruit yield. The lowest yield (2.45 t/ha) was produced by Avinash-2. The results of the experiment revealed that the variety that produces higher marketable fruit yield also produces higher non-marketable fruit yield. In a varietal experiment conducted by Bhattarai and Subedi (1996) reported that the non-marketable fruit yield of open pollinated tomato varieties grown in open field condition ranged from 0 to 2.3 t/ha.

The results of the experiment showed that NSITH-162 was the earliest variety for flowering, fruiting and harvesting. The highest fruit set observed in NSITH-162 indicates that this variety is more tolerant to heat and adverse environment. LTH-61, BL-410 and NSITH-162 have over 99% plant survivability indicating that these varieties are suitable to the environment and resistant to bacterial wilt and other pests and diseases. NSITH-162 produced highest number of fruit clusters/plant, fruits/cluster and highest marketable fruit yield. The results of the experiment reveal that NSITH-162 could be recommended for rainy season production under plastic house condition.

REFERENCES

Bhattarai SP and PP Subedi. 1996. Heat and bacterial wilt tolerant tomato varietal evaluation during 1992/93-1994/95 season. *LARC Working Paper No. 96/56*. Lumle Agriculture Research Centre, Kaski, Nepal.

Jaiswal JP, SP Bhattarai and PP Subedi. 1997. Varietal and micronutrient trials on spring and rainy season tomato conducted at outreach research sites 1995/96. *LARC Working Paper No. 97/22*. Lumle Agriculture Research Centre, Kaski, Nepal.

Pandey YR and B Chaudhary. 2004. Evaluation of tomato varieties and their planting dates for commercial production under Jumla agro-ecological condition. **In:** *Proceedings of the Fourth National Horticultural Research Workshop* (BB Khatri, BP Sharma, PP Khatiwada, KP Paudyal BR Khadge and HN Regmi, eds). Horticulture Research Division-NARC, Khumaltar. Pp. 380-385.

Pandey YR. 2004. Evaluation of cauliflower varieties and planting dates for commercial production under Jumla agr-ecological condition. **In:** Agricultural research for enhancing livelihood of Nepalese people (BK Joshi, SL Joshi and KP Paudyal, eds). Proceedings of 2nd SAS-N Convention, 30 July - 1 Aug 2003 Kathmandu. Pp. 207-210.

Evaluation of Vegetable Type Cowpea Varieties for Commercial Production in the River Basin and Low Hill Areas

Yama R. Pandey*, Amar B. Pun and Ram C. Mishra

Regional Agricultural Research Station-NARC Lumle, PO Box 1, Kaski, Nepal

ABSTRACT

Five vegetable type cowpea varieties were evaluated in farmer's field with farmers participation at Chambas, Tanahu (450 masl) in two consecutive years 2003 and 2004 rainy season to identify suitable vegetable type cowpea varieties for commercial production in the river basin and low hill areas of western region. The experiment was arranged in randomized complete block design (RCBD) with 5 replications, farmer as replication. Prakash variety used as the check was earliest in flowering and days to first harvest from sowing with an average of 37 and 45 days respectively. Pod diameter and pod length among the varieties was significantly different. The biggest sized and longest pods were produced by IT 86F-2062-5 (Green) with an average of 0.990 cm in diameter and 25.60 cm in length. The highest green pod yield (4.971 t/ha) was produced by IT 86F-2062-5 (Green). Despite the earliness in flowering, fruiting and harvesting, Prakash produced the smallest (0.668 cm) and shortest (16.21 cm) pods and ultimately the lowest yield (2.443 t/ha). IT 86F-2062-5 (Green) produced the biggest size (0.990 cm diameter) and longest (24.60 cm) green pods as compared to other varieties IT 86D-792, IT 86F-2062-5 (White), IT 86D-798 and Prakash with white color, small size and fibrous pods. The results of the experiment and farmers preferences revealed that the variety IT 86F-2062-5 (Green) could be recommended for commercial production in the river basin and low hill areas of western region.

Key words: Cowpea, green pods, river basin, variety, vegetable

INTRODUCTION

Cowpea (*Vigna unguiculata*) is one of the important vegetable crops of Nepal. It is grown throughout Nepal for its green pods as vegetable, seeds as pulse and foliage as fodder and sometimes restoring the soil fertility. Cowpea is warm season crop and thrives best between 21-35^0 C (Chakraborty 1997). In Nepal, cowpea can be grown successfully both in spring-summer and rainy-autumn seasons in the plains and hills. Different cultivars respond differently to temperature and day length and thus there are distinct cultivars for spring-summer and rainy seasons (Chakraborty 1997). In general, cowpea is grown in the plains and Tarai areas during summer season and it is grown in the hills during rainy season and harvested in autumn season. Local varieties grown in the hills are long duration (more than 120 days), indeterminate in growth with long harvesting period (more than 45 days). Local and exotic varieties grown in the plains are both determinate and indeterminate in growth, short duration (60-80 days) and short growing and harvesting period. With the advancement of new technologies and development of new varieties, both determinate and indeterminate cowpea varieties are available for longer season of the year in the plains and Tarai of Nepal. Most vegetables crops can successfully be grown from Tarai to the high hills in normal and off-season provided appropriate varieties and technologies for production (Pandey and Pokhrel 2000).

There are mainly two types of cowpeas growing in Nepal for grain and vegetable purposes. Generally grain type cowpea varieties produce short pods with more number of seeds and mature early whereas vegetable type varieties produce long pods with less number of seeds and mature late and the pods remain tender and soft for longer period. Cowpea varieties with long pods and indeterminate in growth

habit are generally known as '*Tane bodi*' and these all are vegetable type. However, with the development of new varieties, vegetable type cowpeas both determinate and indeterminate in growth habit are available in Nepal. Cowpea is generally grown in marginal land with little or no inputs and therefore the yield is very low. Formal research on vegetable type cowpea is very limited and estimation of area and production of this type cowpea is still not recorded. However, National Grain Legumes Research Program (NGLRP), Rampur, Nepal has reported that cowpea occupies 6000 ha and produces 3660 tons of grains with the productivity of 610 kg/ha. National Grain Legumes Research Program has reported that IT 86D-792 produced significantly highest mean yield of 1205 kg/ha grain yield as compared to Aakash (971 kg/ha) and Prakash (917 kg/ha). Average 100 seed weight of IT 86D-792 is higher (16.87 g) as compared to IT 82D-787, Aakash and Prakash. It is also reported that IT 86D-792 is comparatively suitable for vegetable purpose (NGLRP 2000).

Since staking has been scarce in peri-urban areas, cultivation of vegetable type cowpea varieties like *Sarlahi Tane,* a popular variety in Nepal, on a large scale is difficult due to its indeterminate growth habit which necessitated staking for good yield. Therefore, farmers needed a determinate vegetable type variety that could produce pods earlier than *Sarlahi Tane*. National Grain Legumes Research Program had already released '*Prakash*' variety for grain purpose but later it gained popularity for fresh vegetable purposes because of its earliness and determinate growth habit. However, it could not replace indeterminate vegetable type cowpea *Sarlahi Tane* because of its fibrous pods (Bhattarai and Subedi 1996). Generally cowpea is grown from Tarai to mid hills (NGLRP 2000), river basin and low hill areas (below 500 masl) are the potential areas for cowpea production. The objective of the experiment was to select and recommend the suitable varieties for vegetable purpose.

MATERIALS AND METHODS

The experiment was conducted at outreach research site Chambas, Tanahu (450 masl) of Regional Agricultural Research Station, Lumle during the rainy season of two consecutive years 2003 and 2004. The experiment was arranged in a randomized complete block design (RCBD) with 5 replications, farmer as a replication. Five cowpea varieties namely IT 86D-792, IT 86D-798, IT 86F-2062-5 (Green), IT 86F-2062-5 (White) and Prakash were included in the experiment. The experiment was conducted in rainfed upland condition immediately after upland rice harvesting. The individual plot size of the experiment was 50 m^2 (10- × 5-m) with one raised bed per plot. Plant spacing was maintained 50- × 30-cm. The crop was sown on 25 August 2003 and 28 August 2004 and started harvesting 44 days after sowing and ended 74 days after sowing. Compost 10 tons and NPK 20:40:20 kg/ha was applied as basal dose during field preparation. Insecticide (Nuvan) was sprayed (1 ml/liter water) twice (40 and 55 days after sowing) against fruit borer and aphid. The observations on days to flowering, days to first harvest, days to last harvest, number of clusters/plant, number of pods/cluster, pod length, pod diameter and marketable fresh pod yield were collected and statistically analyzed using Genstat computer software. Twenty percent of the total plant population (75 plants/plot) was tagged after plant establishment and data were collected from these plants for clusters/plant, pods/cluster, pod diameter and pod length. The pod diameter was recorded by Vernier Callipers. Farmer's field day was organized where more than 40 farmers participated and evaluated for preference ranking of the varieties.

RESULTS AND DISCUSSION

Days to flowering from sowing

The major objective of this observation was to study the earliness character of the varieties. The difference among the varieties on days to flowering from sowing was significant (Table 1). Prakash took the shortest period (37 days) from sowing to flowering in the first and second year. IT 86F-2062-5 (White) and IT 86D-798 took the longest period (44 days) from sowing to flowering. NGLRP (2000)

reported that Prakash was the earliest in flowering (40 days) and the cowpea varieties flowered earlier (43 days) at Rampur than Surkhet (51 days) and Nepalgunj (52 days). The difference in flowering days might be due to the varietal character, sowing time and growing environment.

Days to first harvest from sowing

The major objective was to study the earliness character of the varieties. The difference among the varieties on days to first harvest from sowing was highly significant (Table 1). Prakash took the shortest period (44 days in 2003 and 45 days in 2004) from sowing to first harvest whereas IT 86F-2062-5 (White) took the longest period (61 days). Earliness plays important role on fetching higher market price and more income. Even a single day plays important role for market price in vegetables. Bhattarai and Subedi (1996) conducted cowpea varietal experiment at Mallajh (1000 masl) and reported that Prakash was the earliest in harvesting (51 days). The difference in harvesting days might be due to the varietal character, sowing time and growing environment.

Table 1. Performance of cowpea varieties on flowering days, first harvest and last harvest days from sowing at Chambas, Tanahu during 2003 and 2004

Variety	Days to flowering from sowing			Days to first harvest from sowing			Days to last harvest from sowing		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
IT 86D-792	38	38	38	50	51	50	72	72	72
IT 86F-2062-5 (Green)	40	39	40	56	56	56	70	70	70
IT 86F-2062-5 (White)	44	45	44	61	61	61	74	74	74
IT 86D-798	44	44	44	59	60	60	74	74	74
Prakash	37	37	37	45	44	45	70	71	71
Mean	41	41	41	54	54	54	72	72	72
P value	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001
LSD (0.05)	1.01	0.78	0.56	0.80	0.88	0.59	0.96	0.80	0.58
CV, %	1.8	1.4	1.5	1.1	1.2	1.2	1.0	0.8	0.9

Days to last harvest from sowing

The major objective was to study the harvesting period and frequency of harvesting of the varieties. The difference among the varieties on days to last harvest from sowing was highly significant (Table 1). Prakash took the longest harvesting period (26 days) from first harvest to last harvest whereas IT 86F-2062-5 (White) took the shortest harvesting period (13 days) from first harvest to last harvest. Harvesting period and frequency play important role on higher production, productivity and income. Determinate varieties have short harvesting period and less picking frequency as compared to indeterminate varieties. Bhattarai and Subedi (1996) reported in the experimental result that determinate variety (Prakash) has short period than indeterminate variety (Sarlahi Tane).

Number of clusters per plant

The objective of this observation was to evaluate the varieties for pod setting character and the relation of clusters to the yield. The difference among the varieties on number of clusters/plant was significant (Table 2). The highest number of clusters (7.80 in 2003 and 8.04 in 2004 with the mean of 7.92) was produced by IT 86F-2062-5 (White) whereas the lowest number of clusters (5.43 in 2003 and 5.51 in 2004 with the mean of 5.43) was produced by IT 86F-2062-5 (Green). It is one of the major criteria to select better variety for its higher yield and preferable pod size. In general, cluster numbers directly influences the fruit yield, but the results of the experiment showed that it is not the only determinant factor whereas pod length and size also play important role on yield.

Number of pods per cluster

The objective of this observation was to evaluate the varieties for pod setting character and effect of the pod size and number to the yield. The difference among the varieties on number of pods/cluster was non-significant (Table 2). However, the highest number of pods (4.77 pods/cluster) was produced by IT 86D-792. It is one of the major criteria to select better variety for its higher yield and preferable pod size. In general, higher the number of pods/cluster more pod yield is obtained but the results of the experiment showed that fruit size (length and diameter) is also determining factor for yield estimation.

Table 2. Performance of cowpea varieties on clusters/plant, pods/cluster and pod length at Chambas, Tanahu during 2003 and 2004

Variety	Number of cluster/plant			Number of pods/cluster			Pod length, cm		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
IT 86D-792	6.90	7.01	6.96	4.58	4.95	4.77	16.74	16.99	16.87
IT 86F-2062-5 (Green)	5.35	5.51	5.43	4.55	4.62	4.58	25.40	25.80	25.60
IT 86F-2062-5 (White)	7.80	8.04	7.92	4.50	4.62	4.56	17.25	17.63	17.44
IT 86D-798	7.48	7.54	7.51	4.50	4.69	4.60	17.28	17.63	17.46
Prakash	6.13	6.61	6.37	4.50	4.59	4.55	16.20	16.22	16.21
Mean	6.73	6.94	6.84	4.53	4.70	4.61	18.57	18.86	18.71
P value	< .001	< .001	< .001	0.901	0.010	0.065	< .001	< .001	< .001
LSD (0.05)	0.32	0.27	0.22	0.22	0.20	0.16	0.38	0.31	0.26
CV, %	3.5	2.9	3.6	3.6	3.2	3.9	1.5	1.2	1.6

Pod length

The objective of this observation was to evaluate the varieties for pod length and its effect to the pod yield. The difference among the varieties on pod length was highly significant (Table 2). IT 86F-2062-5 (Green) produced the longest pods (25.40 cm and 25.80 cm in 2003 and 2004 respectively with the mean 25.60 cm) whereas Prakash produced the shortest pods (16.21 cm). The pod length of IT 86D-798, IT 56F-2062-5 (White) and IT 86D-798 was 17.46, 17.44 and 16.87 cm respectively. It is one of the major criteria to select better variety for its higher yield and preferable pod size. Longer pods are the preferred and market appealing character of cowpea. It is obvious that the longer pods produce more yield than short pods.

Pod diameter

The objective of this observation was to evaluate the varieties for pod diameter and its effect to the pod yield. The difference among the varieties on pod diameter was highly significant (Table 3). IT 86F-2062-5 (Green) produced the biggest size pods with an average of 0.990 cm in diameter whereas Prakash produced the smallest size pods with an average of 0.668 cm in diameter. T). The pod size of IT 86D-792, IT 86D-798 and IT 56F-2062-5 (White) was 0.790, 0.773 and 0.756 cm respectively. It is one of the major criteria to select better variety for its higher yield and preferable pod size. Bigger and longer green pods are the preferred and market appealing characters of cowpea. In general, bigger and longer the pod size, higher yield is obtained. Pod size is the major determining factor for yield estimation. The results revealed that the green pod yield is directly related to the pod size (length and diameter). The variety that produced the longest and biggest size pods, highest green pod yield was recorded.

Table 3. Performance of cowpea varieties on pod diameter and fresh pod yield at Chambas, Tanahu during 2003 and 2004

Variety	Pod diameter, cm			Fresh pod yield, t/ha		
	2003	2004	Mean	2003	2004	Mean
IT 86D-792	0.788	0.791	0.790	3.518	3.693	3.605
IT 86F-2062-5 (Green)	0.985	0.994	0.990	4.845	5.098	4.971
IT 86F-2062-5 (White)	0.750	0.762	0.756	3.743	3.882	3.813
IT 86D-798	0.773	0.772	0.773	3.710	3.730	3.720
Prakash	0.663	0.672	0.668	2.438	2.449	2.443
Mean	0.792	0.798	0.795	3.651	3.770	3.711
P value	< .001	< .001	< .001	< .001	< .001	< .001
LSD (0.05)	0.03	0.01	0.01	0.04	0.14	0.10
CV, %	2.8	0.7	1.9	0.8	2.8	3.0

Marketable fresh pod yield

Marketable fresh pod yield is the major determinant variable for selecting a particular variety for its commercialization and income generation capability. The difference among the varieties on marketable

fresh pod yield was highly significant (Table 3). IT 86F-2062-5 (Green) produced the highest marketable fresh pod yield of 4.971 t/ha. Similarly, IT 86F-2062-5 (White) produced 3.813 t/ha and Prakash produced the lowest yield (2.443 t/ha). IT 86D-798 and IT 86D-792 produced fresh pod yield 3.720 and 3.605 t/ha respectively. Bhattarai and Subedi (1996) reported that Sarlahi Tane produced the higher pod yield than Prakash. NGLRP reported that all tested varieties produced higher grain yield than Prakash at Rampur, Nepal. NGLRP, Rampur conducted CVT in different locations and found that IT 86D-792 produced the highest grain yield (1205 kg/ha). Prakash variety was found to be the earliest variety for flowering, pod setting and harvesting. Among the yield determinant parameters such as number of clusters/plant, pods/cluster, pod length and pod diameter, only one character was not found as the determinant character for yield estimation. However, combination of pod length and diameter directly influenced the pod yield. Despite the earliness in character, farmers did not like Prakash due to its fibrous, small and short pod characters. Farmers during field visit in Farmers' field day mentioned that the preference characters for cowpea are earliness, staking support, yield, pod color, pod length, pod size, eating quality (fiber content) and appearance. Based on the preferred characters, farmers ranked the varieties first to last IT 86F-2062-5 (Green), IT 86D-792, IT 86F-2062-5 (White), IT 86D-798 and Prakash.

Farmers preferred green color, big and long size with tender and fibreless pods for home consumption and also consumer's preferred characters for the market. The average production cost and income of cowpea was calculated NRs 40,000 and 100,000/ha respectively with net profit NRs 60,000/ha. Because of all positive characters, farmers preferred IT 86F-2062-5 (Green) for commercial production. Therefore, this variety could be recommended for river basin and low hill areas for commercial production.

ACKNOWLEDGEMENTS

We would like to express our sincere appreciation to Dr RP Sah, NARC and RK Neupane, National Grain Legume Program, Rampur for their encouragement and technical support to accomplish this work. We would like to thank Dr S Nigam, ICRISAT and Project Leader IFAD TAG 532 project for providing technical guidance and fund to implement this project at Lumle. The authors are also thankful to the coordinating farmers and field staff at Chambas for implementation of the project. We also wish to record our appreciation for word processing of this paper by RR Adhikari.

REFERENCES

Bhattarai SP and PP Subedi. 1996. Varietal trial on vegetable pea and varieties by plant density trials on vegetable bean and cowpea at outreach research sites during 1993/94 season. *LARC Working Paper No. 96/35.* Lumle Agriculture Research Centre, Kaski.

Chakraborty AK. 1997. *Vegetables crops in India* (TK Bose and MG Som, eds). Naya Prokash, 206 Bidhan Sarani, Calcutta, 700006, India.

NGLRP. 2000. *Annual Report*. National Grain Legume Research Programme, Rampur, Chitwan. Pp. 39-43.

Pandey YR and TR Pokhrel. 2000. Varietal evaluation of late season cauliflower. **In:** *Proceedings of the Third National Horticultural Research Workshop* (KP Paudyal, PP Khatiwada and BB Khatri, eds). Horticulture Research Division-NARC, Khumaltar. Pp. 46-49.

Evaluation of Different Varieties of Onion and Their Transplanting Times for Off-Season Production in Mid Hills of Nepal

Ishwori P. Gautam, Bhogendra Khatri and Govinda P. Paudel

Regional Agricultural Research Station-NARC, Lumle, Kaski, Nepal

ABSTRACT

A field experiment was conducted at the agro-ecological research site (AER site) of the Regional Agriculture Regional Station, Lumle, at Deurali in Palpa (1200 masl) during rainy season of 2004 and 2005. The main objective of the experiment was to evaluate the different varieties of onion and their transplanting time for off-season production in mid hill conditions. Treatments were four onion varieties, namely LR-241, N-53, Nasik Red and Red Creole and four transplanting dates as 25 July, 5 August, 15 August, and 25 August. The trial was conducted in RCBD with factorial arrangement of treatments and replicated three times considering farmer as a replication. The plot size was maintained 1.4 m^2 (1.4 × 1 m^2). Observation was recorded on plant height, plant stand at maturity, diameter and length of bulbs, neck thickness and yield of green bulbs and green tops. The varieties showed a significant different only on the fresh bulb production. Transplanting dates showed a significant difference on the plant height, plant stand at maturity and marketable bulb production. The highest fresh bulb yield (16.63 t ha^{-1} observed on the variety N-53. Similarly, August 15 transplanting date produced the highest bulb yield (15.31 t ha^{-1}) among four transplanting dates. This novel technology for off-season onion bulb production through seedlings would be good opportunity for increasing the income of many hill farmers which have no access to low land and irrigation facility during normal onion production season. The production of green tops in this period is consumable and easily saleable in the local market. So farmers get extra income from this technology.

Key words: Bulb yield, off-season onion, transplanting date, varieties

INTRODUCTION

The onion (*Allium cepa* L.) is an important vegetable crop in Nepal based on per capita consumption, area under cultivation and number of house–holds involved in farming (Budhathoki 1997). It stands at the third position in production among the vegetable crop in the world after tomato and cabbage (FAO 1996). The per capita consumption of fresh onion in Nepal is 7.7 kg, which is very low than recommendation of 18 kg per annum. The in-country production of onion which accounts less than 50% of total supplies in the major market centers of Nepal even during the harvesting season ie from April to June (Koirala et al 1995) will not fulfilled the demand of our requirement. Nepal is importing large quantity of dry onion bulbs every year from India and overseas to full filled the demand of Nepalese farmers. Besides India, Nepal imported dry onion bulbs, which account $ 6788.40 (NRs 4,88,768) from overseas in 2002/2003 (MoAC 2002/2003). Onion is physiologically a long-day plant and normally planted in *Rabi* season (October/November) and harvested in the months of May/June. However, there is a steady demand of onion bulb throughout the year. The storage of onion bulbs for long duration in ordinary conditions posses a great problem due to high humidity and high temperature from June to September. Storage report indicated that there was 43.9% storage loss of onion in different storage method without curing of bulbs and 31.9% even after curing over the storage period of 4 months (Bhattarai and Subedi 1998). The loss caused in storage was due to sprouting, rotting, rooting and shrinkage. So, farmers are compelled to sale their product at minimum price at harvesting time, where as there is increase in the price and scarcity of dry onion bulbs from September onwards in the markets.

To full fill the demand of onion during off-season the alternative methods for onion production through sets have been developed but farmers did not fully adopted this technology due to poor yield and difficult to produce and storage of standardizes sets. The rainy season onion production through use of sets have been tested at Rising Patan (400 masl), Sigana (1000 masl), Lumle (1600 masl) and Lopre (2200 masl). Among these tested sites the crop was failed to produce any yield at Lopre (2200 masl) and showed very poor yield in other sites 1.92, 5.55, 1.24 t ha^{-1} respectively, at Rising Patan, Sigana and Lumle (Bhattarai et al 1994*)*.

In India, farmers are growing short duration variety (which requires less than 12 hours photo period) during rainy season through use of seedlings, which shares about 39.55% of total onion production in that country (Gautam 2001). However, the research on use of seedlings, appropriate variety and their planting time for off-season dry bulb production is lacking in Nepal. Therefore, this study was conducted to evaluate the different varieties of onion and their transplanting times for off-season onion production through use of seedlings in AER site Palpa during the rainy season of 2004 and 2005.

MATERIALS AND METHODS

The study was conducted at the AER site Deurali (1200 masl) in Palpa district during the rainy season of 2004 and 2005. The treatments consist of combinations of four onion varieties, namely LR-241, N-53, Nasik Red and Red Creole and four transplanting dates as 25 July, 5 August, 15 August and 25 August. The trial was conducted in RCBD with factorial arrangement of treatments and replicated three times considering farmer as a replication. The plot size was 1.4 m^2 (1.4- × 1-m).

Onion seeds were sown in raised nursery bed starting from 10th June at 10 days intervals. The young seedlings were protected from heavy rainfall by providing plastic tunnel. One protective spray of Bavistin (1.5 ml l^{-1} water) was done against damping off in nursery beds. About 15-20 cm and 45 days old seedlings were transplanted at a spacing of 20- × 10-cm. Fertilizers was applied at the rate of 20 t ha^{-1} compost and 100:50:100 kg N:P_2O_5:K_2O t ha^{-1}. The half dose of nitrogen and full dose of phosphorus and potash was applied at the time of final land preparation and remaining half dose of nitrogen was top-dressed equally two times at 45 and 90 after transplanting of seedlings. Drainage canal was made around the plot to drain the excess water. Weeding and other intercultural operations were carried out as per the normal season onion. Neck fall was not observed in maturity stage during this season so the crop was harvested when flowering stalks started to appear. Immediately after harvesting the green tops were separated by leaving 2.5 cm neck. Observation was recorded on plant height, plant stand at maturity, diameter and length of bulbs, neck thickness and yield of green bulbs and green tops.

RESULTS AND DISCUSSION

Plant height

The plant height was measured at the maturity stage and average was computed. The pooled analysis of two year data showed there was a non significant difference on the height due to varieties. However, transplanting dates showed a highly significant difference on plant height. The longest plant height (59.81 cm) was observed on the August 25 transplanting date and it was found at a par with August 5 (56.81 cm) transplanting date. Where as the shortest plant height (39.7 cm) was on July 25 transplanting date. The effect on the plant height due to interaction of varieties and transplanting dates was found non significant (Table 1).

Neck diameter

Neck diameter (thickness) in onion is an important character, because it indicates bulb storage ability. The onion with thin neck diameter store better than thick diameter. The neck thickness of sampled

plants was measured with the help of Vernier Caliper in centimeter (cm). The four tested varieties and interaction of varieties and transplanting dates showed a non significant difference on the neck diameter. However, transplanting dates showed a significant difference on neck diameter. The lowest average neck diameter 4.35 cm and 4.78 cm was found on July 25 transplanting dates, respectively in first and second year. The detail of different varieties and planting dates is presented in Table 2. The high neck thick ness in the all treatments was due to measurement of thickness of plant just after harvesting. Furthermore, there was no toppling and sunken of neck during this season as it happened in normal season onion.

Table 1. Effect of varieties and transplanting dates on plant height of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	41.75	56.50	53.75	63.30	41.75	56.50	53.75	63.30	50.64
N-53	43.10	55.15	54.15	59.45	43.10	55.15	54.15	59.45	51.95
Nasik Red	37.70	57.85	47.15	54.85	37.70	57.85	47.15	54.85	47.77
Red Creole	36.25	56.95	40.15	61.65	36.25	56.95	40.15	61.65	48.65
Mean	39.70	56.81	48.88	59.81	39.70	56.81	48.88	59.81	49.75
	Variety		Transplanting date		Variety × Transplanting date				
F-test	ns		***		ns				
LSD (0.05)	-		5.039		-				

Table 2. Effect of varieties and transplanting dates on neck diameter of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	4.00	4.90	4.20	4.60	5.05	5.00	5.75	6.35	4.98
N-53	4.55	4.10	4.25	5.60	5.65	5.55	5.90	6.55	5.27
Nasik Red	4.47	5.30	4.15	5.15	3.95	6.35	5.35	6.10	5.10
Red Creole	4.40	3.25	5.25	4.90	4.45	6.50	5.80	6.90	5.18
Mean	4.32	4.39	4.46	5.06	4.48	5.85	5.70	6.48	5.13
	Variety		Transplanting date		Variety × Transplanting date				
F-test	ns		*		ns				
LSD (0.05)	-		0.830		-				

Harvesting date

The mean harvesting date was 156 days after transplanting. However, the harvesting date for the first year was longer than the second year. There was decreased in harvesting date for later transplanting (Table 3). The varieties and their interaction with transplanting dates showed a non significant difference on harvesting date. However, transplanting dates showed a highly significant difference on it.

Table 3. Effect of varieties and transplanting dates on harvesting date of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	170	160	157	147	163	150.5	145.5	155.5	156.06
N-53	170	160	157	147	163	150.5	145.5	155.5	156.06
Nasik Red	170	160	157	147	163	150.5	145.5	155.5	156.06
Red Creole	170	160	157	147	163	150.5	145.5	155.5	156.06
Mean	170	160	157	147	163	150.5	145.5	155.5	156.06
	Variety		Transplanting date		Variety × Transplanting date				
F-test	ns		***		ns				
LSD (0.05)	-		5.128		-				

Bolting percentage of plant

The mean bolted of the plant was observed 2.22 percentage. Before implementation of the experiment it was assumed that the long day onion variety Red Creole would bolt and may not produce bulb, but the bolting percentage on Red Creole was found non significant difference among other varieties. The four transplanting dates and their interaction with varieties were also fond non-significant on the bolting percentage (Table 4). Results showed that bolting of onion plant is not affected by day length only and there may be other factors such as temperature, nutrients, status of the field etc, which could modify the bolting of the plant.

Table 4. Effect of varieties and transplanting dates on bolting percentage of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	3.51	3.51	3.51	3.51	3.1	1.27	0.00	0.00	2.30
N-53	3.51	3.51	3.51	3.51	1.85	1.10	0.92	0.00	2.24
Nasik Red	3.51	3.51	3.51	3.51	0.00	0.00	0.46	0.00	1.81
Red Creole	3.51	3.51	3.51	3.51	5.00	0.00	1.25	0.00	2.54
Mean	3.51	3.51	3.51	3.51	2.49	0.59	0.66	0.00	2.22
	Variety		Transplanting date		Variety × Transplanting date				
F-test	ns		ns		ns				

Diameter of Fresh bulb

The diameter of the bulb was measured just after harvesting and average data are being presented in Table 5. There was significance difference on diameter of bulb due to varieties. However, transplanting date and their interaction with varieties showed a non-significant difference on bulb diameter. The highest mean diameter (5.73 cm) was found on N-53 and lowest (4.90 cm) was found on Red Creole.

Table 5. Effect of varieties and transplanting dates on bulb diameter of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	5.35	5.00	5.61	5.06	5.70	6.10	5.91	5.35	5.51
N-53	5.55	5.56	5.20	5.00	5.85	5.76	6.08	6.82	5.73
Nasik Red	5.52	4.97	4.97	5.06	5.51	6.15	5.82	5.84	5.48
Red Creole	5.02	4.74	4.76	5.18	4.48	5.83	4.27	4.93	4.90
Mean	5.36	5.07	5.13	5.08	5.39	5.96	5.52	5.73	5.40
	Variety		Transplanting date		Variety × Transplanting date				
F-test	*		ns		ns				
LSD (0.05)	0.494		-		-				

Length of Fresh bulb

Higher length of bulb is a disqualification in case of onion. In this experiment none of the varieties, neither transplanting dates nor their interaction showed a significant difference on the length of fresh bulb. However the length of bulb varied from 3.89 to 7.71 cm with an average of 4.39 cm. The detail data is presented in Table 6.

Marketable Fresh bulb yield

The yield of fresh onion bulb was significantly affected by both varieties and transplanting dates. The mean highest fresh bulb (16.6 t ha^{-1}) was observed on the variety N-53 where as lowest yield (7.25 t ha^{-1}) was recorded on Red Creole.

Table 6. Effect of varieties and transplanting dates on bulb length of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	3.95	4.0	4.90	3.20	4.55	5.25	4.25	4.70	4.35
N-53	3.90	4.40	3.65	3.85	4.45	4.60	4.25	4.10	4.15
Nasik Red	5.60	5.35	4.60	4.40	4.00	4.80	4.50	5.45	4.84
Red Creole	3.65	4.0	4.30	4.10	4.20	4.80	4.20	4.60	4.23
Mean	4.27	4.44	4.36	3.89	4.40	4.86	4.30	4.71	4.39
	Variety		Transplanting date		Variety × Transplanting date				
F-test	ns		ns				ns		

Similarly, different transplanting dates also showed a significant difference on the yield of onion. The highest bulb yield (15.31 t ha^{-1} and 14.70 t ha^{-1} was observed on August 15 transplanting date respectively in first and second year. The lowest yield (10.38 t ha^{-1}) was observed on August 5 transplanting date in first year and 9.19 t ha^{-1} on July 15 transplanting date in second year. The low yield in these transplanting dates could be due to unfavorable climatic condition like temperature and day length, field situation etc. The interaction effect of varieties and transplanting dates showed a non significant difference on the marketable yield of onion. The detail yield of varieties and their interaction with different transplanting dates is presented in Table 7. Previously it was reported that the dry bulb production of onion during rainy season was not possible through seedling and it was done through sets. The bulb production through sets requires specific knowledge on production of specific size sets, required more time, and difficult to storage sets for longer period. Therefore the alternative method for onion bulb production through seedling was tested. The onion bulb production through seedling was practiced in India. The short days cultivars can initiate and form the bulbs under photoperiod of 12 hours or less. Besides photoperiod, environmental factors such as temperature, nutrition and spacing, and internal factors such as age of seedling and stage of development of plant control the development of bulbs.

Table 7. Effect of varieties and transplanting dates on fresh bulb yield of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	13.25	7.50	13.75	13.13	11.29	10.29	17.36	11.96	12.32
N-53	17.41	14.10	16.43	18.57	11.36	18.07	17.50	20.04	16.68
Nasik Red	17.68	8.13	16.61	12.86	12.23	14.55	20.30	15.18	14.82
Red Creole	9.82	11.79	14.46	11.43	0.88	3.39	3.62	2.64	7.25
Mean	14.54	10.38	15.31	14.0	9.19	11.58	14.70	12.45	12.77
	Variety		Transplanting date		Variety × Transplanting date				
F-test	***		*				ns		
LSD (0.05)	2.712		2.712				-		

Green top yield

The green top yield of onion produced in off-season is also consumable and easily saleable in the local markets. So onion production in this season has great advantage to increase the income of poor farmers. The use of different varieties and different planting dates showed a significant difference on the production of green top yield (biomass). However, the interaction of varieties and transplanting dates showed a non significant difference on the green top yield. The average green top yield was recorded 6.14 t ha^{-1} and detail of the treatments is presented in Table 8. Based on the above results N-53 variety of onion is recommended for off-season (rainy season) production through seedling in mid hill condition. The best time of transplanting of seedling is recommended on August 15 in Palpa but it may vary in other places. Therefore further verification trials are needed in different agro-ecological condition.

Table 8. Effect of varieties and transplanting dates on bulb diameter of rainy season onion at Deurali, Palpa during 2004 and 2005

Treatments	2004				2005				Mean
	25 July	5 Aug	15 Aug	25 Aug	25 July	5 Aug	15 Aug	25 Aug	
LR-241	4.46	4.45	4.46	6.74	4.16	6.48	10.96	10.13	6.56
N-53	5.30	5.25	5.36	7.55	3.96	7.61	11.25	14.07	7.54
Nasik Red	6.30	4.89	3.90	5.47	4.73	7.75	7.05	11.25	6.42
Red Creole	4.79	3.76	4.64	6.32	0.96	2.59	6.14	3.05	4.03
Mean	5.21	4.59	4.68	6.52	3.53	6.11	8.85	9.63	6.14
	Variety		Transplanting dates		Variety x Transplanting dates				
F-test	*		*				ns		
LSD (0.05)	2.447		2.447		-				

ACKNOWLEDGMENT

The authors would like to thank KP Upadhyay, JN Chaudhary for their technical help, Ram Jee Paudel and KP Devkota for assistance in the field work and RR Adhikari for computer work.

REFERENCES

Bhattarai SP and PP Subedi.1998. Effect of curing and storage method on post-harvest loss of bulb onion in low hills. *LARC Working Paper No. 98/20*. Lumle Agriculture Research Centre, Lumle, Kaski, Nepal. Pp. 3-5.

Bhattarai SP, B Adhikari and GB Gurung. 1994. Set size standardization and time of planting trial on off-season onion. *LARC Working Paper No. 94/45*. Lumle Agriculture Research Centre, Lumle, Kaski, Nepal. Pp 6-16.

Budhathoki K. 1997. The effects of environmental conditions on the growth and development of onions (*Allium cepa*, L.) in Nepal. *Ph. D. Thesis*. Department of Agriculture and Horticulture, Wye College, University of London.

FAO. 1996. Year book production. FAO Statistics Series Rome 55:29-150.

Gautam IP. 2001. Effect of nitrogen and boron on Kharif season onion production. *M.Sc. Thesis*. Chandra Sekhar Azad University of Agriculture and Technology, Kanpur, India.

Koirala GP, GB Thapa and GR Joshi.1995. Can Nepalese farmers compete in the domestic market? A comparison of the relative setting and performance in agriculture of Nepal and India. *Research Report Series No. 34*. Winrock International, PO Box 1313, Kathmandu, Nepal.

MoAC. 2002/2003. *Statistical information on Nepalese agriculture 2002/03*. Agribusiness Promotion and Statistics Division, Ministry of Agriculture and Cooperatives. HMG/N, Singhadarbar, Kathmandu, Nepal.

Common Buckwheat-based EST Primers in the Genome of Other Species of *Fagopyrum*

Bal K. Joshi*, Kazutoshi Okuno, Ryo Ohsawa and Takashi Hara

Laboratory of Plant Breeding, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan

* Current address: Nepal Agricultural Research Council, Kathmandu, Nepal
<joshibalak@yahoo.com>

ABSTRACT

If the EST primers designed for one species can be used in related species, then the cost involved in developing markers for DNA fingerprinting, genetic relationship studies, mapping, etc. for other species is significantly reduced. We tested the applicability of 17 EST primers developed from common buckwheat in other wild and cultivated *Fagopyrum* species. A total of 18 accessions consisting of 4 subspecies and 2 species were used. Sequences of 93 cDNA clones were used to design primers using Primer3. Amplification products were different in band intensity. In most of the cases, the bands of *F. homotropicum* were with high intensity. All primers showed single band except in Accession C9022. Three primers 23, 31 and 69 produced very clear singe band. All primers amplified the genomic DNA of *F. homotropicum* (2x). Eight primers amplified the DNA of all accessions. Results indicated that the transferability of EST markers developed for common buckwheat decreased with an increase in genetic distance between them.

Key words: Common buckwheat, EST markers, *Fagopyrum* species, transferability

INTRODUCTION

Dominant molecular markers eg RAPD, AFLP, etc are expected to provide little or no information regarding synteny. Because EST PCR markers are derived from gene coding regions they are more likely to be conserved across populations and species than markers derived from random regions of DNA. EST is a partial sequence of a gene and is mapped on the respective gene position on the genome either by PCR based marker or RFLP probe. Mapping information can be compared among genomes in different species by the comparison of genetic sequences (Sato et al 2005).

The ability to transfer mapped STS markers within the Poaceae family has been demonstrated, both between cereal species (Erpelding et al 1996) and between cereal and forage grass species (Taylor et al 2001). STS primers developed from black spruce cDNA sequences have been shown to direct amplification in several different conifer species in the study of Rowland and Bhanaraj (2003) that tested whether many of the EST PCR primer pairs developed for blueberry are capable of amplifying DNA fragments in other members of the family Ericaeae. Of 26 primer pairs tested in cranberry 23 (89%) resulted in successful amplification. Of 39 primer pairs tested in rhododendron 29 (74%) resulted in successful amplification.

Applicability of SSR of *Chamaecyparis obtusa* has been assessed in 11 other species from five genera in the Cupressaceae and in *Cryptomeria japonica* (Nakao et al 2001). The evolutionary conservation of DNA sequences flanking mircrosatellite sites allows microsatellite markers developed in one species to be used in other related species (Echt et al 1999). Species within the same genera show similar tendencies for PCR amplification. The applicability test of the microsatellite markers developed in *C.*

obtusa indicates that possible applications to other species are restricted even within the Cuppressaceae. The low applicability of *C. obtusa* microsatellite markers to other related species may be due to the genetic diversity of the species within the Cupressaceae (Nakao et al 2001).

Amplification was more consistent using the species-specific primer design for each gene (Yu et al 2004). Forty-four percent of the primers designed specifically for wheat sequences were successful in amplifying DNA from both wheat and rice species. EST-derived markers are likely to be more highly conserved, and therefore may be more transferable between species than anonymous sequence derived markers (Taylor et al 2001, Yu et al 2004). Moreover, ESTs that share homology to expressed genes can be specifically targeted for genetic mapping and can be useful for aligning genomes of distantly related species for comparative analysis. EST-derived SSRs have been evaluated on rice, durum wheat, barley and hexaploid wheat. In general, EST-SSRs have demonstrated less polymorphism compared to genomic SSRs, but have showed a high frequency of cross-species transferability. Yu et al (2004) tested EST-SSR primers developed from hexaploid wheat and rice ESTs on four cereal species (wheat, rice, barley, maize) and 62% of the functional primers produced PCR amplicons from two or more of the species. 44% of the primers derived from wheat EST sequences amplified rice DNAs. Goff et al (2002) reported that 59% of rice cDNA sequences from Harushima et al (1998) matched two or more copies in the rice genome sequence identified by a BLASTN analysis. SSRs derived from ESTs are especially valuable as molecular markers because they are derived from gene transcripts and are more likely to be conserved among species (Yu et al 2004).

Although there are many advantages to using EST-PCR markers, considerable cost is involved in terms of time, money, and other resources. In developing this type of marker RNA must be extracted from sometimes small amounts of the appropriate tissue, a cDNA library must be constructed, hundreds of clones must be picked and plasmid DNA isolated from them, the clones must be sequenced, and primers must be designed, synthesized, and tested. If the EST-PCR primers designed for one species can be used in related species, then the cost involved in developing markers for DNA fingerprinting, genetic relationship studies, mapping, etc. for other species is significantly reduced. In addition, if the markers are shown to be homologous, they can be used for comparative mapping studies between the species. In general, the wider the taxonomic range across which primers are transferable, the more economically attractive primer development becomes. Successful amplification is only one measure of utility. Therefore we tested the applicability of EST primers developed from common buckwheat in other *Fagopyrum* species.

MATERIALS AND METHODS

DNA extraction

A total of 18 accessions consisting of 4 subspecies and 2 species (Table 1) were used. Seeds were collected from Kyoto University, Japan. These accessions were seeded in Growth Chamber of Plant Breeding Lab of Tsukuba University, Japan. Leaves from 22 day old seedlings were collected in plastic bag. Two leaves per accession, one leaf from each individual plant were collected. About 8 pieces were made from a single leaf and one piece was used to extract the DNA. Remaining leaf pieces were kept in 2 ml size tube and stored in deep fridge. DNA was extracted from the fresh piece of each leaf using the kit method (DNeasy Plant Mini Kit). Two DNA samples from each accession were used in this study. The extracted DNA was stored in deep fridge and used directly without diluting for further study.

DNA was checked in 2% Agarose S gel containing 2.5% ethidium bromide in 1 x TAE buffer (Figure 1). Electrophoresis was run at 100 V for 30 min. Gels were stained with ethidium bromide and visualized and documented using Kodak 1D software (Kodak EDAS290). Two DNA samples from each accession were loaded to insure DNA extraction.

Primers design

Sequences of 384 cDNA clones provided by Dr J. Aii were used to design primers after removing primer sequences. These sequence data was used in Standard BLAST search to identify unique sequences. 93 clones had unique sequences and these clones were used to design primers. The primer was constructed in summary as follows: (1) identify the sequence of interest from the cDNA library clones; (2) insert the sequence into the input window of the Web-based PCR primer designing program, Primer3 (http://www-genome.wi.mit.edu/cgi-bin/ primer/primer3.cgi) (Rozen and Skaletsky 2000); (3) set the primer optimum size, maximum size, and minimum size; (4) set the primer optimum Tm, maximum Tm, and minimum Tm; and (5) use one of the primers picked by the program.

Optimization of PCR conditions

DNA of four lines of common buckwheat (Kyusu, Canada, Miyazaki and Botansoba) was used to optimize the annealing temperature, PCR cycle and concentration of $MgCl_2$ for 26 primers. Except these three variables all other PCR protocols were same as described below. PCR were run first at annealing temperature (Ta) of 62 with 40 cycles in a 1.5mM $MgCl_2$ concentration. Annealing temperature, PCR cycle number and $MgCl_2$ were considered optimum if the single clear band was observed. If the band was not observed, annealing temperature was decreased by 2^oC. In the case of multiple bands, we increased the temperature by 2^oC. PCR cycle was increased if there was single but not clear band and cycle was decreased in the case of multiple but not clear bands. In some cases of very dim single band, concentration of $MgCl_2$ was increased. If band intensity was low, we increased the cycle. If some bands were high intensity and some were low in multiple bands we decreased the cycle. We repeated this experiment until the single clear band of all 26 primers was achieved.

Table 1. Species and accessions of buckwheat used to check the PCR amplification using EST primers designed from common buckwheat

SN	Accession /line	Species	Remarks
1	C2009	Fagopyrum esculentum ssp ancestralis	Wild species
2	C9740	F. homotropicum (2x)	Wild species
3	C0210	F. homotropicum (4x)	Wild species
4	C9722	F. tataricum ssp tataricum	Cultivated species
5	C9022	F. tataricum ssp potanini	Wild species
6	C8924	F. cymosum (2x)	Wild species
7	B9103	F. cymosum (4x)	Wild species
8	Hokkei 1	F. tataricum ssp tatariucm	Cultivated species
9	Hokkei 2	F. tataricum ssp tatariucm	Cultivated species
10	Hokuriku 4	F. tataricum ssp tatariucm	Cultivated species
11	Hokuriku 5	F. tataricum ssp tatariucm	Cultivated species
12	Ishisoba	F. tataricum ssp tatariucm	Cultivated species
13	Tite 100	F. tataricum ssp tatariucm	Cultivated species
14	CV	F. tataricum ssp tatariucm	Cultivated species
15	Kyusyu	F. esculentum ssp esculentum	Cultivated species
16	Canada	F. esculentum ssp esculentum	Cultivated species
17	Miyazaki	F. esculentum ssp esculentum	Cultivated species
18	Botansoba	F. esculentum ssp esculentum	Cultivated species

Primer selection and PCR run

17 primers (Table 2) were selected after optimizing the PCR condition of 26 EST primers. Amplification reactions were performed in 0.5 ml tubes in a volume of 30 ul consisting of 14.7 µl sterile distilled water, 6 µl 5 x buffer (50 mM Tris-HCl pH 8.3, 250 mM KCl, 500 µM dNTP, 0.1% Triton X-100, 0.05% Gelatin, 7.5 mM), 3 µl of each primer of 2 µM concentration, 0.3 µl Taq DNA polymerase and 3 µl template DNA. DNA amplification reaction were performed in a thermal cycler (GeneAmp PCR system 9700 and 2700 and TAKARA) using the following cycling program: one cycle of 94^oC for 3 min; 40 cycles of 94^oC for 0.30 min, 62^oC (for primers 3, 15, 21, 25, 31, 32, 36, 40, 56, 61, 62, 69, 79,

87), 60 °C (for primers 23, 35, 64) for 0.30 min, 72 °C for 0.30 min; one cycle of 72 °C for 7 min followed by soaking in 4 °C. PCR products were stored in fridge for further analysis.

Electrophoresis run and data analysis

PCR products were analyzed in 2% Agarose S gel as described before. Based on band intensity, primers were related with accessions as showing high, medium and low bands. Number and percent of amplification of accessions by different primers were estimated.

Table 2. EST primers used in this experiment

PN	Primer ID	Primer sequence	Product length, bp	Tm	GC%
3	Fe_cb_0006_primer_4	F: GAGGCTACGGATTTTCTGCC	320	61.091	55.00
		R: TCCTCGTCCTCTTCCTCCTC		60.870	60.00
15	Fe_cb_0032_primer_0	F: CCAAGCCCTTTTCTGCAACC	192	64.126	55.00
		R: CTTTTGCTTCCGTTTTCCCC		62.984	50.00
21	Fe_cb_0045_primer_3	F: CACATTCCTCAGATCCCACC	314	60.326	55.00
		R: TCTCCTCTCCCTCTCCCATC		60.694	60.00
23	Fe_cb_0050_primer_0	F: TCAACTGCCAACTAACACCCA	454	61.502	47.62
		R: CACCAGCCCCACTCTCTTTC		62.145	60.00
25	Fe_cb_0059_primer_0	F: CAAGAGCGTTGTGTTACCGAG	432	60.862	52.38
		R: ACTGTGGGTCGGATTGTCAG		60.987	55.00
31	Fe_cb_0073_primer_0	F: CAAAGCACGTCCAAACAACA	392	60.732	45.00
		R: GGATAATGGCGGTGTCAAAA		60.701	45.00
32	Fe_cb_0078_primer_0	F: ACCGTTCCATGGGATCAAAG	653	62.036	50.0
		R: AGAACAACGCCATGCACAAA		62.599	45.0
35	Fe_cb_0085_primer_0	F: CAGCTAAGGCAGACGGTTGA	148	61.499	55.00
		R: TCATTGCCAGATCTCATTGGA		61.547	42.85
36	Fe_cb_0087_primer_0	F: TTTCCCCTTTCCCTTCTTCC	554	61.601	50.00
		R: AAGACAGCCACCCAACTCAA		60.690	50.00
40	Fe_cs_0003_primer_1	F: AGCAGCAGCCATCCTTGTTC	434	62.811	55.00
		R: TCGCAAGGCTGTTGTTATCC		61.168	50.00
56	Fe_cs_0174_primer_0	F: CAAAGCAGGCAGAGAAAGCA	559	61.753	50.00
		R: GCAGATGCAAAATCAACTTCCC		63.032	45.45
61	Fe_cs_0205_primer_0	F: AGAGCAAGGAGGAGAATGGTG	300	60.771	52.38
		R: CTGAATCAAGGAGCGTTTGG		60.766	50.00
62	Fe_cs_0206_primer_2	F: GGGCAGACTCGGTGCTATTC	291	62.086	60.00
		R: GGTGAAGGGATTGTGGCTGT		62.279	55.00
64	Fe_cs_0211_primer_0	F: TCCCACGTTCATCGTTATAAACTC	273	61.403	41.66
		R: TGTTCATTTACGTCGGTTGTCC		62.038	45.45
69	Fe_cs_0222_primer_0	F: TGGCTGATAGCGGTGAAAGA	377	61.848	50.00
		R: GGATTGTGGGCTGACAAAGA		61.046	50.00
79	Fe_cs_0247_primer_0	F: CGAAACCACCAACAACTAAGCA	429	62.290	45.45
		R: CTAGGCGGTCGAGGATGAAG		62.187	60.00
87	Fe_cs_0268_primer_1	F: TTCACCATGAGTAGGTCGGG	355	60.913	55.00
		R: GATGGCAAGCAGTCAGGAAG		60.945	55.00

RESULTS AND DISCUSSION

Primers with their amplification status are given in Table 3. Amplification products were different in band intensity (Table 4 and Figure 2). In most of the cases, the bands of *F. homotropicum* were with high intensity. All primers showed single band except in Accession C9022. Three primers 23, 31 and 69 produced very clear singe band (Table 5). Products ranged from 200 to 2000 bp. All primers amplified the genomic DNA of *F. homotropicum* (2x). 94.12% of the total primers amplified the DNA of *F. esculentum* ssp *ancestralis* and *F. esculentum* ssp *esculentum*. DNA of *F. cymosum* (2x and 4x) and *F. tataricum* ssp *tataricum* was amplified by least number of primers (58.82%) (Figure 3). Eight primers amplified the DNA of all accessions.

The rate of successful amplification was found to be higher in more closely related species (Konishi 2006) eg *F. esculentum* ssp *ancestralis* (100%) and diploid *F. homotropicum* (79.6%) whereas it was lower in more distantly related species eg *F. tataricum* ssp *potanini* (25.9%), diploid (36.7%) and tetraploid (33.3%) *F. cymosum*. We had the similar results. Results indicated that the transferability of EST markers developed for common buckwheat decreased with an increase in genetic distance between them. It has been reported that the percentage of primer pairs that successfully amplified microsatellite loci was lower in polyploidy species as compared with their diploid counterparts. It is possible that the primer pairs which did not amplify EST loci in a given species under our conditions may become successful in amplifying EST loci in other species under differing annealing temperature.

The transferability of 207 *Gossypium arboreum*-derived expressed sequence tag-simple sequence repeat (EST-SSR) primer pairs was examined among 25 different diploid accessions representing 7 genomes and 23 *Gossypium* species (Guo et al 2006). They found that 124 of the 207 (60%) primer pairs produced amplification products in all 25 accessions. The cross-species amplification of these EST-SSRs in 22 diploid species was 96.5%.

The transferability with genomic SSR markers is generally low when cross-species analyses are conducted, while polymorphisms are numerous and some of the SSRs were found to be genome-specific (Guo et al 2006). Meanwhile EST-SSR markers derived from transcribed regions of the DNA produce a higher rate of transferability, but fewer polymorphisms. Based on wheat genomic SSR markers, the transferability from wheat to rye was found to be only 17% (Kuleung et al 2004); however, based on EST-SSR markers, the transferability from wheat to 18 Triticum-Aegilops species was found to be as high as 84% (Bandopadhyay et al 2004), and from tall fescue to seven grass species was found to be nearly 92% (Saha et al 2004). Polymorphism frequency may be related to the mode of plant reproduction. It is low in self-pollinated species such as rice (43%) and wheat (38%), but is high in cross-pollinated species such as tall fescue and ryegrass (66%) using the same markers.

The ability to transfer mapped STS markers between barley and wheat has been demonstrated (Taylor et al 2001). The transfer of mapped STS markers between cereals and forage grasses could provide PCR-based markers for comparative mapping in these species providing they amplify homologous sequences. Erpelding et al (1996) have shown that STS markers can be readily transferred between wheat and barley. A total of 21 primer sets derived from barley, *T. tauchii* and *P. coerulescens* loci have been assessed for their ability to amplify homologous sequences in *L. perenne* (Taylor et al 2001). Sequencing analysis of the PCR amplification products generated revealed that 11 primer sets (52%) successfully amplified homologous fragments from 10 of the 18 (55%) loci targeted. Analysis of homologous fragments generated in *L. perenne* reveals high levels of sequence identity and conservation in gene structure (ie presence, size and relative position of exons and introns) to barley, wheat and *P. coerulescens* homologues. The rate of success for primers designed from coding sequences was higher (58%) than for primers derived from genomic DNA sequences (44%). Primers that functioned well in one member of a genus are generally also successful in other members of that genus (Perry and Bousquet 1998).

A high percentage of the common buckwheat-derived EST-PCR primer pairs resulted in successful amplification of DNA from other *Fagopyrum* species. EST-PCR fragments of *Fagopyrum* species other than common buckwheat can be compared their homologous to the original cDNA clones from common buckwheat. These markers should be useful for DNA fingerprinting, developing genetic linkage maps, and assessing genetic diversity within genus *Fagopyrum*. The markers which are homologous to the common buckwheat cDNA clones by DNA sequencing should also be useful for comparative mapping and possibly for examination of genetic relationships between species of the genus *Fagopyrum*.

The transferability among these different species presented here can increase the efficiency of transferring genetic information across species and further enhance their introgression into cultivated species by the molecular tagging of important genes existing in these species using the EST markers.

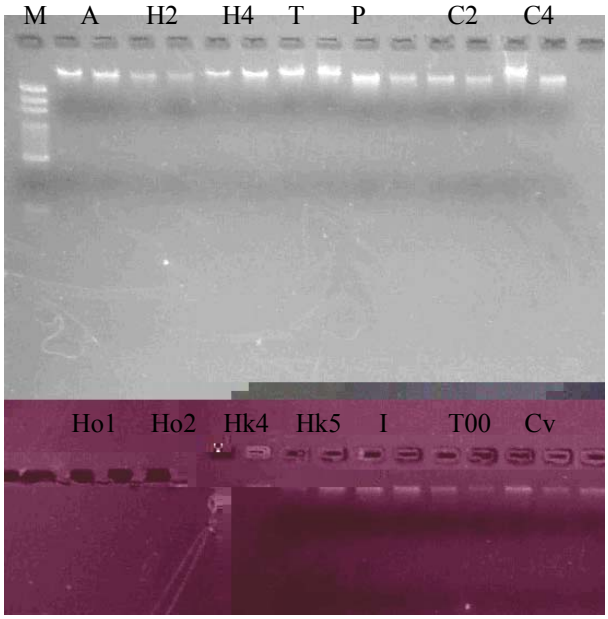


Figure 1. DNA check after extraction following the QIAGEN kit method in 2% agarose gel *(2 samples from each accessions. M, Ladder. A , Fagopyrum esculentum ssp ancestralis. H2 , F. homotropicum (2x). H4, F. homotropicum (4x). T, F. tataricum ssp tataricum. P, F. tataricum ssp potanini. C2, F. cymosum (2x). C4, F. cymosum (4x). Ho1, Hokkei 1. Ho2, Hokkei 2. Hk4, Hokuriku 4. Hk5, Hokuriku 5. I, Ishisoba. T00, Tite 100. Ky, Kyusyu. Ca, Canada. Mi, Miyazaki. Botansoba, Bo)*.

Table 3. Amplification condition of EST primers in different species

SN	Accession/ line	Species	Primers amplified	Primers amplified, %	Non amplified primers
1	C2009	Fagopyrum esculentum ssp ancestralis	3, 15, 21, 23, 25, 31, 32, 35, 40, 56, 61, 62, 64, 69, 79, 87	16 (94.12)	36
2	C9740	F. homotropicum (2x)	3, 15, 21, 23, 25, 31, 32, 35, 36, 40, 56, 61, 62, 64, 69, 79, 87	17 (100)	-
3	C0210	F. homotropicum (4x)	3, 15, 21, 23, 32, 31, 35, 40, 56, 61, 62, 64, 69, 79, 87	15 (88.24)	25, 36
4	C9722	F. tataricum ssp tataricum	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
5	C9022	F. tataricum ssp potanini	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
6	C8924	F. cymosum (2x)	3, 15, 21, 23, 32, 31, 35, 61, 69, 79	10 (58.82)	25, 32, 36, 40, 56, 62, 64
7	B9103	F. cymosum (4x)	15, 21, 23, 32, 31, 35, 61, 62, 69, 79	10 (58.82)	3, 25, 32, 36, 40, 56, 64
8	Hokkei 1	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
9	Hokkei 2	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
10	Hokuriku 4	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 64, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 62

SN	Accession/ line	Species	Primers amplified	Primers amplified, %	Non amplified primers
11	Hokuriku 5	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
12	Ishisoba	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 69, 79	10 (58.82)	25, 32, 36, 40, 56, 62, 64
13	Tite 100	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
14	CV	F. tataricum ssp tatariucm	3, 15, 21, 23, 32, 31, 35, 61, 62, 69, 79	11 (64.71)	25, 32, 36, 40, 56, 64
15	Kyusyu	F. esculentum ssp esculentum	3, 15, 21, 23, 25, 32, 31, 35, 40, 56, 61, 64, 69, 79, 87	16 (94.12)	36
16	Canada	F. esculentum ssp esculentum	3, 15, 21, 23, 25, 32, 31, 35, 40, 56, 61, 62, 64, 69, 79	16 (94.12)	36
17	Miyazaki	F. esculentum ssp esculentum	3, 15, 21, 23, 25, 32, 31, 35, 40, 56, 61, 62, 64, 69, 79, 87	16 (94.12)	36
18	Botansoba	F. esculentum ssp esculentum	3, 15, 21, 23, 25, 32, 31, 35, 40, 56, 61, 62, 64, 69, 79, 87	16 (94.12)	36

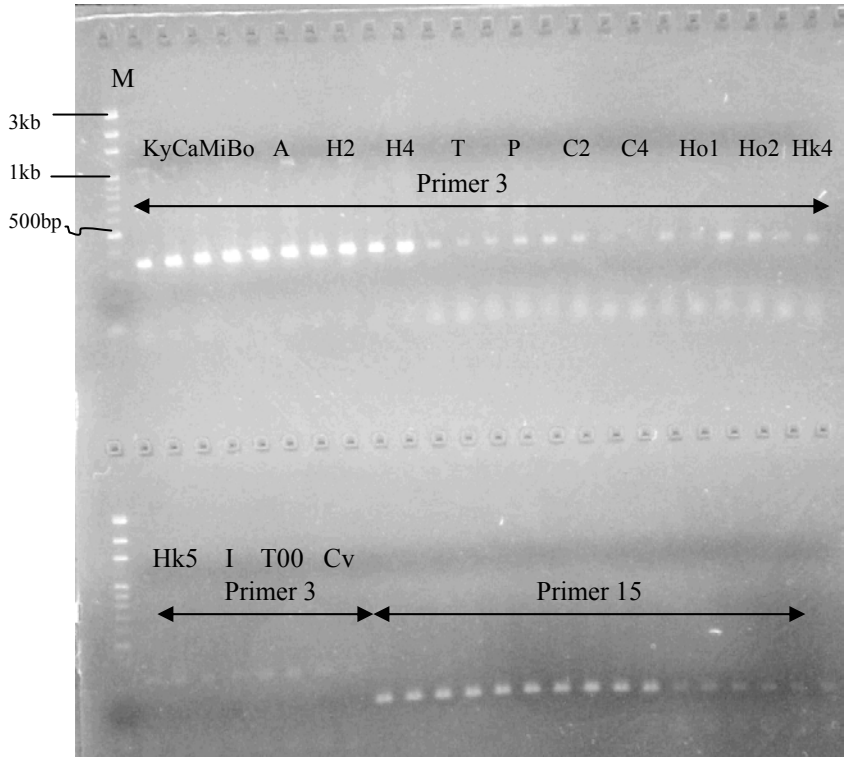


Figure 2. Amplification condition of primers 3 and 15 in different accessions and species of *Fagopyrum* *(see Figure 1 for details)*.

Table 4. Accessions based on the band intensity

SN	PN	Bands intensity		
		High	Medium	Low
1.	3	C2009, C9740, C0210, Kyusyu, Canada, Miyazaki, Botansoba	-	C9722, C9022, C8924, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV
2.	15	-	C2009, C9740, C0210, B9103, Hokke 1, Hokke 2, Hokuri Ku 4, Hokuri Ku 5, Ishisoba, Tite 100, CV, Kyusyu, Canada, Miyazaki, Botansoba	C9722, C9022, C8924
3.	21	C2009, C9740, C0210, Kyusyu, Canada, Miyazaki, Botansoba	-	C9722, C9022, C8924, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV
4.	23	C2009, C9740, C0210, B9103, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV, Kyusyu, Canada, Miyazaki, Botansoba	-	-
5.	25	-	-	C2009, C9740, Kyusyu, Canada, Miyazaki, Botansoba
6.	31	C2009, C9740, C0210, C9722, C9022, C8924, B9103, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV, Kyusyu, Canada, Miyazaki, Botansoba	-	-
7.	32	C2009, C9740, C0210, Kyusyu, Canada, Miyazaki, Botansoba	-	-
8.	35	-	-	C2009, C9740, C0210, C9722, C9022, C8924, B9103, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV, Kyusyu, Canada, Miyazaki, Botansoba
9.	36	-	-	C9740
10.	40	C2009, C9740, C0210	Kyusyu, Canada, Miyazaki, Botansoba	-
11.	56	-	C2009, C9740	C0210, Kyusyu, Canada, Miyazaki, Botansoba
12.	61	B9103, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV	C2009, C9740, C0210, C9722, C9022, C8924, Kyusyu, Canada, Miyazaki, Botansoba	-
13.	62	-	C2009, C9740, Kyusyu, Canada, Miyazaki, Botansoba	C0210, C9722, C9022, B9103, Hokkei 1, Hokkei 2, Hokuriku 5, Tite 100, CV
14.	64	-	C2009, C0210, Kyusyu, Canada, Miyazaki, Botansoba	-
15.	69	C2009, C9740, C0210, C9722, C9022, C8924, B9103, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV, Kyusyu, Canada, Miyazaki, Botansoba	-	-
16.	79	-	B9103, Hokkei 1, Hokkei 2, Hokuriku 4, Hokuriku 5, Ishisoba, Tite 100, CV	C2009, C9740, C0210, C9722, C9022, C8924, Kyusyu, Canada, Miyazaki, Botansoba
17.	87	-	C2009, C9740, C0210, Kyusyu, Canada, Miyazaki, Botansoba	-

Number of band in all cases was single except in accession C9022 by primer 3.

Table 5. Number and % of accessions amplified by EST primers

Primer	Number of accessions in different bands intensity			Product size, bp	Accessions amplified, %
	High	Medium	Low		
3	7	-	10	350, 500	94.44
15	-	15	3	200	100
21	7	-	10	300	100
23	15	-	-	400	100
25	-	-	6	600	33.33
31	18	-	-	800	100
32	7	-	-	700	38.88
35	-	-	18	200	100
36	-	-	1	2000	5.55
40	3	4	-	1200	38.88
56	-	2	5	600	38.88
61	8	10	-	350	100
62	-	6	9	350	83.33
64	-	6	-	300	33.33
69	18	-	-	400	100
79	-	8	10	450	100
87	-	7	-	1400	38.88

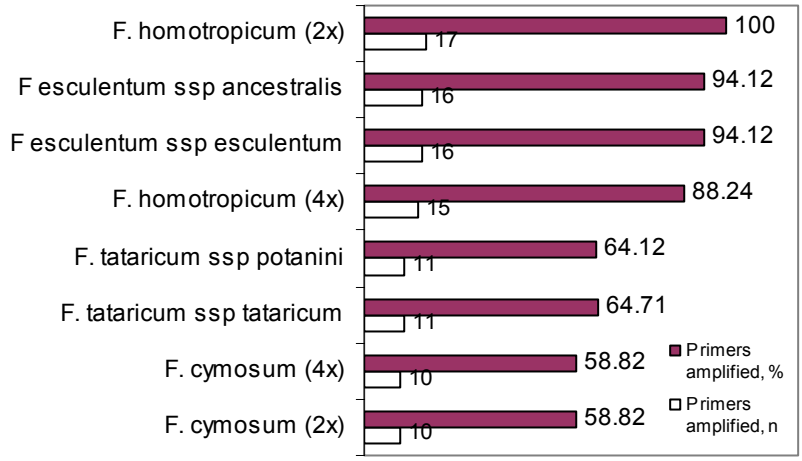


Figure 3. Amplification condition of 17 EST primers in different species of *Fagopyrum*.

ACKNOWLEDGEMENTS

First author express sincere thanks to Dr MP Upadhyay and A Mudwari for their invaluable supports. This study was financially supported by JICA.

REFERENCES

Bandopadhyay R, S Sharma, S Rustig, R Singh, A Kumar, HS Balyan and PK Gupta. 2004. DNA polymorphism among 18 species of *Triticum-Aegilops* complex using EST-SSRs. *Plant Sci.* 166:349-356.

Echt CS, GG Vendramin, CD Nelson and P Marquardt. 1999. Microsatellite DNA as shared genetic markers among conifer species. *Can. J. For. Res.* 29:365-371.

Erpelding JE, NK Blake, TK Blake and LE Talbert. 1996. Transfer of sequence tagged site PCR markers between wheat and barley. *Genome* 39:802-810.

Goff SA, D Ricke, TH Lan, G Presting, R Wang, M Dunn, J Glazebrook, A Sessions, P Oeller, H Varma, D Hadley, D Hutchison, C Martin, F Katagiri, BM Lange, T Moughamer, Y Xia, P Budworth, J Zhong, T Miguel, U Paszkowski, S Zhang, M Colbert, WL Sun, L Chen, B Cooper, S Park, TC Wood, L Mao, P Quail, R Wing, R Dean, Y Yu, A Zharkikh, R Shen, S Sahasrabudhe, A Thomas, R Cannings, A Gutin, D Pruss, J Reid, S Tavtigian, J Mitchell, G Eldredge, T Scholl, RM Miller, S Bhatnagar, N Adey, T Rubano, N Tusneem, R Robinson, J Feldhaus, T Macalma, A Oliphant and S Briggs. 2002. A draft sequence of the rice genome (*Oryza sativa* L. ssp. *japonica*). *Science* 296:92–100.

Guo W, W Wang, B Zhou and T Zhang. 2006. Cross-species transferability of G. arboreum -derived EST-SSRs in the diploid species of Gossypium. *Theor. Appl. Genet.* 112:1573–1581.

Harushima Y, M Yano, A Shomura, M Sato, T Shimano, Y Kuboki, T Yamamoto, SY Lin, BA Antonio, A Parco, H Kajiya, N Huang, K Yamamoto, Y Nagamura, N Kurata, GS Khush and T Sasaki. 1998. A high-density rice genetic linkage map with 2275 markers using a single F2 population. *Genetics* 148:479–494.

Konishi T, H Iwata, K Yashiro, U Tsumura, R Ohsawa, Y Yasui and O Ohnishi. 2006. Development and characterization of microsatellite markers for common buckwheat. Breeding Science 56:277-285.

Kuleung C, PS Baenziger and I Dweikat. 2004. Transferability of SSR markers among wheat, rye and triticale. *Theor. Apple. Genet.* 108:1147-1150.

Nakao Y, H Iwata, A Matsumoto, Y Tsumura and N Tomaru. 2001. Highly polymorphic microsatellite markers in Chamaecyparis obtuse. *Can. J. For. Res.* 31:2248-2251.

Perry DJ and J Bousquet. 1998. Sequence-tagged-site (STS) markers of arbitrary genes: The utility of black spruce-derived STS primers in other conifers. *Theor. Appl. Genet.* 97 :735-743.

Rowland LJ, AL Bhanaraj, JJ Polashock and R Arora. 2003. Utility of blueberry derived EST-PCR primers in related Ericaceae species. *Hort. Science* 38(7):1428-1432.

Rozen S and H Skaletsky. 2000. Primer3 on the WWW for general users and for biologist programmers. **In:** *Methods in molecular biology: Bioinformatics methods and protocols* (S Misener and SA Krawetz, eds). Totowa NJ, Vol. 132. Pp. 365-386.

Saha MC, MAR Mian, I Eujayl, JC Zwonitzer, LJ Wang and GD May. 2004. Tall fescue EST-SSR markers with transferability across several grass species. *Theor. Apple. Genet.* 109:783-791.

Sato K, H Tsujimoto and R von Bothmer. 2005. Introduction of genetic diversity into cereals from their wild relatives. *Czech J. Genet. Plant Breed.* 41 (Special Issue):103-107.

Taylor C, K Madsen, S Borg, MG Møller, B Boelt and PB Holm. 2001. The development of sequence-tagged sites (STSs) in Lolium perenne L.: the application of primer sets derived from other genera. *Theor. Appl. Genet.* 103:648–658.

Yu JK, M La Rota, RV Kantety and ME Sorrells. 2004. EST derived SSR markers for comparative mapping in wheat and rice. *Mol. Gen. Genomics* 271:742–751.

Effect of Harvesting Method and Calcium on Post Harvest Physiology of Tomato[1]

Dhruba R. Bhattarai[2] and Durga M. Gautam[3]

[2] Horticulture Research Division-NARC, Khumaltar
[3] Institute of Agriculture and Animal Science, Rampur, Chitwan

ABSTRACT

An experiment was conducted in Institute of Agriculture and Animal Science, Rampur, Chitwan during 2003 to find out the effect of harvesting method and calcium chloride treatment on post-harvest physiology of tomato. Tomato (Hybrid Gootya) fruits with stalk and without stalk were harvested at breaker stage and dipped in distilled water and different concentrations of calcium chloride viz. 0.25%, 0.50%, 0.75% and 1% for fifteen minutes. Fruit were then air-dried and stored at ambient condition (24 ± 3^0 C and 70 ± 5 % RH). Among the tested treatments the least cumulative physiological weight loss (12.14%) was exhibited by 1% calcium chloride. The shelf life of tomato fruits was significantly affected by harvesting method and calcium treatment. Tomato fruit harvested with stalk had higher shelf-life (15 days) as compared to those harvested without stalk (12.93 days) irrespective to calcium chloride application. The maximum shelf life was noticed in 1% calcium chloride treated fruits (16.50 days) followed by 0.75% calcium chloride treated fruits (16.17 days).

Key words: Calcium chloride, physiological weight loss, shell life, tomato

INTRODUCTION

Tomato is highly perishable and cannot be stored for longer duration. Due to perishability, farmers are losing a bulk of produce each year. Bistha (2002) have reported upto 50% post-harvest loss of tomato in Nepal. Calcium is relatively divalent cation that readily enters the apoplast and is bound in exchangeable from to cell wall and exterior surface of plasma membrane. Nontoxic even at high concentrations it serves as a detoxifying agent. In the cell walls calcium serves as a binding agent in the form of calcium pectates. Calcium has received considerable attention in recent years due to its desirable effects; particularly it can delay ripening and senescence, reduce respiration, extend shelf life and reduce the physiological disorders (Sharma et al 1996).

The shelf life is also affected by stalk. Pathak and Shrivastava (1969) have reported the stalk of fruits showed less infection than without stalk fruit upon ripening. Similarly Singh et al (1993) have reported longer shelf life and better marketability of tomatoes having a small pedicel along with calyx. Therefore, this investigation was undertaken to identify the appropriate dose of calcium chloride and compare the storage behavior of tomato harvested with and without stalk.

MATERIALS AND METHODS

This experiment was conducted during 2003 in Institute of Agriculture and Animal Science, Rampur, Chitwan under Completely Randomized Design (CRD) with three replications. Tomato (Hybrid Gootya) fruits with stalk and without stalk at breaker stage were harvested from farmer field at

[1] A part of MSc thesis submitted by the first author to the Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal in 2003.

Bhandara, Chitwan and brought to IAAS, Rampur. Fruits were dipped in distilled water and different concentrations of calcium chloride viz. 0.25%, 0.50%, 0.75% and 1% for fifteen minutes. The fruits were then air-dried and 1.5 kg of fruits was kept on open tray. Each tray was considered as one treatment and ten fruits were numbered (1 to 10) individually for determining physiological weight loss.

Physiological weight loss (%) was determined by following formula:

Weight loss (%) = [(Initial weight – Final weight) / Initial weight] × 100

Titrable acidity was determined by titration method at red ripe stage. It was calculated by following formula:

Titrable Acidity (%) = (N_B x V_B × milliequivalent wt. of citric acid × 100 × d. f.) / Volume of sample

Where,
N_B = Normality of base, V_B = Volume of the base, d. f. = Dilution factor.

The total soluble solid (^{0} Brix) was determined by hand refractometer (Model: Erma Japan) in red ripe stage of fruits and pH was measured by automatic pH meter.

RESULTS AND DISCUSSION

Physiological weight loss

Cumulative physiological weight loss of the fruits with respect to harvesting methods and calcium chloride treatments is presented in Table 1. Harvesting method did not influence the weight loss of tomato. Physiological weight loss after 10 days of storage ranged from 15.07 to 15.27%. On the other hand, calcium chloride treatment significantly influenced the physiological weight loss of the fruits right after second days of storage and subsequently afterwards. After 2 days of storage, controlled fruits exhibited 4.2% PWL which was significantly higher than calcium treated fruits.

Table 1. Cumulative physiological weight loss (%) of tomato fruits at various days after storage (DAS) as affected by harvesting methods and calcium chloride treatment at ambient condition (24 ± 3^0 C and 70 ± 5% RH)

Harvest method	2 DAS	4 DAS	6 DAS	8 DAS	10 DAS
Without stalk	3.01	6.10	8.36	11.00	15.27
With stalk	2.97	6.04	8.38	10.45	15.07
SEM	0.15	0.29	0.31	0.47	0.41
$CaCl_2$					
Water	4.02	8.71	11.68	14.27	19.03
0.25%	3.21	6.13	8.56	12.06	17.02
0.50%	2.89	5.33	7.85	10.72	14.86
0.75%	2.25	4.81	6.93	8.25	12.80
1.00%	2.57	5.36	6.85	8.31	12.14
LSD (5%)	0.68	1.33	1.44	2.18	1.93
SEM	0.23	0.45	0.49	0.74	0.66

After 10 days of storage, the cumulative weight loss in 1.00, 0.75, 0.50 and 0.25% calcium treated fruits was 12.14, 12.80, 144.86 and 17.02%, respectively as compared to 19.03% in controlled fruits. Interaction effect between method of harvesting and calcium chloride treatment was non-significant.

Calcium is the important mineral constituent and it is the constituent of middle lamellae. Softening of fruits is mainly due to weakening of middle lamellae during ripening. Calcium helps to bind

polygalactonic acid each other and make the membrane strong and rigid. Calcium treatments have been commercially applied in apple to increase the shelf life and reduce the post harvest disorders (Sharma et al 1996). Thus, calcium might have delayed senescence and rate of respiration and transpiration in tomato fruits.

Although statistically non-significant fruits harvested with stalk resulted into lower PWL as compared to those without stalk. A similar result was noted by Singh et al (1993). The reason behind the higher loss associated with the fruits harvested without stalk and stored under ambient condition might be due to more decay loss as exposed surface of stalk or scar left at the time of harvesting creates avenue for the entry of pathogen. Pathak and Shrivastava (1969) have supplied similar explanation. They have also noticed higher decay loss and poor shelf life in mango fruits harvested without stalk.

pH of fruit juice

pH of the fruit juice with respect to harvesting method and calcium treatment is presented in Table 2. pH of fruit juice harvested without retaining the stalk showed slightly higher pH (4.053) compared to those harvested with stalk (4.018). There was no apparent effect of calcium treatment albeit it was recorded maximum (4.067) in control fruit and that of minimum (4.017) to 0.75% calcium treated fruit. Njoroge and Kerbel (1993) have also reported the significant effect of calcium on pH of fruit juice and it was higher (4.49) in control than that of 0.75% calcium treated fruits (4.47). Since calcium chloride is acidic in nature it might have lowered the pH of the treated fruits.

Table 2. Biochemical parameters and shelf life of tomato as affected by harvesting methods and calcium chloride

Treatment	pH	TSS (^{0}brix)	Titrable acidity, %	Shelf life
Harvesting method				
Without stalk	4.05	3.22	0.485	12.93
With stalk	4.03	3.15	0.494	15.00
SEM	0.009	0.064	0.018	0.23
Calcium Chloride				
Water	4.067	3.21	0.479	11.00
0.25%	4.044	3.33	0.514	12.83
0.50%	4.028	3.12	0.526	13.33
0.75%	4.017	3.13	0.433	16.17
1.00%	4.022	3.13	0.496	16.50
SEM	0.018	0.101	0.029	0.39

Total soluble solids

Harvesting method did not affect the Total Soluble Solids (TSS) content of fruit juice although it was slightly higher in the fruits harvested without retaining the stalk (3.218%) as compared to that having it (3.149%). Similarly, it was also not affected by the calcium treatment (Table 2). As the storage period prolonged the TSS of the fruit increased. During the storage weight loss is mainly due to the water loss and that lead to higher concentration of sugars in fruits. The experiment conducted by Subedi and Bhattarai (1995) had also the similar type of results. Agar and Kaska (1995) also reported similar results. Singh et al (1993) conducted an experiment to study the qualitative changes in storage in mango due to harvesting methods and found that there was no significant difference in TSS in fruit harvested with or without stalks after 6 days of storage.

Titrable acidity

There was also non-significant effect of harvesting method and calcium treatment on Titrable acidity (TA) content of fruit juice. TA of the fruit juice with respect to harvesting method and calcium treatment is presented in Table 2. TA of fruit juice harvested with stalk showed slightly higher (0.494%) compared to those harvested without stalk (0.485%).

During the storage the fruit itself might utilize the acids so that the acid in the fruits during storage periods decrease. The change in total titrable acids during storage was mainly due to the metabolic activities of living tissues during which depletion of organic acids takes place. Decrease in total acidity and increase in total sugars and TSS during storage at room temperature was also observed by Ramana et al (1979).

Shelf life

The shelf life of tomato fruits was significantly affected by the harvesting method and calcium treatment. Irrespective of calcium chloride treatment, tomato fruits harvested with stalk had maximum shelf life (15 days) as compared to those harvested without stalk (12.93 days) (Table 2). The longer shelf life and better marketability were also observed in tomato fruits harvested with a small stalk by Singh et al (1993).

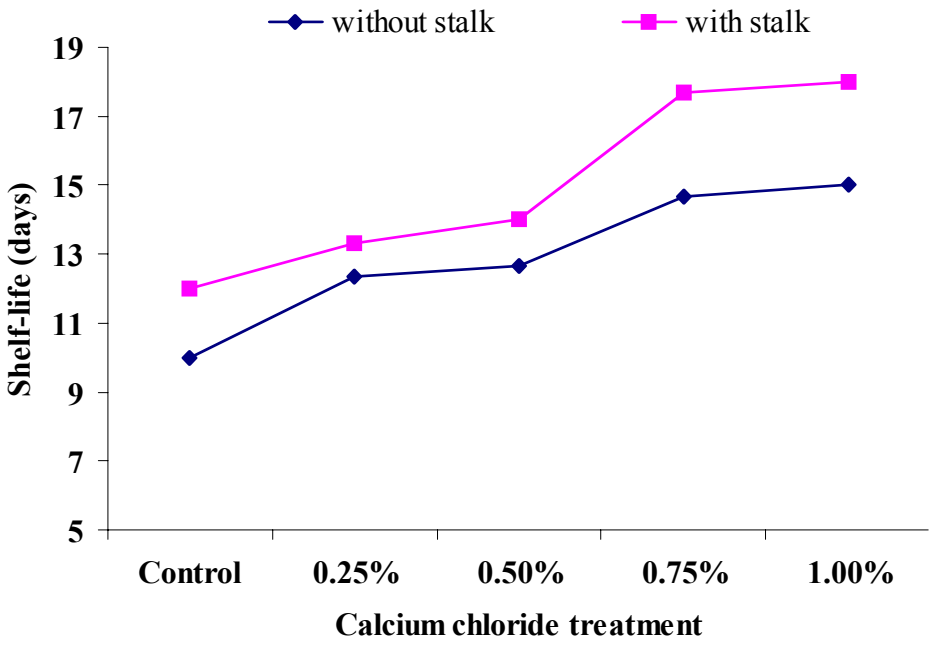


Figure 1. Interaction effect of calcium chloride and harvesting methods on shelf life of tomato.

The calcium treatments significantly influenced the shelf life of tomato fruits. As the concentration of calcium increased, the shelf life of fruits increased. The maximum shelf life (16.50 days) was noticed in 1% calcium chloride treated fruits compared to the control (11 days). These results were in conformity with that of Wills and Tirmazi (1982). Calcium treatment could extend storage life and reduce incidence of physiological disorders and storage rots (Sharma et al 1996).

The interaction between calcium treatment and harvesting methods were non-significant. However, there was a trend of increasing shelf life owing to each increment in the level of calcium in each of harvesting methods (Figure 1). Fruits, which were harvested with stalk and treated with 1% calcium chloride, have highest shelf life of about 17.5 days, where as the shelf life was only 9.5 days for control fruits harvested without stalk.

Tomato is rapidly gaining its importance as essential nutritional vegetable commodity and income generating crop in Nepal. Treating the tomato fruits with calcium chloride at the rate of 1% could extend the shelf life and minimize the physiological weight loss. Tomato fruits harvested with stalk could prolong the shelf life as compared to those harvested without stalk.

ACKNOWLEDGEMENTS

Authors are grateful to SM Shakya, MD Sharma and GD Bhatta for their valuable suggestions and kind help during the research period. The financial support was provided by Hill Agriculture Research Project (HARP) under the research project Improvement in post harvest shelf life of fruits and vegetables in hills of Nepal.

REFERENCES

Agar T and N Kaska. 1995. Effect of different harvest dates and post harvest treatments on the storage quality of Mandarins. **In:** *Proceedings of the International Symposium on Post Harvest Physiology, Pathology and Technologies for Horticultural Commodities: Recent Advances*. 16-21 Jan 1994. Agadir, Morocco. Pp. 75-82.

Bistha DB. 2002. Agriculture marketing and environment issues. **In:** *Agriculture and environment*. Ministry of Agriculture and Co-operatives, HMG/N, Kathmandu, Pp. 91-98.

Njoroge CK and EL Kerbel. 1993. Effect of post harvest calcium treatment on soluble solids, pH, firmness and color of stored tomato fruits. *E. Afr. Agric. Far J.* 58(3):111-116.

Pathak VN and DN Shrivastava. 1969. Epidemiology and prevention of Diplodia stem end rot of mango fruits. *Phytopathology* 65:164-175.

Ramana KVR, GR Setty, NVN Murthy, S Saroja and AM Nanjundaswamy. 1979. Effect of ethephone, benomyl, thiobendazole and wax on color and shelf life of coorg mandarin (*Citrus reticulata* Blanco). *Trop. Sci*. 21:265-272.

Sharma RM, R Yamdagni, H Gaur and RK Shukla. 1996. Role of calcium in horticulture - A review. *Haryana J. Hort. Sci.* 25(4):205.

Singh BP, SK Palra and DK Tonden. 1993. Effect of method of harvesting on storage behaviour of mango. *Indian J. Hort.* 50(1):5-9.

Subedi PP and SP Bhattarai. 1995. The effects of low cost cellar structure upon the storage of mandarin fruits in the sub tropics. **In:** *Proceedings of the International Symposium on Post Harvest Physiology, Pathology and Technologies for Horticultural Commodities: Recent Advances*. 16-21 Jan 1994. Agadir, Morocco. Pp. 137-146.

Wills RBH and SIH Tirmazi. 1982. Use of calcium to delay ripening of tomatoes. *Hort. Science* 12(6):551-552.

Effect of Potassium on Potato Tuber Production in Acid Soils of Malepatan, Pokhara

Bishnu H. Adhikary*[1] and Krishna B. Karki[2]

[1] National Maize Research Programme-NARC-Rampur-Chitwan-Nepal
[2] Soil Science Division-Khumaltar-Lalitpur-Nepal

ABSTRACT

Soils of Pokhara valley, especially Malepatan, are fine textured silt loam, extremely acidic in nature (3.7-4.0 pH) and are medium in soil potassium content. On-station experiments were conducted to assess the response of potassium (K_2O) and its application methods on potato tuber yield in an extremely acid soil condition. Six potassium levels (0, 50, 75, 100 kg ha^{-1} as basal application, 50 kg basal plus 50 kg top dressed, and 50 kg basal plus 50 kg foliar application) were tested in the experiment for three consecutive years (2000, 2001 and 2002). A randomized complete block design (RCBD) with 3 replications was employed. Variety used was MS 42. Nitrogen (N), phosphorus (P_2O_5) and compost were applied as basal dose in each plots at the rate of 100 kg, 50 kg and 20 t ha^{-1}, respectively. Three years mean result on the plant growth characters revealed that tallest plant height was recorded (33.22 cm) when 50 kg ha^{-1} potassium was applied basally and 50 kg ha^{-1} top-dressed. The trend was quite similar in tillers production (6.96 branches $plant^{-1}$) and biomass production (168.66 g $plant^{-1}$). Maximum of 473.33-g $plant^{-1}$ of tubers was produced when 100 kg of potassium was applied basal single dose. Highest tuber yield of 24.75 t ha^{-1} of tuber were produced when 50 kg potassium was applied basally and 50 kg top- dressed, a total of 100 kg ha^{-1}. Highly significant response of potassium levels on tuber production was observed in all the years. The results of this investigation suggested that application of potassium (K_2O) at the rate of 50 kg ha^{-1} basal and 50 kg ha^{-1} top-dressed in 45 days could increase potato tuber yield satisfactorily in extremely acid soil condition.

Key words: Basal application, potassium levels, *Solanum tuberosum,* tuber production and top-dressing

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important crops for Nepalese people. It is grown from the terai to the high mountain region. Because the food produced through photosynthesis in plant leaves needs in translocation and synthesis of carbohydrates to form tuber this crop, including other essential elements needs higher amount of potassium (Mengel and Rahmatullah 1994). In addition this element is needed to resist cold and other adverse conditions by plants. Deficient potato and *Brassica* plants develop crumpled and raised lamina followed by necrosis (Singh et al 1997). Nepalese soils due to its high in silt content are high in available Potassium K (Schrier et al 1994). But continues cropping nutrient exhausting crop mine soil nutrients and farmers do not replenish the harvested nutrients (Joshi 1997) that lead to serious nutrient deficiency and reduction in crop yield (Ghani and Brown 1997, Gami et al 2001, Regmi et al 2002).

Potassium (K) in soil is present in three different forms that is total K, exchangeable and K in soil solution (Mengel and Kirkby 1987). Soil solution K has a high chance of leaching and thus loss from the soil system. Exchangeable K plays an important role in soil plant availability. Potassium from mica as dominant mineral in Nepalese soil (Schrier et al 1994) and K from mica contributes a part of soil potassium (Mengel and Rahmatullah 1994, Baeumler et al 1997). Because of low replenishment widespread deficiency of potassium has been reported in many of the intensively cultivated soils (Karki

et al 2000) and hence K application through fertilisers has been responding satisfactorily (Regmi et al 2002). Potato being a high nutrient mining crop it needs higher amount of N, P and K for its economic tuber production. Farmers applying 20-25 t ha^{-1} of compost/farmyard manure are not sufficient to replenish the harvested nutrients and hence need sufficient amount of mineral fertilizer addition with heavy manure application (Joshi 1997). Despite of application of sufficient amount of N and P_2O_5 fertiliser lack of potassium has limited yield in Indo Gangatic Plains (IGP) of Nepal and India (Gami et al 2001, Regmi et al 2002). Therefore, we conducted this experiment with the objectives of evaluating the response of potassium through different methods of application on the tuber production of potato was.

MATERIALS AND METHODS

Experiment was conducted in Agricultural Research Station (ARS), Pokhara in extremely acid soils (3.7- 4.0 pH) of Malepatan Soil during the year 2000 to 2002 to. The experiment was designed in a randomized complete block design (RCBD) with 3 replications. The variety used was MS-42 and the crop was planted in the month of November in all the years with a spacing of 25- × 75- cm in a plot size of 12.187 m^2 (3.25- × 3.75-m). All amount of N, P_2O_5 and compost were applied basally at the rate of 100 kg, 50 kg and 20t ha^{-1}, respectively. Soil samples were taken before crop planting and after crop harvest to observe K_2O status in the soil. Plant growth and production parameters were studied and analysed statistically (Gomez and Gomez 1984). The following treatments were applied in the experiment:

T1 = 50 kg ha^{-1} potassium (K_2O) applied as basal dose.
T2 = 75 kg ha^{-1} potassium applied as basal dose.
T3 = 100 kg ha^{-1} potassium applied basal.
T4 = 100 kg ha^{-1} potassium (50 kg basal and 50 kg top-dressed in 45 days after seeding).
T5 = 0 kg potassium (control plot).
T6 = 100 kg ha^{-1} potassium (50 kg basal and 50 kg sprayed in 45 days after seeding ie 0.5% solution).

Collected soil samples were air dried and passed through 2 mm sieve and stored for analysis. Soil pH was measured in soil water paste ration of 1:2.5 and measured with combined glass electrode. Nitrogen was analyzed by Micro-Kjeldahl methods and available P_2O_5 by Bray P-1 method. Available K was extracted by 1N neutral ammonium acetate solution and detected through flame ignition.

RESULTS

Effect of potassium levels on the growth of potato plants

Three years results on plant growth characters clearly indicated that mean plant height was maximum (33.23 cm) in T4 when the crop was fertilized with 100 kg ha^{-1} potassium (50 kg K_2O basal and 50 kg top-dressed in 45 days). Minimum plant height (26.6 cm) was found in T5 (control). The numbers of tiller and crop biomass expressed almost similar trend. The maximum number of tillers (9.96) was produced in T4 and minimum (5.21) was in T5. The biomass (121.33 g $plant^{-1}$) was highest in T4 control was 121.33 g $plant^{-1}$ (Table 1).

Application of 100 kg ha^{-1} of potassium applied as basal dose (T3) produced maximum tuber weight (473.33 g $plant^{-1}$), followed by T4 (50 + 50 kg ha^{-1}), T2 (75 kg ha^{-1} basal dose only) and T1 (50 kg ha^{-1}). Minimum tuber weight (314 g $plant^{-1}$) was recorded in control plot (T5). The treatment T4 (50 kg basal + 50 kg ha^{-1} as top dressed) produced slightly lower tuber yield (461.66 g $plant^{-1}$) than T3. Application of 50 kg ha^{-1} K (T1) produced 369 g $plant^{-1}$ of potato tubers that is higher than the control, whereas its application as T6 (50 kg ha^{-1} basal and 50 kg ha^{-1} as foliar spray) produced the tuber yield of 403.66 g

plant^{-1} (T6) that is much higher than the control (T5). There was note worthy difference in the yield and other agronomic properties of the plant but the results were not statistically significant.

Table 1. Growth characters of potato plants as influenced by potassium levels and application methods (2000/02)

Treatment	Plant height, cm	Tiller numbers plant^{-1}	Biomass plant^{-1}, g	Tuber weight plant^{-1}, g
T1	28.75	5.80	134.00	369.00
T2	31.08	6.33	148.33	417.66
T3	31.43	6.43	156.00	473.33
T4	33.23	6.96	168.66	461.66
T5	26.60	5.21	121.33	314.00
T6	29.36	6.33	162.33	403.66
Mean	30.07	6.17	148.44	406.55
SD	2.12	0.54	16.34	54.16

Effect of potassium levels on tuber production

Analyzing the size of potato tubers (diameter) the result in first year (year 2000) was not significant. The data revealed that significant response of K_2O levels on tuber diameter was observed in the years 2001 and 2002 (Table 2). The maximum 3 years mean result on tuber size (diameter) was recorded in T3 (5.12 cm) when the crop was treated with 100 kg ha^{-1} of basal application of K_2O, whereas the control (T5) produced the minimum diameter (4.62 cm). Three years results on the production of tuber numbers (Table 2) indicated a sharp response on K_2O levels in the first and second years (2000 and 2001) but the result was at par with the control in the third year (2002). The mean result showed that highest number of tubers (13.72 tubers plant^{-1}) was produced when the crop was fertilized with 100 kg basal application of K_2O (T3) followed by 50 kg basal plus 50 kg top-dressed K_2O (T4). Control treatments (T5) produced minimum number of tubers (10.24 tuber). The yield results of the other two years were significant.

Table 2. Growth of potato tubers as affected by potassium levels and application methods for three consecutive years (2000/02)

Treatment	Tuber diameter, cm			Mean	Tuber number plant^{-1}			Means of tuber
	2000	2001	2002	diameter, cm	2000	2001	2002	number plant^{-1}
T1	3.31	4.18	6.62	4.70	9.76	12.36	12.26	11.46
T2	3.35	4.47	6.72	4.84	10.73	14.66	11.96	12.45
T3	3.69	4.61	7.08	5.12	11.90	15.86	13.40	13.72
T4	3.51	4.66	7.10	5.09	10.93	15.50	13.36	13.26
T5	3.54	3.77	6.55	4.62	8.83	10.23	11.66	10.24
T6	3.48	4.67	7.04	5.06	10.96	14.93	13.06	12.98
Mean	3.48	4.39	6.85	4.90	10.51	13.92	12.61	12.35
F-test	ns	* *	*		* *	* *	ns	
CV, %	6.47	4.72	4.15		2.51	6.23	13.0	
LSD (0.05)	-	0.536	0.507		0.684	2.245	-	

*** Significant at 0.01 level. * Significant at 0.05. ns, Non significant.*

Highly significant response of K_2O was observed in all the years on the production of tuber weights. The yield results indicated that a maximum of 28.96 t ha^{-1} and 25.18 t ha^{-1} of tubers were produced in the first and second year, respectively (Table 3). Maximum yield was obtained when the crop was supplied with 100 kg ha^{-1} of basal K_2O (T3) in first two years but in the 3rd year (2002), the maximum production (23.51 t ha^{-1}) was recorded with the application of 50 kg basal + 50 top-dressed K_2O kg ha^{-1} (T4).

Table 3. Potato tuber production as influenced by potassium levels and application methods for three consecutive years (2000/02)

Treatment	Tuber production, t ha^{-1}			3 years mean, t ha^{-1}	Increment, %
	2000	2001	2002		
T1	24.44	20.46	13.15	19.60 bc	17.85
T2	25.72	22.42	17.07	21.73 ab	30.66
T3	28.96	25.18	19.90	24.68 a	48.40
T4	26.99	23.77	23.51	24.75 a	48.80
T5	21.90	15.32	12.69	16.63 c	00.00
T6	27.35	23.19	16.57	22.36 ab	34.45
Mean	25.89	21.72	17.14	21.62	
F-test	* *	*	* *	* *	
CV, %	2.89	9.03	14.97	6.00	
LSD (0.05)	1.93	5.07	6.66	3.36	

Means in a column with the common letter(s) are not significantly different at 5 % level of significance.

Three years mean yield result indicated a sharp response of K_2O on tuber production (Table 3). Highest yield result (24.73t ha^{-1}) was obtained with T4 (50 kg basal and 50 kg top dressed) followed by T3 (24.68 kg ha^{-1}) that was 100 kg basal application of K. Third highest yield result was obtained from T6 (50 basal and 50 kg ha^{-1}spraying) basal application. Control produced the lowest yield (16.63 kg ha^{-1}). The treatment T1 (50 kg ha^{-1}) basal application yielded slightly superior yield than the control. The maximum of potato tubers were produced when the crop was fertilized with 50 kg K_2O ha^{-1} as basal application and 50 kg ha^{-1} top-dressed (T4) but the yield was at par with T3 (100kg kg ha^{-1} single dose) and T6. Non-significant difference yield results were observed among T1, T2 and T6. But these treatments produced tuber yield that is significantly different from control. The yield results from control treatment was inferior to T2, T3, T4 and T6 indicating there was no different among the application of 50 kg ha^{-1} K_2O as good as no application of potassium fertiliser. Similarly 100 kg basal or 50:50 carries the same meaning.

Application of 50 kg ha^{-1} basal K_2O to potato increased tuber yield by 17.85 % over the non-treated crop whereas the highest increment (48.8%) was observed when the crop was supplied with 100 kg ha^{-1} K_2O (50 kg basal and 50 kg top-dressed in 45 days).

Table 4. Soil test results before crop planting and after crop harvesting

Treatments	PH	OM, %	N, %	P_2O_5, kg ha^{-1}	K_2O, kg ha^{-1}	K_2O, kg ha^{-1}
T1	3.96	3.26	0.127	129.33	265.66	(437.33)
T2	4.00	3.61	0.137	95.00	242.66	(561.66)
T3	4.06	3.70	0.154	130.66	224.33	(438.33)
T4	4.00	3.88	0.165	63.66	209.33	(658.66)
T5	4.03	3.70	0.138	58.66	278.33	(331.00)
T6	3.70	3.79	0.154	70.00	216.00	(558.33)
Mean	3.95	3.65	0.145	91.21	239.38	(497.55)

The numbers in the parenthesis indicate the soil test values after the crop harvest.

Six composite soil samples from the experimented plots combining the soil samples from the replicated plots were collected before crop planting and analyzed for the soil pH, organic matter (OM) N, P_2O_5, and K_2O content. Soil test result indicated that soil reaction (pH) of the experimental plots was extremely acidic. According to soil test report, mean pH value was found to be 3.95 pH. The pH value ranged from 3.7 to 4.06 (Table 4). Organic matter (OM) content varied from 3.26 -3.88 percent. The mean OM content was observed to be 3.65 percent. Phosphorus (P_2O_5) content were observed to be high (58.66 - 130.66 kg ha^{-1}), while the nitrogen (0.127 to 0.165 % N) and potassium content (209.33 to 278.33 kg ha^{-1} K_2O) were observed to be medium in the soils of experimental plots before crop planting. Adhikary et al (2003) analyzed soil samples of Malepatan during the year 1995 and reported that the soil potassium content was found to be medium (150 to 237 kg K_2O ha^{-1}), which agreed with the soil

analysis report of this investigation (216.0 to 278.33 kg K_2O ha^{-1}). In another experiment, Adhikary et al (2004) reported that the K_2O content of Malepatan soil was found to be high (292.33 to 524.0 kg K_2O ha^{-1}).

Soil samples were also analyzed after crop harvesting for the K_2O content. The results revealed that the soil potassium content was observed to be high (658 kg K_2O ha^{-1}) in the plots treated with 100 kg ha^{-1} K_2O, applied as 50 kg basal dose and 50 kg as top-dressing. Lowest K_2O content (331 kg ha^{-1}) was recorded in the plot where the crop was not fertilized with potassium (T5) followed by the crop supplied only with 50 kg ha^{-1} of K_2O (T1) applied basally (437.33 kg ha^{-1}).

DISCUSSION

Effect of K fertilisers on the agronomic character of potato is clearly seen as exposed by the plant growth, tuber number and tuber weight per plant by the application of 100 kg of K_2O kg ha^{-1} either as single dose or split dose. It is because of the total amount of K required by the plant. In general, potato tubers are planted in November and dry spell generally start from this month. If irrigation is not supplied yield drastically reduces when K_2O is limited. Treatment T3 and T4 has sufficient amount of K that is required for controlling evapo-transpiration and translocation of glucose from leaf to the different parts of the plant body (Mengel and Kirkby 1987). The effect of fertilisers on the agronomic growth and difference made by the treatments shows that the application of K fertiliser alone made no difference. The Malepatan soil is silt dominated (Karki et al 2005). Light soil with higher amount of silt contains mica and it is the parent materials for K and releases slowly available to the plants (Schrier et al 1994). It could be in combination with the compost including N and P allied (Tsuno and Fujise 1998). It is mainly the 20 t ha^{-1} organic manure application all the three years has built soil organic matter that hold up the released K from leaching and supplied continuously at the time required by the plants (Mengel and Kirkby 1987). Compost contains about 2% total K and could be mineralised and add to the available K in soil (Karki 2004).

Size of the tuber as affected by the application of potassium fertiliser is normal because of the function of K is to translocate the carbohydrates from the place of photosynthesis to the tuber. The increase of size of the tuber could not only the effect of potassium fertilizer but also the combination of N, P_2O_5 and high dose of organic manure (Davenport et al 1999).

Potassium is a mobile element and does not remain in soil for long after released from the reserve. Soil solution K either is fixed in clay lattice, or exchanged with $NH4^{+1}$ ions in a exchange complex. Higher rate of application of K fertiliser has higher chances of fixation than application of little K (Schneider 1997). When it in the solution it could be leached down to the subsurface horizon and is unavailable to plant (Wulf et al 1998) and leaching occurs mainly in winter. However, K leached to sub-surface horizon is not permanently lost but is accessible to plant roots up to the depth of 60 cm. But the response of potato to split application of K fertilisers was higher and especially to praying after 45 days of transplanting because of loss through leaching is minimized and uptake of K through stomata could have avail the required K since potato plants needs K supply continuously to transport photosynthates to the tubers and hence spraying of K yielded higher yield of potato tubers (Rao and Rao 2000).

There has been no remarked difference in the residual effect of the treatments on pH. There is noteworthy increased in organic matter content in the soil after the experiment. Treatment with higher amount of K application has increased the soil K content in all the three years. It is proportional to applied K (Wulf et al 1998). Moreover, release of non-exchangeable K could have increased the available K since, mica being the one of the component of silt and contributing total K that is could be positively correlated to mica and clay content in soil texture (Han et al 1999). Similar trend is also observed in total N content but the P did not show a definite trend. Increased trend in residual K even in

control treatments could be due to the mineralization of organic manure that has been applied in all the treatments as well as the silt fraction of the soil texture. Gurung and Sherchan (1993) and Schrier et al 1994, made similar observations. Repeated application of organic manure results in build up of soil organic matter associated increased nutrient release over time and available K is positively correlated to organic carbon (Singh et al 1997). Random trend shown in phosphorus content soil after the third crop harvest could be due to fixation of P in acidic soils with Al^{+3}, Fe^{+3}, Zn^{+2}, Mn^{+2} and Cu^{+2}. Soil test value of K in this experiment is found higher if K application is withheld just because of soil residual K is higher it might fall sharply (Wulf et al 1998).

The results of this investigation concluded that plant height, branch numbers and biomass of the potato crops were found increased when the K_2O was supplied at the rate 50 kg basal and 50 kg top-dressed, a total of 100 kg K_2O ha^{-1}. Tuber size and their numbers $plant^{-1}$ were found affected by the K_2O levels and its applications methods. A maximum tuber diameter of 5.12 cm and 13.72 tuber numbers were observed when the crop was fertilized with 100 kg basal application of potassium. The highest tuber weight (24.75 t ha^{-1}) was produced when the crop was fertilized with 100 kg K_2O ha^{-1}, 50 kg basally applied and the other 50 kg top-dressed. It seems that the potassium when top-dressed could produce increased tuber yield in acid soil condition. Application of 100 kg K_2O ha^{-1}, 50 kg as basal application and another 50 kg as top-dressing after 45 days of crop planting, applied along with 100 kg N, 50 kg P_2O_5 and 20 t ha^{-1} of compost is recommended for increased tuber yield of potato in extremely acidic soil condition of Pokhara valley.

ACKNOWLEDGEMENTS

The authors wish to express their heartfelt thanks to Nepal Agricultural Research Council for supporting with funds for this research. Special thank goes to Dr SL Maskey, Soil Science Division-NARC, Khumaltar for her help and support for soil analysis and Dr MS Ghale for encouragement and moral support and C Adhikari for collecting data.

REFERENCES

Adhikary BH, BB BC and P Bhattarai. 2003. Economics of nitrogen application on cauliflower (*Brassica oleracea* var. botrytis) production in acid soil of Pokhara valley. **In:** *Proc. of the Third National Horticultural Research Workshop.* Horticulture Research Division, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, 7-8 June, 2000. Pp. 36-40.

Adhikary BH, C Adhikary, SP Dahal, DB Ranabhat and MS Ghale. 2004. Growth and production of pineapple as affected by manure and fertilizer levels. **In:** *Proc. of the Fourth National Workshop on Horticulture* Advances of Horticulture Research in Nepal. Nepal Agricultural Research Council (NARC)-NARI and Horticulture Research Division, Khumaltar, Lalitpur, 2-4 March 2004. Pp. 75-79.

Baeumler R, DP Madhikarmi and W Zech. 1997. Fine silt and clay mineralogical changes of a soil chronosequence in the Langtang valley (central Nepal). *Z. Pflanzenern. Bodenk.* 160: 413-421.

Davenport JR, EM Bentley and KM Whiteley. 1999. Potassium fertilizers and potato yield and quality in the Columbia Basin. **In:** *Proc. 38th American Washington State Potato conference and Trade shows*, Moses Lake, Washington, 2-4 Feb 1999. Pp. 137-143.

Gami SK, JK Ladha, H Pathak, MP Shah, E Pasuquin, SP Pamde, PR Hobbs; D Joshy and R Mishra. 2001. Long-term changes in the yield and soil fertility status in 20 year rice-wheat experiment in Nepal. *Biol. Fertil. Soils* 34:73-78.

Ghani A and MW Brown. 1997. Improvement of Soil Fertility in Nepal Through Balanced Application of Fertiliser. AgResearch. Hamilton, New Zealand. *A Study Report for Ministry of Foreign Affairs and Trade*. Govt of New Zealand.

Gomez KA and AA Gomez 1984. *Statistical procedures for agriculture research* (2nd ed). An International Rice Research Book. Wiley Interscience Publication, John Wiley and Sons, New York. 680 pp.

Gurung GB and DP Sherchan. 1993. Study on the effect of long-term application of compost and chemical fertilisers on crop yields and physicochemical properties of soil on rice-wheat - cropping pattern. *Working Paper No 87*. Pakhribas Agriculture Station. 6 pp.

Han J, K Egashira and JL Han. 1999. Potassium status and fertility evaluation of major upland soils in northeastern part of China. Faculty of Agriculture, Kyushu University. *Science Bulletin* 54:77-83.

Joshi D. 1997. *Soil fertility and fertilizer use in Nepal.* Soil Science Division, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal. 82 pp.

Karki KB, A Mentler and WEH Blum. 2000. Food security and crop productivity in Kathmandu valley/Nepal. **In:** *Proceeding of International Workshop in Food Security of Urban and Peri-urban Systems in Developing Countries*, 15-18 November 2000. Vienna, Austria. Pp. 28-31.

Karki KB, KB Thapa and P Karki. 2005. Tea and coffee growing soils of Nepal. **In:** *Proc. National Workshop on Commercial Crop for Poverty Alleviation in Nepal*. (In Press).

Karki KB. 2004. Status of potassium in intensively cultivated soils from Kathmandu Valley. *Nepalese J. Sci. and Tech.* 5:83-89.

Mengel K and EA Kirkby. 1987. *Principles of plant nutrition.* International Potash Institute, Bern, Switzerland.

Mengel K and Rahmatullah 1994. Exploitation of potassium by various crop species from primary minerals in soils rich in micas. *Biol. Fertil. Soils* 17:75-79.

Rao CS and AS Rao. 2000. Minimal exchangeable potassium status of 15 smectitic soils in relation to potassium, uptake and plant mobilization rate of soil reserve potassium. *Communication in Soil Science and Plant Analysis* 31:913-921.

Regmi AP, JK Ladha, E Pasuquin, H Pathak, PR Hobbs, LL Shrestha, DB Gharti and E Duveiller. 2002. The role of Potassium in sustaining yields in a long-term rice-wheat experiment in the Indo-Gangetic plains of Nepal. *Biol. Fert. Soils* 36:240-247.

Schneider A. 1997. Release and fixation of potassium by a loamy soil as affected by initial water content and potassium status of soil samples. *European J. Soil Sci*. 48:263-271.

Schrier H, PB Shah, LM Lavkulich and S Brown. 1994. Maintaining soil fertility under increasing land use pressure in the middle mountains of Nepal. *Soil Use and Management* 10:137-142.

Singh D, V Singh, R Singh, D Singh, V Singh and R Singh. 1997. Potassium status of soils and response of rice to applied potassium. *J. Pot. Research* 15:83-87.

Tsuno Y and K Fujise. 1998. An experiment of the determinant of mineral nutrient on the tuber yield of sweet potato. *Proc. Crop Scie. Soc.* 37:273-279. Japan.

Wulf F, V Schultz, A Jungk and N Claassen. 1998. Potassium fertilization in relation to soil test, crop yield and K-leaching. *Z. Pflanzenernaerung Bodenk.*161:591-599.

City Waste Compost and Sustainability of Rice-Wheat Cropping System

Krishna B. Karki

Nepal Agricultural Research Council (NARC), Khumaltar, Nepal,
<krishna@drkbk.wlink.com.np>

ABSTRACT

An experiment was conducted on *Rhodic Ustochrept* soil in Central Hill of Nepal growing wheat-mungbean-rice in rotation. Grain yields as affected by 28 t ha^{-1} a of town compost were compared with the same amount of farmyard manure and N:P:K (120:60:40). NPK produced significantly higher wheat grain (3897 t ha^{-1}). Other yield results were at par with one another. NPK produced lowest mungbean yield. After growing second crop fertility seems to be exhausted thus rice yield indicated no notable residual fertilising effect. FYM and town compost left noteworthy amounts of P, Ca, Mg and K even after rice harvest.

Key words: Organic manure, plant nutrients, sustainability

INTRODUCTION

Population growth and concentration, rising affluence, technological changes, and rising expectation and awareness all lead to higher levels of consumption and waste generation. In Kathmandu valley, 400 g wastes are produced per person every day of which 80% is biodegradable. The remaining 20% includes paper, plastics and other wastes. The present population of the valley produces about 320 tons of waste, which could give 48 tons of compost everyday (Joshi 2000). The end product of the degradable waste (compost) is consumed by agriculture since it contains sufficient amounts of plant nutrients, including most of the micro-elements. If it is properly managed it could be a valuable resource and alternative for the imported and expensive mineral fertilisers. But most of the municipality wastes contain dangerous heavy metals which might find their way into the food chain and pose hazard to human as well as animal. Because of its beneficial effects in supplying plant nutrients, enhancing the cations exchange capacity, improving soil aggregation, water retention and also supporting soil biological activities, organic manure is regarded as most valuable resource in agriculture (Dudal and Deckers 1993). Aapplication of ample amounts of manure leads to soil sustainability (Swift and Woomer 1993). In addition organic soil amendments control some root pathogens (Buruchara 1992).Therefore, compost produced from city waste is potentially very valuable resource in Nepalese agriculture. With the aim of comparing crop yield as affected by these manures and its residual values in succeeding crop a study was conducted in the farmers' field at Kalleritar of Dhadhing district in 1993/1994.

METHODOLOGY

The study was carried out on a river terrace soil classified as *Rhodic Ustochrept* (*Cambic fluvisol*), which was medium in texture, deep and well drained. A field experiment was conducted growing wheat followed by mungbean and rice. The experiment was conducted in a randomized block design (RBD) with farmyard manure (FYM 28 t ha^{-1}), city waste compost (28 t ha^{-1}) and NPK fertilizers (120:60:40) and the results were compared with control. Fertilizers were applied to wheat crop, and mungbean and rice were grown on residual fertilizer leftover by the wheat crop. Mungbean biomass was incorporated

into the soil after the mungbean pods were harvested and then rice seedlings were planted. The crops were harvested on maturity, cleaned and adjusted with 14% moisture and then weighed. The yield data were analyzed with MSTATC statistical package with 5% level of significance. Soil samples before and after the experiments were collected and extracted using acid ammonium acetate + EDTA and organic manure digested in Aqua Regia and measured in inductive plasma photometer (ICP).

RESULTS AND DISCUSSION

The chemical properties of compost and FYM (decomposed mixture of dung, urine and bedding materials) are presented in Table 1. Both the materials contain sufficient amounts of plant nutrients. FYM contains twice the amount of total nitrogen than that of town compost contains which is a superior fertilizing material than town compost. All nutrients were higher in FYM except calcium.

Table 1. Plant nutrient contents of organic manures as extracted by Aqua Regia

Element	Town compost	FYM
Total N, %	0.445	0.965
Organic C, %	14.74	14.505
Total P, mg kg^{-1}	3094.74	4235.89
Total K, mg kg^{-1}	7866.02	17917.91
Magnesium, mg kg^{-1}	4426.51	9784.70
Calcium, mg kg^{-1}	15552.40	11370.22

Soil fertility level at the experimental site was low. This resulted in a good response of applied fertilizers. Wheat grain yield with application of NPK fertilizer was 3897 kg ha^{-1}, which was significantly higher than the result from other treatments (Table 2). It could be because the nutrient elements in the mineral fertilizer were in the readily available form whereas it needs to be mineralized in the case of organic manure. The rate of mineralization during the cold season is slow (Suzuki et al 1990) because in such condition during winter mineralization of mineral nutrients from organic sources is less than 30% in a year (Takenaka et al 1990). Responses of organic manures were at par with those of control. Ratanapratip et al (1987), Bory and Nemeth (1992) had obtained similar results.

Table 2. Grain yields as affected by fertilizer application

Treatment	Grain yield, kg ha^{-1}		
	Wheat grain yield	Mung bean yield	Rice grain yield
Control	1194 B	515	1170
FYM	1477 B	481	1345
Town compost	1610 B	567	1277
NPK	3897 A	426	1063
F test	**	Ns	ns
CV, %	8.83	16.34	12.6
SD	93.667	34.57	40.26

Figures indicated by the same alphabets are not significantly different at 5% level.

Grain yield of mungbean was highest (567 kg ha^{-1}) as affected by town compost and the lowest value was obtained due to NPK application (426 kg ha^{-1}). Similar yield results were also obtained in North Indian plains in rice-wheat rotation (Maskina et al 1989).

Rice grain yield was 1345 kg ha^{-1} with the application of FYM (Table 2). Soil fertility before the experiment was low and the addition of organic manure and the biomass of mungbean did not add notable amounts of nutrient elements as indicated by rice grain yield which were at par with one another. Depending upon the amount of green manure incorporated into the soil, the use of green manure alone could produce a rice grain equivalent of 60 to 120 kg ha^{-1} N (Bhopari et al 1992, Maskina

et al 1989, Kolar, Grewal 1988). In this case mungbean biomass after the harvest of the matured pods did not add sufficient amount of nitrogen in the soil. Nitrogen is one of the most limiting nutrients in the Nepalese soil (Sillanpää 1982).

In this experiment, organic manure exhibited considerable residual value (Table 3). There were positive results from the plots previously treated with the FYM and town compost and a negative response from the NPK treated plots. It could be due to significantly higher yield of wheat due to NPK application and very little fertilizing elements could have been available for the third crop (rice). Therefore, there was no significant difference in the yield response with the application of organic manures and NPK treatments. When applied to each and every crop the effect of applied organic manures could be observed only after two or three years (Sherchan and Chand 1991). Results from long term fertility research showed FYM applied at the rate of 10 t ha^{-1} $year^{-1}$ yielded almost the same amount of wheat grain as 100:30:0 NPK, which was significantly higher than the production from the application of half the dose of NPK + stubble incorporation (Sherchan and Baniya 1991).

Table 3. Physico-chemical properties of surface soil

Properties	Before experiment	After experiment			
		Control	FYM	Town compost	NPK
PH	6.75	6.98	6.87	6.98	7.01
Total N, %	0.065	nd	nd	nd	nd
Organic carbon, %	1.2	nd	nd	nd	nd
Acid Ammonium Acetate+ EDTA Extractable plant nutrients (mg kg^{-1})					
Ca	1749.12	1545	1748.99	1900.00	1660.15
Mg	37.45	36.9	41.499	40.2	38.34
P	135.96	76.93	119.97	136.01	86.75
K	157.12	121.64	181.79	166.47	149.38

nd = not detected.

In all the treatments there was slightly increased in soil pH. The rise in pH might due to flooding showing reduced condition for a long time (Ponnamperuma 1972). In control treatment exchangeable Ca was much below and all the other treatments exhibited considerable increase and in most of the cases higher than the amount present before experiment. There was considerable amount of available Mg and K even after the third harvest. Control treatments showed decrease in the mineral nutrients indicating nutrient mining from the soil (Ghani and Brown 1997, Joshi 1997). Comparing the amount of potassium before and after the experiment in all the treatments organic manure addition gave noteworthy amount but the NPK treatment resulted in lower than the K that has been found before the experiment. The harvested crops had exhausted plant nutrients as indicated by lower Ca, Mg, P and K values in control plots than the values before the experiment. There was heavy mining of K from soil and replenishment through fertilizer and organic manure being was not enough to satisfy the harvested K. This decreases K reserve in soil. If this condition continues in intensively cultivated fields K reserve will be exhausted and no crop yield can be obtained from soil (Karki 2004). Similar effects were also produced in the NPK treated plots. Obviously the town compost and FYM treated plots added notable amounts of these elements (Table 3). Similar results have been reported by Bhandari et al (2002), Ladha et al (2000).

Sustainability of rice –wheat system

Most of the authors dealing with sustainable agriculture like Swift and Woomer (1993), Dudal and Deckers (1993), Bauer and Black (1994) have emphasized on low inputs, and organic farming taking into consideration of the environment and its degradation. In this context use of low input organic farming treatments have been compared to mineral fertilizer and found that the low input agriculture has favorable physical and chemical residual effect on soil and crop production. Comparing the effect of organic manure to that of control and chemical fertilizer on grain yield the result of first crop is obviously highest, due to application of mineral fertilizer but its residual effect decreased after second and the third crop. It is evident from these results that the application of mineral fertilizer especially N

could produce sustainable crop yields if it could be used for every crop but not only once a year. Nevertheless, the residual effect of the applied P and K fertilizer is worth mentioning. Even after removal of these elements by three harvests there were sufficient for a fourth crop. These results show that the organic manure had positive results in maintaining soil quality and hence sustainability.

CONCLUSION

Although the amount of plant nutrients in town compost is comparatively low, yet the crop yield is not inferior to that with FYM application. Application of NPK on the other hand yielded significantly higher only in the case of wheat. Residual plant nutrient contents in the soil after the crop harvest were found higher where town compost and FYM was applied. It could thus be concluded that organic manure has valuable effects on the chemical properties of soil.

ACKNOWLEDGEMENT

Funding for this study was provided by Solid Waste Management and Resources Mobilization Centre, Kathmandu and is thankfully acknowledged.

REFERENCES

Bauer A and AL Black. 1994. Quantification of the effect of soil organic matter content on soil productivity. *Soil Sci. Soc. Am. J.* 58:185-193.

Bhandari AL, JK Ladha, H Pathak, AT Padre, D Dawe and RK Gupta. 2002. Yield and soil nutrient changes in a long-term rice-wheat rotation in India. *Soil Science Society of America Journal* 66:162-170.

Bhopari BS, Y Singh and BD Sharma. 1992. Effect of green manuring with susbenia aculata on physical properties of soil and growth of wheat in rice-wheat and maize-wheat cropping system in a semiarid region of India. *Arid Soil Research and Rehabilitation* 5:135-143.

Bory EL and I Nemeth. 1992. Effect of organic and inorganic nutrients forms on leaf cover, dry matter accumulation and yield of wheat. *Novenytermeles* (Hungary) 41:337-350.

Buruchara RA. 1992. Use of soil amendment in the management of beans. **In:** *Proc. Seminar on Bean Breading in the Great Lake*. CIAT, Cali. Columbia.

Dudal R.and J Deckers. 1993. Soil Organic matter in relation to soil productivity. **In:** *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture* (K Mulongoy and R Merec, eds). 377-380.

Ghani A and MW Brown. 1997. *Improvement of soil fertility in Nepal through balanced application of fertilizers*. Report submitted to Ministry of Foreign Affairs and Trade, Wellington.

Joshi D. 1997. *Soil fertility and fertilizer use in Nepal*. Soil Science Division, Khumaltar, Lalitpur, Nepal. Pp. 70.

Joshi PS. 2000. Role of municipality in food security. **In:** *Proc. International Conference and Workshop: Food Security of Urban and Peri-urban System in Developing Countries*, Vienna, 15-18 November 2000. Pp. 25-28.

Karki KB. 2004. Status of potassium in intensively cultivated soils of Kathmandu valley. *Nepal Journal of Science and technology* 5:83-89.

Kolar JS and HS Grewal. 1988. Green manure to sustain productivity and save nitrogen for Rice-wheat cropping systems. *IRRI Newsletter* 13:29.

Ladha JK, KS Fischer, M Hossain, PR Hobbs and B Hardy. 2000. Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic Plains: A synthesis of NARS-IRRI partnership research. *Disc. Paper no. 40*. International Rice Research Institute, Philippines.

Maskina MS, B Singh, OP Meelu, B Singh and Y Singh. 1989. Integrated N Management with green manures in rice-wheat rotation. *IRRI Newsletter* 12:38-39.

Ponnamperuma FN. 1972. Chemistry of submerged soil. *Adv. Agron.* 24:29-91.

Ratanapratip P, T Suwanawet and W Kongpolprom. 1987. Effect of soil improvements and chemical fertilizers on wheat yield. **In:** *Proceedings Wheat Research and Development Workshop 1987/88*. Pp. 364-378.

Sherchan DP and SP Chand. 1991. A review of current soil related research activities at Pakhribas Regional Agricultural Centre. **In:** *Workshop Proceedings*, Jhikhu Khola Watershed, 22-25 April, ISS/IDRC/UBC Canada. Pp. 83-104.

Sherchan KK and BK Baniya. 1991. Crop production trend in response to soil and nutrients: Soil Fertility and erosion issues in the Middle Mountain Region of Nepal. **In:** *Workshop Proceedings*, Jhikhu Khola Watershed, 22-25 April, ISS/IDRC/University of British Columbia, Vancouver, Canada. Pp. 51-60.

Sillanpää, 1982. Micronutrients and nutrients status of soil: A global study. *FAO Soil Bulletin* No. 48:242-250.

Suzuki MRS, K Kamekawa, S Sekia and H Shiga. 1990. Effect of continuous application of organic fertilizer for sixty years on soil fertility and rice yield in paddy field. *Trabsaction XIV International Congress of Soil Science*. Pp. 14-19.

Swift MJ and PL Woomer. 1993. Organic matter and sustainability of agricultural system: Definition and measurement. **In:** *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture* (K Mulongoy and R Merec, eds). Pp. 3-18.

Takenaka M, T Miyoshi, K Hori and T Matsuguchi. 1990. Effect of soil temperature on nitrogen mineralization of different soil types of winter wheat fields. *Transaction XIV International Congress of Soil Science* IV:587-588.

Mapping *Phalaris minor* under the Rice-Wheat Cropping System in Different Agro-Ecological Regions of Nepal

Jagat D. Ranjit[1], Robin R. Bellinder[2], Peter Hobbs[3], Nabin K. Rajbhandari[1] and Palit Kataki[4]

[1] Agronomy Division, NARC, Kumaltar
[2] Cornell University, NY, USA
[3] CIMMYT, Nepal
[4] Soil Management-Collaborative Research Support Programme, Cornell Uni./Nepal

ABSTRACT

A survey was conducted in order to map the spread of *Phalaris minor* in wheat in nine districts in the mid-hill, Terai and inner Terai areas of the rice-wheat cropping system in Nepal during 1998/99. Both qualitative and quantitative data were collected from 540 farmers and *P. minor* was recorded in all of the nine surveyed districts. Percent summed dominance ratio (SDR) and average number per unit area (m^2) of *P. minor* was compared to different districts of mid-hills, inner Tarai, and Tarai belts along with other weeds in the wheat crop. *P. minor* ranked as the first and second important weed of wheat that reduced the wheat yield from 10 to 50 percent. Its populations varied from district to district. However, the infestation appeared to be in increasing trend. Future strategies need to consider in increasing growers' abilities to identify *P. minor* at early growth stages when it is particularly difficult to differentiate from wheat seedlings. It is suggested that frequent monitoring of weeds in different tillage and weed management practices should be initiated. Besides farmers' training in the future there needs to be emphasis placed on increasing farmer's awareness on the serious negative impact of *P. minor* on wheat yield and quality.

Key words: Agro-ecology, *Phalaris minor*, survey, weeds, wheat

INTRODUCTION

Wheat is the pre-dominant winter crop in Nepal and more than one-third of the total area planted to rice is followed by wheat. It is an important crop from the point of food security. Wheat occupies 66.9 million hectares with an average productivity of 1.82 t/ha (MOAC 2002/03). The production of rice and wheat crops in the same year is the predominant cropping pattern in the country. Weeds are a major problem in both crops grown under this system. Many weeds have been identified in the wheat crop. Among them *P. minor* is consistently prevalent at all sites in increasing trend. Changes in the *P. minor* populations, biotypes, and the flora of weeds in wheat in the intensively cultivated rice-wheat cropping system of South Asia have been alarming. Reports of high populations (> 500 plants/m^2) of herbicide-resistant (isoproturon) bio-types of *P. minor* in wheat fields of Northern India and Pakistan, have led to partial or complete crop failure has been a matter of concern for the last ten years. There is speculation that with every crop season, resistant biotypes of *P. minor* are spreading eastwards from these countries into Nepal. The spread may occur through *P. minor* contamination in the harvested wheat crop which is then sold and moved to other parts of South Asia. *P. minor* may have developed resistance to isoproturon due to frequent use of it to control grass weeds in wheat. In Nepal, yield loss in wheat ranged from 15% to 70%. Use of 2,4-D and isoproturon to control broadleaf and grass weeds is common in Nepal's Tarai region (Ranjit 1981, 1983, 1997 and Malla and Ranjit 1980).

Due to a lack of quantitative information regarding the spread of *P. minor* in Nepal, a survey was conducted during the 1998/99 wheat season to assess its presence and severity in different agro-ecological regions of Nepal emphasizing the study under the rice-wheat cropping system.

Distribution: *P. minor* is distributed throughout the world. It has been identified in Canada, South-central USA, Mexico, Central America, Colombia, Venezuela, Bolivia, Peru, Brazil, Argentina, Southern Africa, Northern Africa, Iberian Peninsula, Italy, France, South-east-Europe, Middle East, India, Indonesia, Australia, New Zealand, the Pacific Islands and Nepal.

Habitat: It commonly grows during the winter season in wheat, barley legumes, waste places, rotational crops and several other winter crops. The infestations are particularly serious where wheat follows paddy rice.

Morphology: *P. minor* Retz. (English name = Littleseed canarygrass, small seed canarygrass, Mediterrnean canarygrass and canarygrass) is an annual, erect (50 to 100 cm) grass of poaceae family (Plates 1, 2 and 3). The leaf blade is linear - acuminate. The ligule is 2-6 mm membranous and often fringed or truncate. In the seedling stage the leaves are bluish green in color. The sheath at the base often exudes a red pigment when broken. The inflorescence is dense, oblong or ovate, 2-10 cm long and 1-2 cm wide. Spikelets are 1-flowered, subsessile, 4-6.5 mm long and 2.5-3 mm wide. Glumes are subequal, 4-6.5 mm long with a broad erose-dentate or entire wing near the tip (Basel and Berlin 1981). Morphologically *P. minor* is similar to wheat plants in its early vegetative stage, which makes identification difficult. Hence, the physical removal of *P. minor* infestations in wheat is very difficult, particularly when the wheat is broadcast seeded rather than planted in rows. *P. minor* seed heads mature earlier than do seed heads in wheat and can be easily identified at that stage. However, competition with the crop for that length of time reduces yields significantly. It is very competitive, as it grows taller and more vigorously than wheat. A single *P. minor* plant, when allowed to reach maturity free from any other competition, has the potential to produce 14,600 seeds in a single season (Sen 1981, Yaduraju 1997).

Plate 1. *P. minor* plant.

Plate 2. *P. minor* infestation in wheat.

Plate 3. Seeds of *P. minor*.

MATERIALS AND METHODS

Nine districts in eastern, central and western regions of Nepal were selected for the survey in year 1998/99. Four Village Development Committees (VDCs) were chosen randomly from each district. A survey questionnaire was developed that divided questions to focus on three groups: village units, households and field. Fifteen farmers from each VDC were selected and interviewed. The districts, VDCs and villages are given in Table 1, Figure 1.

Table 1. Surveyed districts and VDCs

Tarai			Mid hills		
District	VDCs	Village	District	VDCs	Village
Banke	Betahani	Santalia	Dhankuta	Pakhribas	Pakhribas
	Jaispura	Jaispura		Tankhuwa	Tamikhuwa
	Herminiya	Munispura		Belhara	Githitar
	Bankatti	Halbaldoli		Dhankuta	Patlekhola
Rupandehi	West Amuwa	Gothawa	Syangja	Dahathum	-
	Basantpur	Parsauni		Walling	Bhumari
	Kamahriya	Sundi W		Sorek	Paken
	Sakraun-Pakadi	Pakadi W		Khilung-Duerali	Simalchaur
Parsa	Bauhari	Dokaila-Tole	Bhaktpur	Chitapol	Simaltar
	Belwa	Ismailpur		Sipadol	Doleswor
	Lakhanpur	Lakhanpur		Nangkhel	Shantigaum
	Pokhariya	Pokhariya		Bageswori	Thuligaun
Sunsari	Pakali	Naya Tole			
	Madhuban	Madhuban			
	Babiya	Jamuwa			
	Laukahi	Laukahi			
Inner Tarai					
District	VDCs	Village			
Dang	Saudiyar	Guruwa Goan			
	Rampur	Rampur			
	Manpur	Nimbuwa			
	Narayanpur	Belawa			
Chitwan	Khairahani	Badauli			
	Pithuwa	Madhavpur			
	Piple	Kapan Tole			
	Gitanagar	Indrapuri			

Weed samples were collected from four ¼ m^2 quadrats in each farmer's field. Fifteen farmers' fields in each VDC were evaluated. Thus, the data were collected from 540 farmers (9 districts × 4 VDC × 15 farmers = 540) and weed samples were taken from 2160 quadrats (9 districts × 4 VDC × 15 farmers × 4 quadrats = 2160). Latitude, longitude and altitude were recorded in each VDC with the help of GPS instruments. After the quantitative weed measurements eg density, relative density, frequency, and relative frequency, summed dominant ratio (SDR) were calculated (Rao 1985 and Sen 1981). The relative density, relative frequency and summed dominance ratio (SDR) were calculated as follows:

Density = Total number of individuals of a species in all quadrats / Total number of quadrats used

Frequency= (Number of quadrats in which a given species occurs/Total number of quadrats used) × 100

Relative density = (Density of a given species / Total density for all species) × 100

Relative frequency = (Frequency of a given species / Total frequency for all species) × 100

Summed Dominant Ratio (SDR) = (Relative density + Relative frequency) × 100

Summed Dominant Ratio (SDR) is expressed in percentage.

RESULTS AND DISCUSSION

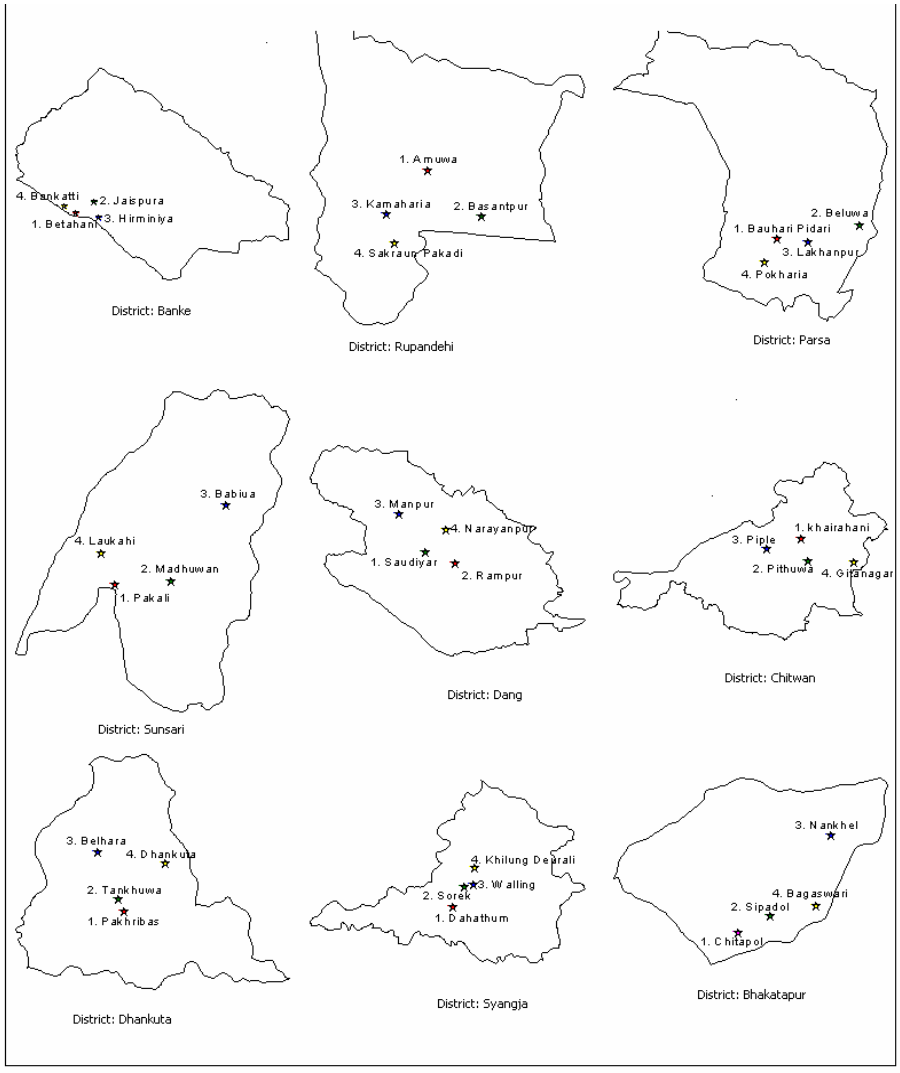


Figure 1. Surveyed districts showing Village Development Committees

Nine rice-based and seven-maize based cropping systems were prevalent in the surveyed districts, but rice-wheat was the major cropping system. Multiple weeds belonging to different botanical families were identified in addition to *P. minor*. In most of the districts *P. minor* was among the 1st five weeds. But this weed was not found in all the VDCs Table 2, 3 and 4.

Table 2. *P. minor* and other weed species in the Tarai districts of Nepal 1998/99

District: Banke							
VDC							
1) Betahani		2) Jaispura		3) Hirminiya		4) Bankatti	
Chenopodium album	(28.9)	Polygonum plebejum	(29.8)	Soliva anthemifolia	(31.8)	Chenopdium album	(23.3)
Phalaris minor	(13.1)	Anagalis arvensis	(15.6)	Anagalis arvensis	(20.41)	Gnaphalium sp.	(16.7)
Medicago denticulatus	(9.55)	Cyodon dactylon	(9.91)	Gnaphalium sp.	(9.72)	Anagalis arvensis	(15.37)
Anagalis arvensis	(8.74)	Chenopodium album	(9.36)	Chenopodium album	(7.96)	Vicia sativa	(11.41)
Lathyrus aphaca	(8.5)	Gnaphalium sp.	(7.5)	Fumaria parviflora	(7.18)	Cynodon dactylon	(6.97)
Polygonum plebejum	(6.22)	Vicia hirsute	(6.99)	Vicia hirsuta	(5.26)	Soliva anthemifolia	(6.49)
Cynodon dactylon	(6.6)	Soliva anthemifolia	(5.16)	Vicia sativa	(4.73)	Cyprus sp.	(5.68)
Fumaria parviflora	(5.48)	Medicago denticulatus	(3.92)	Phalaris minor	(4.0)	Lathyrus aphaca	(3.92)
Cyperus sp.	(2.95)	Cyperus sp.	(3.06)	Medicago denticulatus	(2.14)	Circium arvense	(3.69)
Vicia sativa	(2.46)	Phalaris minor	(2.55)	Cynodon dactylon	(2.63)	Medicago denticulatus	(3.26)
Rumex sp.	(2.5)	Rumex sp.	(2.0)	Cyprus sp.	(1.67)	Fumaria parviflora	(2.45)
Gnaphalium sp.	(1.72)	Lathyrus aphaca	(1.38)	Spergula arvensis	(1.52)	Phalaris minor	(0.76)
Circium arvense	(1.15)	Galinsoga parviflora	(0.81)	Cysella bursa pastories	(0.51)		
Soliva anthemifolia	(0.96)	Unidentified (B)	(0.66)	Unidentified	(0.50)		
Equisitum sp.	(0.67)	Fimbristylis littoralis	(0.63)				
Unidentified (D)	(0.49)	Unidentified (a)	(0.63)				

District: Rupandehi							
VDC							
1) Amuwa		2) Basantpur		3) Kamahariya		4) Sakraun Pakadi	
Cynodon dactylon	(19.0)	Phalaris minor	(24.59)	Polygonum plebejum	(30.19)	Anagalis arvensis	(26.05)
Polygonum plebejum	(18.32)	Soliva anthemifolia	(19.9)	Anagalis arvensis	(22.21)	Phalaris minor	(14.06)
Medicago denticulatus	(17.89)	Anagalis arvensis	(15.62)	Lathyrus aphaca	(9.63)	Polygonum plebejum	(13.03)
Anagalis arvensis	(12.4)	Polygonum plebejum	(13.04)	Chenopodium album	(5.61)	Lathyrus aphaca	(7.85)
Chenopodium album	(8.30)	Medicago denticulatus	(8.44)	Rumex sp.	(5.17)	Soliva anthemifolia	(6.65)
Rumex sp.	(4.19)	Lathyrus aphaca	(5.22)	Gnaphalium sp.	(4.8)	Cynodon dactylon	(6.39)
Alopecuros sp.	(3.65)	Vicia sativa	(5.81)	Fumaria parviflora	(3.7)	Chenopodium album	(6.29)
Lathyrus aphaca	(3.52)	Circium arvense	(2.26)	Cynodon dactylon	(3.63)	Medicago denticulatus	(6.01)
Cyperus sp.	(3.74)	Cynodon dactylon	(1.69)	Medicago denticulatus	(3.48)	Cyperus sp.	(3.15)
Vicia sativa	(3.64)	Chenopodium album	(1.64)	Circium arvense	(3.65)	Rumex sp.	(2.80)
Lactuca sp.	(0.99)	Seinebeira pinnatifida	(0.63)	Cyperus sp.	(2.23)	Circium arvense	(2.33)
Fumaria parviflora	(0.89)	Cardamine pratense	(0.62)	Vicia sativa	(1.98)	Vicia sativa	(1.91)
Gnaphalium sp.	(0.89)	Gnaphalium sp.	(0.55)	Oxalis corniculata	(1.37)	Alternanthera sp.	(1.61)
Phalaris minor	(0.85)			Ageratum conyzoides	(1.31)	Fumaria parviflora	(1.24)
Soliva anthemifolia	(0.82)			Alopecuros sp.	(0.67)	Gnaphalium sp.	(0.62)
Ageratum conyzoides	(0.82)			Alternanthera sp.	(0.65)		

District: Parsa							
VDC							
1) Bauhari Pidari		2) Beluwa		3) Lakhanpur		4) Pokhariya	
Polygonum plebejum	(29.77)	Polygonum plebejum	(21.3)	Unidentified (A)	(28.21)	Anagalis arvensis	(19.18)
Soliva anthemifolia	(19.0)	Anagalis arvensis	(19.6)	Polygonum plebejum	(20.0)	Phalaris minor	(14.35)
Anagalis arvensis	(12.0)	Soliva anthemifolia	(10.54)	Cynodon dactylon	(19.88)	Polygonum plebejum	(12.94)
Phalaris minor	(9.66)	Chenopodium album	(10.34)	Chenopodium album	(7.129)	Soliva anthemifolia	(10.12)
Chenopodium album	(9.12)	Phalaris minor	(9.10)	Phalaris minor	(5.85)	Rumex sp.	(10.0)
Vicia sativa	(6.17)	Vicia sativa	(8.21)	Xanthium strumarium	(4.89)	Gnaphalium sp.	(7.80)
Fumaria parviflora	(3.0)	Cynodon dactylon	(5.62)	Medicago denticulatus	(3.64)	Chenopodium album	(6.75)
Alternanthera sp.	(2.71)	Gnaphalium sp.	(3.38)	Soliva anthemifolia	(2.76)	Vicia sativa	(6.39)
Gnaphalium sp.	(2.51)	Medicago	(2.81)	Leucas aspera	(2.58)	Senecio vulgaris	(3.15)

		denticulatus					
Cynodon dactylon	(2.47)	Alternanthera sp.	(2.71)	Anagalis arvensis	(1.35)	Cynodon dactylon	(3.04)
Lathyrus aphaca	(1.85)	Cyperus sp.	(2.89)	Rumex sp.	(1.93)	Alopecuros sp.	(1.69)
Oxalis corniculata	(0.59)	Digitaria ascendens	(2.47)	Senecio vulgaris	(0.59)	Medicago denticulatus	(1.80)
Centella asiatica	(0.59)	Stellaria media	(0.70)	Vicia sativa	(0.58)	Cyperus sp.	(0.67)
Rumex sp.	(0.60)			Lathyrus aphaca	(0.55)	Fumaria parviflora	(0.53)
						Circium arvense	(0.51)
						Equisitum sp.	(0.51)
						Lathyrus aphaca	(0.51)

Table 2. Contd….

District: Sunsari							
VDC							
1) Pakali		2) Madhuwan		3) Babiya		4) Laukahi	
Chenopodium album	(21.5)	Digitaria ascendens	(16.4)	Soliva anthemifolia	(21.0)	Soliva anthemifolia	(21.2)
Cynodon dactylon	(19.4)	Alopecuros sp.	(13.8)	Polygonum plebejum	(13.0)	Chenopodium album	(16.6)
Lactuca sp.	(11.3)	Cynodon dactylon	(10.8)	Anagalis arvensis	(11.7)	Polygonum plebejum	(15.8)
Polygonum plebejum	(8.1)	Polygonum plebejum	(10.2)	Lathyrus aphaca	(11.5)	Gnaphalium sp.	(7.4)
Lamium amplexicaule	(7.5)	Phalaris minor	(11.0)	Phalaris minor	(11.1)	Cynodon dactylon	(5.8)
Vicia sativa	(7.2)	Chenopodium album	(8.35)	Cynodon dactylon	(5.4)	Phalaris minor	(5.5)
Alternanthera sp.	(0.7)	Gnaphalium sp.	(6.64)	Fumaria parviflora	(5.1)	Cyperus sp.	(5.0)
Medicago denticulatus	(5.5)	Centella asiatica	(5.35)	Chenopodium album	(4.6)	Fumaria parviflora	(5.0)
Lathyrus aphaca	(4.6)	Rumex sp.	(3.81)	Rumex sp.	(4.5)	Rumex sp.	(4.8)
Gnaphalium sp.	(3.6)	Lactuca sp.	(3.13)	Medicago denticulatus	(4.3)	Leucas aspera	(2.7)
Anagalis arvensis	(3.2)	Alternanthera sp.	(2.88)	Cyperus sp.	(4.0)	Vicia sativa	(2.1)
Digitaria ascendens	(2.7)	Anagalis arvensis	(2.22)	Digtaria ascendens	(0.6)	Lactuca sp.	(1.6)
Phalaris minor	(2.7)	Vicia sativa	(1.0)	Alopecuros sp.	(0.6)	Digtaria ascendens	(1.2)
Unidentified (Z)	(0.8)	Mazus	(0.82)	Alternanthera sp.	(0.6)	Medicago denticulatus	(1.1)
Fumaria parviflora	(0.7)	Lindernia sp.	(063)	Cardamine pratense	(0.4)	Lathyrus aphaca	(0.7)
Cyperus sp.	(0.7)	Stellaria media	(0.6)	Circium arvense	(0.4)	Anagalis arvensis	(0.5)
		Soliva anthemifolia	(0.58)	Melilotus parviflora	(0.4)	Alternanthera sp.	(0.5)
		Equisitum sp.	(0.55)	Vicia sativa	(0.4)	Circium arvense	(0.5)
		Lathyrus aphaca	(0.55)	Lactuca sp.	(0.4)	Equisitum sp.	(0.5)
		Medicago denticulatus	(0.55)			Oxalis corniculata	(0.5)
						Eleusine indica	(0.5)
						Unidentified	(0.5)

Values in the bracket indicates percent Summed Dominant Ratio (SDR) of weeds.

Table 3. *P. minor* and other weed species in the inner terai districts of Nepal 1998/99

District: Dang							
VDC							
1) Soudiyar		2) Rampur		3) Manpur		4) Narayanpur	
Phalaris minor	(23.3)	Anagalis arvensis	(18.99)	Anagalis arvensis	(21.20)	Cynodon dactylon	(18.09)
Lathyrus aphaca	(21.14)	Lathyrus aphaca	(13.68)	Medicago denticulatus	(13.26)	Lathyrus aphaca	(15.84)
Alopecuros sp.	(10.95)	Phalaris minor	(13.13)	Phalaris minor	(11.83)	Alopecuros sp.	(13.42)
Cynodon dactylon	(8.18)	Polygonum plebejum	(10.36)	Cynodon dactylon	(10.42)	Anagalis arvensis	(13.37)
Anagalis arvensis	(7.96)	Alopecuros sp.	(11.62)	Polygonum plebejum	(8.64)	Vicia sativa	(9.39)
Polygonum plebejum	(8.07)	Chenopodium album	(8.54)	Gnaphalium sp.	(8.64)	Polygonum plebejum	(8.92)
Chenopodium album	(6.13)	Cynodon dactylon	(7.05)	Cyperus sp.	(4.58)	Phalaris minor	(8.43)
Vicia sativa	(4.01)	Gnaphalium sp.	(4.65)	Vicia sativa	(4.58)	Oxalis corniculata	(3.86)
Eqisitum sp.	(3.35)	Vicia sativa	(4.00)	Lathyrus aphaca	(3.24)	Chenopodium album	(2.35)

Fumaria parviflora	(2.72)	Medicago denticulatus	(2.20)	Alopecuros sp.	(2.65)	Medicago denticulatus	(1.79)
Dactyloctenium aegyptiacum	(1.65)	Fumaria parviflora	(1.47)	Oxalis corniculata	(2.23)	Gnaphalium sp.	(1.75)
Lindernia sp.	(0.82)	Cyperus sp.	(1.43)	Fimbristylis littoralis	(2.22)	Rumex sp.	(1.66)
Vicia hirsute	(0.65)	Circium arvense	(1.34)	Cannabis sativa	(0.67)	Equisitum sp.	(0.58)
Gnaphalium sp.	(0.56)	Lactuca sp.	(0.65)	Polygonum sp.	(0.64)	Centella asiatica	(0.56)
Unidentified	(0.52)	Equisitum sp.	(0.90)	Rumex sp.	(0.59)		
Unidentified	(0.52)						

District: Chitwan							
VDC							
1) Khairahani		2) Pithuwa		3) Piple		4) Gitanagar	
Cynodon dactylon	(31.72)	Gnaphalium sp.	(23.16)	Cynodon dactylon	(23.41)	Polygonum plebejum	(32.11)
Cyperus sp	(11.92)	Polygonum plebejum	(22.6)	Ageratum conyzoides	(14.47)	Chenopodium album	(27.75)
Vicia sativa	(10.64)	Chenopodium album	(17.62)	Vicia sativa	(10.95)	Cynodon dactylon	(9.65)
Digtaria ascendens	(8.93)	Vicia sativa	(9.20)	Gnaphalium sp.	(9.08)	Anagalis arvensis	(6.77)
Polygonum plebejum	(7.89)	Anagalis arvensis	(7.73)	Chenopodium album	(8.57)	Vicia sativa	(6.23)
Ageratum conyzoides	(4.58)	Fumaria parviflora	(4.91)	Oxalis corniculata	(5.69)	Fumaria parviflora	(5.94)
Digitaria ascendens	(4.58)	Unidentified	(4.91)	Polygonum plebejum	(5.38)	Solanum nigrum	(2.65)
Chenopodium album	(4.26)	Oxalis corniculata	(3.59)	Digitaria ascendens	(4.89)	Digtaria ascendens	(2.13)
Alopecuros sp.	(3.16)	Cynodon dactylon	(1.83)	Solanum nigrum	(3.26)	Phalaris minor	(1.78)
Unidentified	(2.74)	Medicago denticulatus	(1.48)	Unidentified	(3.78)	Gnaphalium sp.	(1.63)
Phalaris minor	(2.65)	Phalaris minor	(0.82)	Phalaris minor	(2.27)	Lathyrus aphaca	(0.84)
Gnaphalium sp.	(2.27)	Lathyrus aphaca	(0.71)	Xanthium strumarium	(2.27)	Oxalis corniculata	(0.84)
Equisitum sp.	(1.73)	Ageratum conyzoides	(0.74)	Fumaria parviflora	(1.78)	Rumex sp.	(0.82)
Solanum nigrum	(0.82)	Amaranthus veridis	(0.70)	Polygonum capitatum	(1.24)	Lactuca sp.	(0.90)
Oxalis corniculata	(0.72)			Cyperus sp.	(1.17)		
Unidentified	(0.66)			Amaranthus veridis	(0.90)		
Medicago denticulatus	(0.66)			Alternanthera sp.	(0.90)		

Values in the bracket indicate percent Summed Dominant Ratio (SDR) of weeds.

Table 4. *P. minor* and other weed species in the mid-hill districts of Nepal 1998/99

District: Dhankuta							
VDC							
1) Pakhribas		2) Tankhuwa		3) Belhara		4) Dhankuta	
Stellaria media	(29.24)	Polygonum plebejum	(31.94)	Gnaphalium sp.	(18.81)	Cynodon dactylon	(18.84)
Lamium amplexicaule	(12.77)	Stellaria media	(31.48)	Oxalis corniculata	(18.66)	Chenopodium album	(18.67)
Polygonum capitatum	(10.34)	Galinsoga parviflora	(6.53)	Polygonum plebejum	(13.15)	Phalaris minor	(17.9)
Galinsoga Parviflora	(9.69)	Unidentified	(6.53)	Cynodon dactylon	(9.53)	Polygonum plebejum	(14.59)
Vicia sativa	(9.25)	Alopecuros sp.	(6.04)	Chenopodium album	(6.18)	Alopecuros sp.	(11.48)
Fumaria parviflora	(4.03)	Polygonum capitatum	(4.29)	Anagalis arvensis	(3.87)	Stellaria media	(4.12)
Centella asiatica	(2.85)	Alternanthera sp.	(2.16)	Unidentified	(3.58)	Centella asiatica	(3.69)
Drymaria cordata	(2.85)	Chenopodium album	(1.47)	Xanthium strumarium	(3.53)	Oxalis corniculata	(2.49)
Ageratum conyzoides	(2.84)	Centella asiatica	(1.35)	Argemone maxicana	(3.16)	Vicia sativa	(2.13)
Lathyrus aphaca	(2.40)	Medicago denticulatus	(1.08)	Galinsoga parviflora	(2.86)	Alternanthera sp.	(1.51)
Artimesia vulgaris	(2.06)	Oxalis corniculata	(1.08)	Medicago denticulatus	(1.99)	Ageratum conyzoides	(1.29)
Digitaria sp.	(1.95)	Phalaris minor	(1.02)	Cyperus sp.	(1.81)	Digitaria ascendens	(0.98)
Bidens pilosa	(1.79)	Cardamine pratense	(1.02)	Polygonum capitatum	(1.81)	Gnaphalium sp.	(0.84)
Xanthium strumarium	(1.77)	Lactuca sp	(1.02)	Circium arvense	(1.63)	Cannabis sativa	(0.75)
Chenopodium album	(1.53)	Cynodon dactylon	(0.99)	Stellaria media	(1.53)	Lactuca sp.	(0.75)
Oxalis corniculata	(1.51)	Gnaphalium sp.	(0.99)	Vicia sativa	(1.44)		
Unidentified	(1.05)	Digitaria sp.	(0.99)	Ageratum conyzoides	(1.34)		
Gnaphalium sp.	(0.92)			Alopecuros sp.	(1.34)		
Medicago denticulatus	(0.89)			Lactuca sp.	(1.34)		
Cynodon dactylon	(0.79)			Phalaris minor	(1.25)		
Cyperus sp.	(0.77)			Fumaria parviflora	(1.25)		
Polygonum phlebijum	(0.77)						

District: Syangja							
VDC							
1) Dahathum		2) Walling		3) Sorek		4) Khilung Deurali	
Chenopodium album	(15.68)	Soliva anthemifolia	(27.9)	Polygonum hydropiper	(37.0)	Polypogom fugax	(26.95)
Cynodon dactylon	(14.37)	Vicia sativa	(16.4)	Stellaria media	(17.2)	Stellaria media	(10.8)

Melilotus parviflora	(11.95)	Chenopodium album	(10.5)	Vicia sativa	(8.5)	Cynodon dactylon	(9.08)
Vicia sativa	(10.2)	Stellaria media	(9.67)	Soliva anthemifolia	(6.7)	Melilotus parviflora	(9.04)
Unidentified (Z)	(9.03)	Cynodon dactylon	(7.55)	Chenopodium album	(6.6)	Vicia sativa	(8.49)
Alopecuros sp.	(7.98)	Polypogom fugax	(5.5)	Alopecuros sp.	(5.6)	Chenopodium album	(8.2)
Stellaria media	(5.82)	Melilotus parviflora	(4.35)	Polypogom fugax	(4.7)	Phalaris minor	(5.55)
Polypogom fugax	(4.73)	Lactuca sp.	(3.38)	Gnaphalium sp.	(2.9)	Gnaphalium sp.	(4.79)
Lactuca sp.	(4.66)	Alopecuros sp.	(3.04)	Cynodon dactylon	(2.4)	Solanum nigrum	(3.29)
Phalaris minor	(3.99)	Phalaris minor	(2.22)	Lathyrus aphaca	(1.8)	Unidentified (Z)	(2.61)
Gnaphalium sp.	(3.05)	Polygonum hydropiper	(1.84)	Phalaris minor	(1.2)	Lactuca sp.	(2.32)
Drymaria cordata	(3.05)	Polygonum sp.	(1.65)	Lactuca sp.	(1.2)	Polygonum sp.	(2.0)
Oxalis corniculata	(1.25)	Oxalis corniculata	(1.35)	Fimbristylis littoralis	(1.0)	Fumaria parviflora	(1.83)
Fumaria parviflora	(1.06)	Mazus sp.	(1.18)	Cardamine pratense	(0.7)	Alopecuros sp.	(1.62)
Ageratum conyzoides	(1.06)	Gnaphalium sp.	(1.06)	Unidentified (Z)	(0.6)	Ageratum conyzoides	(1.43)
Equisitum sp.	(0.99)	Unidentified (Z)	(1.06)	Fumaria parviflora	(0.6)	Drymaria cordata	(0.58)
Cardamine pratense	(0.64)	Lathyrus aphaca	(0.54)	Melilotus parviflora	(0.6)	Equisitum sp.	(0.53)
Polygonum	(0.50)	Equisitum sp.	(0.54)	Oxalis corniculata	(0.6)	Convolvulos arvensis	(0.47)
		Fumaria parviflora	(0.53)			Unidentified	(0.44)

District: Bhaktapur							
VDC							
1) Chitapol		2) Sipadol		3) Nangkhel		4) Bageswari	
Poa annua	(30.5)	Poa annua	(46.0)	Solivanathemifolia	(22.17)	Alopecuros sp.	(43.72)
Phalaris minor	(25.0)	Unidentified	(8.99)	Poa annua	(21.54)	Phalaris minor	(14.69)
Chenopodium album	(11.2)	Chenopodium album	(8.72)	Phalaris minor	(13.78)	Chenopodium album	(9.24)
Alopecuros sp.	(6.07)	Phalaris minor	(8.2)	Alopecuros sp.	(8.74)	Unidentified (K)	(6.48)
Soliva athemifolia	(5.21)	Polygonum sp.	(5.55)	Chenopodium album	(7.76)	Soliva athemifolia	(4.42)
Avena fatua	(5.1)	Vicia hirsute	(5.32)	Unidentified (K)	(5.05)	Avena fatua	(3.73)
Stellaria media	(4.33)	Lamium amplexicaule	(4.96)	Polygonum sp.	(4.58)	Polygonum sp.	(2.51)
Vicia hirsuta	(4.18)	Steilaria media	(4.39)	Steilaria media	(14.47)	Vicia sativa	(1.97)
Unidentified (K)	(3.6)	Cannabis sativa	(2.07)	Vicia hirsuta	(2.92)	Rumex sp.	(0.80)
Lamium amplexicaule	(2.07)	Alopecuros sp.	(2.07)	Avena fatua	(2.68)		
Vicia sativa	(2.05)	Rumex sp.	(1.97)	Cannabis sativa	(2.50)		
Gnaphalium sp.	(0.75)	Cardamine pratense	(1.4)	Gnaphalium sp.	(1.11)		
		Soliva athemifolia	(0.68)	Medicago denticulatus	(0.62)		
				Equisitum sp.	(0.62)		
				Rumex sp.	(0.59)		
				Vicia sativa	(0.56)		

Values in the bracket indicate percent Summed Dominant Ratio (SDR) of weeds.

P. minor is spreading in almost all the surveyed districts. The numbers of *P. minor*/m^2 ranged from 8 to 95. The highest numbers/m^2 were recorded in Rupandehi with significant populations also found in Dhankuta, Sunsari, and Bhaktapur Table 5.

Table 5. Average population of *P. minor* per unit area (m^2) in different districts

District	*Phalaris minor*	District	*Phalaris minor*
Banke	20 (16)	Chitwan	8 (8)
Rupandehi	95 (23)	Dhankuta	60 (8)
Parsa	19 (32)	Syangja	9 (20)
Sunsari	55 (29)	Bhaktapur	52 (54)
Dang	19 (41)		

Figures within parenthesis show the number of farmers.

Depending on the district, *P. minor* has been spelled by different names. It is locally known as Gahun ka mama (Banke), Jwate (Dang), Ghodjawa (Rupandehi), Ledai and Madhuwaine (Parsa), Ragate and Tagonaicha (Bhaktpur), and Tauke and Thulomatte (Syangja).

Farmers' perceptions: In seven districts, both grass and broadleaf weeds were reported as significant problems in wheat. In Bhaktapur, farmers' were most concerned with grassy weeds, while in Chitwan, broad-leaf weeds were the major problem weeds Table 6. In all districts except Chitwan, *P. minor* was reported as a problem weed but severity rankings differed districts.

Table 6. Ranking of three major weeds of wheat crop as perceived by the farmers in different districts

Banke	Dang	Rupand	Sunsari	Parsa	Dhankuta	Chitwan	Syangja	Bhaktapur	Rank
C. album	*P.minor*	*P. minor*	*C. album*	*P.minor*	*S. media*	*C. album*	*P. minor*	*P.minor*	1
P. minor	*C. album*	*L.aphaca*	*Rumex sp.*	*A.arvensis*	*C. album*	*Fumaria sp.*	*P. fugox*	*A. fatua*	2
Fumaria sp.	*M. denticulata*	*Vicia sp.*	*P.minor*	*C. album*	*P.minor*	*Ageratum sp.*	*Vicia sp.*	*Alopecuros sp.*	3

Yield losses caused by *P. minor*: Farmers estimated that wheat yield losses due to weeds ranged from 10 to 50% depending upon the weed population severity. Fifty-six percent of farmers said *P. minor* could reduce 10-50% yield in wheat while 44% of growers were not able to determine actual losses due to *P. minor*.

Farmer's awareness of *P. minor*: Most of the farmers were unaware of *P. minor* as a problem weed. Sometimes they were confused and gave the same local name for two plant groups. This weed is frequently used for livestock feed in mid-hills of the surveyed districts. Farmers of Banke district were aware of this weed and felt that *Phalaris* is a problem weed in lentil and chickpea as well as in wheat. Farmers do not know exactly when this weed was introduced in their wheat crop but estimate that it occurred within the last 6 years. However, more than 20% of farmers in Syangja, Bhaktapur, Parsa, Rupandehi and Dang districts indicated that *P. minor* had been present in their fields for more than a decade.

Source of *P. minor* introduction: Forty-five percent of the farmers did not know the source of introduction of this weed in their fields. However, 22% said it came from shared seed, 28% said through certified seed purchased outside and 5% said from other sources, eg movement with irrigation water. *P. minor* was used for livestock feed in almost all districts. Farmers cut the weed after it starts heading when they can separate it from wheat.

Management: Although *P. minor* was seen as spreading and increasing in wheat fields, weeding was generally not practiced in almost all the surveyed districts, largely due to the inability of farmers to differentiate between wheat and *P. minor* seedlings in the vegetative stage. Due to the fact that many growers do not have row-planters and wheat seed is, broadcast by hand identification is extremely difficult. Weeding is done mainly during the heading stage when *P. minor* can be distinguished from the wheat plants due to its distinctive seed heads. *P. minor* is then pulled from the field to feed livestock. In addition to yield losses caused by competition from *P. minor*, the act of physical removal close to wheat

harvest increases crop damage. Survey results indicated that 42% of farmers were not weeding the wheat crop, 43% cut the weed for livestock feed, and 2% are using herbicides to control weeds.

CONCLUSION

P. minor was recorded from almost all the surveyed districts and VDCs with varied population. The number of this weeds are increasing in wheat crop where the rice-wheat system has been practiced for long time. This mapping study will certainly benefit the researchers, extensionists, students, and farmers in the future. Future strategies need to focus on specific methods of increasing growers' abilities to identify *P. minor* at early growth stages when it is particularly difficult to differentiate from wheat seedlings. It is suggested that frequent monitoring of weeds in different tillage and weed management practices should be initiated to visualize the weed shifts in the future. It is recommended that efforts be made to increase farmers' awareness of the negative impact of this weed on yields and quality of wheat through training and field visits of the infested sites.

ACKNOWLEDGMENTS

Our sincere thank goes to TP Pokhrel, Nepal Agriculture Research Council and SL Shrestha, Agronomy Division for their encouragement and valuable support. We acknowledge the financial support of the Soil Management-Collabarative Research Support Program (SM-CRSP), Cornell University, USA. We highly appreciate B Adhikari, CIMMYT/Nepal for his help in data analysis and SK Rai, Soil Science Division for mapping of the data. We are very thankful to R Ghimire, T Adhikari and A Millar for their help throughout the survey period. Our thanks go to Pramila Khatri for word processing.

REFERENCES

Basel EH and HS Berlin. 1981. Grass weeds - 2 CIBA - GEIGY Ltd. Basle, Switzerland, pp115.

Malla ML and JD Ranjit. 1980. Weed Control Expt in Wheat and Barley. **In:** *Proceeding 8th Winter Crop Workshop*. 4-5 Sept 1980, NWDP Bhairahawa. Pp. 179-183.

MOAC. 2002/03. *Statistical information on Nepalese agriculture*. Agri-Business Promotion and Statistics Division, Ministry of Agriculture and Co-operative, HMG/N, Kathmandu, Nepal.

Ranjit JD. 1981. Weed control trial in wheat. **In:** *Proceeding Wheat Research Report* held at NWDP, Bhairahawa August 1982. Pp. 211-218.

Ranjit JD. 1983. Weed control trial in wheat. Paper presented at *11th Winter Crop Workshop*, 3-5 Sept 1984. NWDP, Bhairahawa.

Ranjit JD. 1997. Weeds and weed management in rice-wheat system. **In:** *Proceedings of the Rice-Wheat Research end-of-Project Workshop* held at Kathmandu, Nepal from 1-3 Oct 1997. Pp. 23-30.

Rao AN. 1985. *Vegetation Analysis*. Lecture presented at first weed science training course. IRRI, Philippines.

Sen DN. 1981. *Ecological approaches to Indian weeds*. Geobios International, India.

Yaduraju NT. 1997. *Phalaris minor* a grassy weed in rice-wheat system. *ICAR News*. P. 12.

Management of Leaf Blight (*Bipolaris sorokiniana*) Disease of Wheat with Cultural Practices

Prem CP Chaurasia[1] and Etienne Duveiller[2]

[1] Regional Agriculture Research Station, Tarahara, Sunsari, Nepal
[2] CIMMYT, Kathmandu

ABSTRACT

An experiment was conducted at agronomy farm of Agriculture research Station, Tarahara, Nepal for three consecutive years viz 2000/2001,2001/2002, and 2002/2003 to evaluate the effects of different cultural practices on leaf blight diseases of wheat caused by *Bipolaris sorokiniana* under terai conditions. The experiment was conducted in factorial Randomized Complete Block Design with four replications. Four factors, two wheat verities RR-21 and Nepal 297,two number of irrigations (two and three irrigations), two doses of Nitrogen fertilizer viz. 60kg N/ha and 120 kg N/ha and two dates of sowing of wheat were examined. Different yield components, grain yield (kg/plot) and disease severity were recorded to judge the effects of these factors on severity of leaf blight of wheat. Nepal Line 297 had significantly less AUDPC based on flag leaf infection and whole plan as compared to RR-21. Number of irrigations had no significant effect on AUDPC, as there was frequent rain during experimental period. Doses of Nitrogen fertilizer had significant effect on AUDPC based on flag leaf infection. It was higher in case of 60 kg N/ha. The third week of November sowing of wheat had lower value of AUDPC as compared to December sowing. Plant height, panicle lengths were highly significantly higher in case of RR-21 as compared to Nepal-297. Thousand kernel weight, and grain yield kg/ha were significantly higher in Nepal-297. All agronomic parameters except thousand kernel weight and number of tillers/plan were significantly higher in 120kg N/ha. The third week of November sowing of wheat had less plant height and panicle length, higher thousand kernel weight and more grain yield. Leaf blight severity was highly significantly less in case of Nepal-297. Doses of Nitrogen fertilizer had significant effect on plant height, panicle length, thousand kernel weight, percentage flag leaf infection and AUDPC based on flag leaf infection. Based on the results of three years of experimentations, it can be concluded that Nepal-297 had less disease, number of irrigations had no effect on disease severity, higher doses of nitrogen fertilizer had less flag infection and late sowing of wheat also had less disease. Numbers of irrigation's effects were inconclusive as there were frequent rains during experimentation period. Based on above conclusion, it is recommended that growing wheat verity like Nepal-297, use of higher doses of nitrogen fertilizer and sowing of wheat / first week of Dec help in minimizing the severity of leaf blight. However late sowing had lowered grain yield.

Key words: AUDPC, culture practices, disease management, leaf blight

INTRODUCTION

Wheat *(Triticum acstivum* L.) is one of the most important winter crops in eastern terai. In 2001/2002 there was wheat in 6670,077 ha all over in the Nepal with the total production of 1258045 tons. In the same year it was cultivated in 123,479 ha in the Eastern Development Region with total production of 242579 tons. In eastern terai it was cultivated in 89,334 ha with production of 188,240 tons and average productivity was 2107 kg. The most of the acreage of the wheat of eastern terai is covered by wheat verities such as Nepal-297, RR-21, UP-262 and others. These verities are prone to heavy attack of the diseases called leaf blight that is caused by Bipolaris sorokiniana (telcom. *Cochlobolus sativus*). These diseases are widely distributed through out wheat growing areas of the country particularly in terai (NWRP 1996). Since its first record, the disease severities have been increased and are found to affect

the leaves of the most commercial wheat verities (Karki and Horsford 1986). Magnitude of yield loss due to the disease may vary among locations and years. A disease incidence of up to 90% on cv-RR-21 was recorded in terai belt (NWRP 1977). The highest grain yield loss was reported for RR-21, which ranged between 23.2% and 23.88%. A yield loss in Nepal-297 recorded at Bhairahawa was 15.2% (Shrestha et al 1998). Several fungicides including Bavistin (mothyl benzimidazol-2-ylearbamate), Benlate (methyl1- (butylearbmoy) benzimidazol-2-ylearbamate), Dithane M-45 (zinc ethyle bisdithiocarbamate) were tested as foliar spray to control the disease in Nepal. (NWRP 1977, Bimb 1979). Tilt (propiconazole) was also found to be quite effective in reducing leaf blight. However, it is expensive and not easly available in Nepalese market. (Mahato and Sedhai 1994).

It is generally accepted that resistance of high yielding genotypes is not yet satisfactory (Duveiller et al 1998). The application of two irrigations reduced the severity of foliar blight as compared to no irrigation (Shrestha et al 1998). Ruckstuhl (1998) reported that low or imbalance soil nutrient levels predispose plants to more severe leaf blight attack. Singh et al (1998) found low incidence of disease when wheat crop was sown on 30th Nov. as compared 20th Dec. With above in formations, this study was undertaken to determine, the effects of different cultural practices such as wheat genotypes, doses of nitrogen fertilizer, number of irrigations and dates of wheat sowing on severity of leaf blight under terai condition.

MATERIALS AND METHODS

The experiment was conducted using factorial Randomized Complete Block Design for three consecutive years: 2000/ 2001, 2001/2002, and 2002/2003 at Regional Agriculture Research Station, Tarahara, Sunsari, Nepal. There were four replications. The plot size was 4- × 3-m. The four factors were two wheat genotypes (RR- 21 and Nepal-297), two numbers of irrigations (two and three), two doses of Nitrogen (60 kg N/ha and 120 kg N/ha) and two dates of wheat sowing (3rd week of Nov and first week of Dec). Phosphorous and potash were applied at the rate of 40 kg/ha each as basal. Half of the nitrogenous fertilizer was applied as basal and remaining half as fist top dressing after 30 days of wheat sowing. There were sixteen treatments combinations in each replication. Plants height in cm. (five plants from each plot of each treatment), number of tillers/plant (five plants from each plot), thousand kernel weight in gram, grain yield/ plot in kg, disease score at three times based on whole leaves and flag leaf infection were recorded using double digits methods (Duveiller 2000). Area under Disease Program Curve (AUDPC) was calculated using Shanner and Finney (1998) method. Data were analyzed using MSTAT-C computer program.

RESULTS AND DISCUSSION

Effect of genotypes on yield, yield components and disease

In first year of experimentation, there was no significant effect of genotypes on AUDPC based on whole plans scoring but there was highly significantly less AUDPC based on flag leaf infection in case of Nepal-297. Thousand kernel weight was significantly more in Nepal-297. All other parameters except plant height were non significant. In second years of experimentation all parameters were highly significantly different (Table 1).

Number of tillers/plant, thousand kernel weight, and grain yield/ plot were higher in case of Nepal-297. Panicle length, AUDPC based on whole plant, percentage terminal disease, AUDPC based of flag leaf infection were less in Nepal-297 (Table 2).

Table 1. Effect of different factors on disease components and yield of wheat in 2000/2001

	Factors	Plant height, cm	No of tillers/plant	Panicle length, cm	Thousand grain wt, g	Grain yield/plot, kg	Disease		
							AUDPC total leaf	% Flag leaf inf.	AUDPC flag leaf
1	**Varity**								
	RR-21	95.9	4.1	7.9	37.2	1.9	1115.1	50.0	401.3
	Nepal-297	85.2	3.9	7.7	44.0	2.0	1132.8	48.8	33.0
	Significance	**	ns	ns	**	ns	ns	ns	**
2	**No of irrigations**								
	Two irrigations	90.7	4.1	7.9	40.7	1.9	1113.3	49.8	362.4
	Three	90.3	3.9	7.8	40.6	1.9	1134.6	48.9	341.9
	Significance	ns	ns	ns	ns	ns	ns	ns	
3	**Doses of fertilizer**								
	60 kg N/ha	90.1	3.8	7.8	40.5	1.7	114.5	50.0	366.2
	120 kg N/ha	91.0	4.1	7.9	40.8	2.1	1102.7	48.8	338.1
	Significance	ns	*	ns	ns	**	ns	ns	*
4	**Date of sowing**								
	Mid Nov sowing	92.1	4.3	7.9	42.5	2.4	1150.7	52.0	421.2
	1st week of Dec sowing	89.0	3.8	7.7	38.8	1.5	1097.2	46.7	283.0
	Significance	**	**	ns	**	**	**	**	**

Table 2. Effect of different factors on leaf blight disease, yield and yield components in 2001-2002

	Factors	Plant height, cm	No of tillers/ plant	Panicle length, cm	Thousand grain wt, g	Grain yield/plot, kg	Disease		
							AUDPC total leaf	% Flag leaf inf.	AUDPC flag leaf
1	**Varity**								
	RR-21	100.3	6.	10.7	40.1	1.809	476.6	29.2	153.0
	Nepal-297	90.9	7.8	9.5	45.7	2.621	426.6	20.7	102.8
	Significance	**	**	**	**	**	**	**	**
2	**No of irrigations**								
	Two irrigations	95.8	7.5	10.3	42.9	2.220	443.8	28.0	144.5
	Three	95.4	7.3	9.9	42.7	2.230	459.4	21.9	111.4
	Significance	ns	ns	ns	ns	ns	ns	**	
3	**Doses of fertilizer**								
	60 kg N/ha	94.4	7.4	9.8	43.8	2.182	462.5	30.4	158.2
	120 kg N/ha	96.8	7.4	10.4	41.9	2.248	440.6	19.4	97.7
	Significance	*	ns	**	**	ns	ns	**	**
4	**Date of sowing**								
	Mid Nov sowing	94.3	7.5	9.5	45.7	2.322	467.0	33.6	172.5
	1st week of Dec sowing	96.9	7.3	10.7	40.0	2.108	435.0	16.3	83.4
	Significance	*	ns	**	**	*	ns	**	**

In third year of experimentation, all parameter except number of tillers and AUDPC based on whole plant were highly significant and Nepal-297 had less plant height, an panicle length, more thousand kernel weight, and grain yield/plot, less terminal disease score and AUDPC based on flag leaf infection (Table 3).

AUDPC based on whole plant was not significantly different between genotypes because RR-21 is leaf blight susceptible and Nepal-297 was moderately susceptible wheat verities. Chaurasia (1997) reported that from yield loss point of view flag leaf infection is more important. AUDPC based on flag leaf infection was highly significantly less in case of Nepal-297 as compared to RR-21 (Figure 1).

Table 3. Effect of different factors on disease components and yield of wheat in 2002/2003

	Factors	Plant height, cm	No of tillers/ plant	Panicle length, cm	Thousand grain wt, g	Grain yield/plot, kg	Disease		
							AUDPC total leaf	% Flag leaf inf.	AUDPC flag leaf
1	**Varity**								
	RR-21	100.2	3.5	10.2	43.2	2.266	1204.6	47.5	600.6
	Nepal-297	82.2	3.5	9.3	46.8	2.508	1171.8	40.9	550.5
	Significance	**	ns	**	**	**	ns	**	**
2	**No of irrigations**								
	Two irrigations	96.1	3.4	9.8	45.1	2.353	1181.3	47.7	577.9
	Three	96.2	3.5	9.7	44.8	2.240	1195.3	44.6	593.1
	Significance	ns	ns	ns	ns	ns	ns	ns	ns
3	**Doses of fertilizer**								
	60 kg N/ha	94.3	3.1	9.4	45.7	2.127	1260.9	46.8	637.2
	120 kg N/ha	98.1	3.9	10.1	44.3	2.647	1115.6	45.6	533.9
	Significance	**	**	**	**	**	**	ns	**
4	**Date of sowing**								
	Mid Nov sowing	94.3	3.5	9.6	15.8	2.228	1296.8	46.5	655.6
	1st week of Dec sowing	98.1	3.5	9.8	44.2	2.545	1079.8	45.8	515.5
	Significance	**	ns	ns	**	**	**	*	**

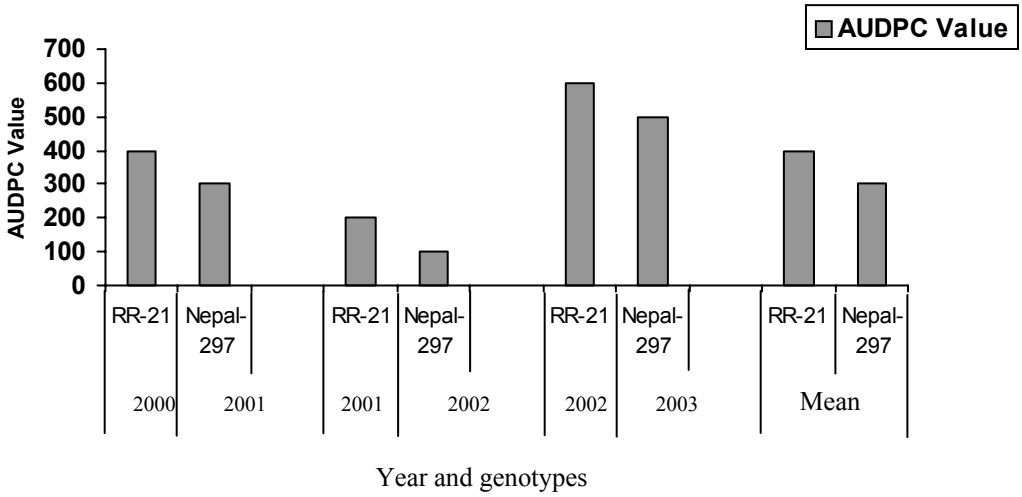


Figure 1. Area Under Disease Progress Curve value based on flag leaf infection of two genotypes in different years at Tarahara.

Therefore, it is expected that yield loss due to disease will be less in Nepal-297 as compared to RR-21.Shrestha et al (1998) reported more yield loss in RR-21 as compared to Nepal-297. This is inconformity of our finding that yield loss depends more on magnitude of severity of disease on flag leaf infection as compared to AUDPC based on whole plant leaf infection.

Effect of number of irrigations on yield, yield components and disease

In first year of experimentation, there was no significant effect of number of irrigation on non of the parameters recorded because there was frequent rain during experimentation period (Figure 2).

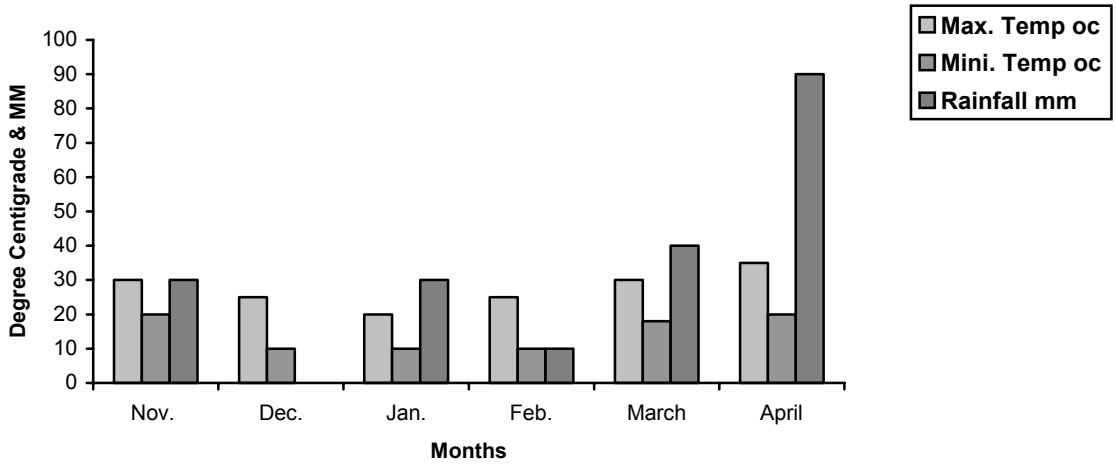


Figure 2. Mean whether parameters of experimental period, 2000-2003.

In second year of experimentation, AUDPC based on flag leaf infection was significantly less in case of Nepal-297. In third year, none of the parameters recorded were significantly affected by number of irrigations as there was rain during experimentation period. Sharma and Duveiller (2004) reported less yield reduction due to HLB in optimum soil moisture condition compared to less soil moisture condition.

Effect of doses of nitrogen fertilizer on yield, yield components and diseases

In the first year of experimentation, there was no significant effect of doses of nitrogen fertilizer on plant height, panicle length, thousand kernel weights and AUDPC based on whole plant. But AUDPC based on flag leaf infection, gain yield/plot, numbers of tillers/plant were significantly different. Number of tillers/plant, grain yield kg/plot were significantly more in higher dose of nitrogen, and disease AUDPC based on flag infection was less in higher dose of nitrogen (Table 1). Higher dose of nitrogen had significant effect in increasing plant height, panicle length and decreasing thousand kernel weight and AUDPC based on flag leaf infection (Table 2) in 2nd year of experimentation. Higher dose of nitrogen had highly significant effect in increasing plant height, number of tillers/plant, panicle length and grain yield/plot but had highly significant effect in lowering the AUDPC based on whole plant and flag leaf infection (Table 3, Figure 3).

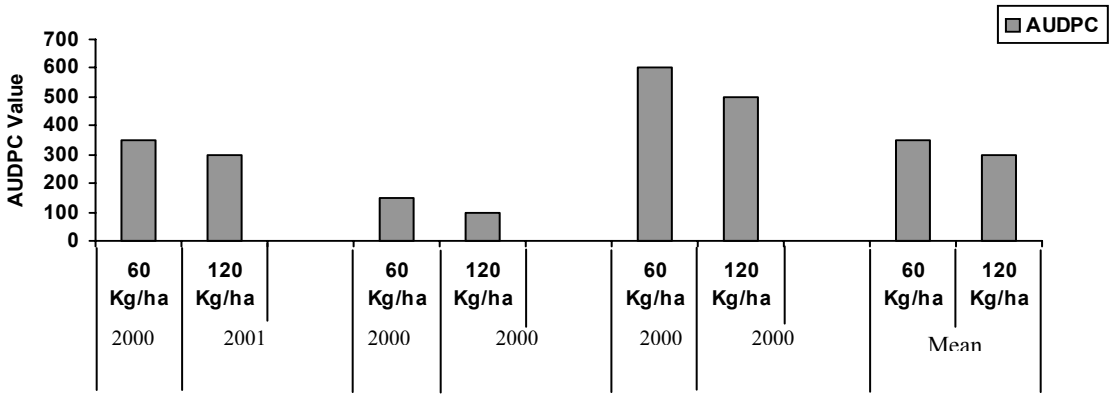


Figure 3. Effect of doses of nitrogen fertilizer on AUDPC based on flag leaf infection in different years.

Ruckstuhul (1998) reported that low or imbalance soil nutrient levels predispose plants to more severe attack of leaf blight. Sharma and Duveiller (2004) also reported that higher value of AUDPC was found under low soil fertility condition compared to higher soil fertility condition. Our finding also indicated that low dose of nitrogen fertilizer had more disease as compared to higher dose of nitrogen. However, it is in conflict with finding of Singh et al (1998) who reported more disease with higher dose of nitrogen fertilizer.

Effect of dates of sowing of wheat on yield, yield components and disease

In first year of experimentation, first week of December sowing had highly significant effect on plant height, number of tillers/plant, thousand kernel weight, grain yield/plot, AUDPC based on whole plant as well as on flag leaf infection. These values were lower ion case of delay sowing of wheat. Disease was less when wheat was sown late but it also reduces the yield (Table 1). In second year of experimentation, late (1st week of Dec) wheat sowing had highly significant effect on plant height, panicle length, thousand kernel weight, grain yield/plot, terminal disease score and AUDPC based on flag leaf infection. All these parameters except plant height were less (Table 2).

Similar results were found from the third year experimentation (Table 3). There was significant effect of late sowing on AUDPC based on whole plant as well as flag leaf infection (Figure 4).

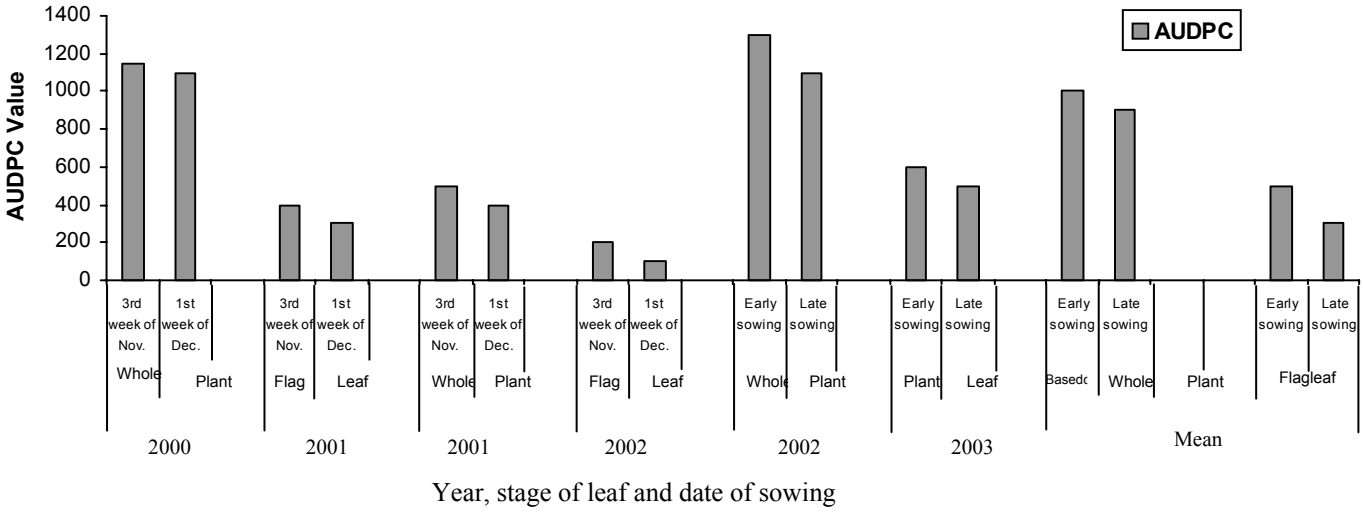


Figure 4. Effect of date of sowing on AUDPC based on whole plant & flag leaf infection in different years.

Singh et al (1998) reported low incidence of leaf blight when wheat was sown on 4th week of Nov. as compared to late sown of wheat. Our findings contradict with there. Our findings indicated that there was less AUDPC when crop was sown late (1st week of Dec) as compared to early sown (3rd week of Nov).

Form three years of experimental results, it can be concluded that Nepal-297 had relatively less area under disease progress curve, number of irrigations showed no significant effect on AUDPC as there was frequent rain during experiment period. Hundred kg of nitrogen application/hectare and late sowing (1st week of Dec) had resulted significantly less Area Under Disease Progress Curve values. Therefore to minimize the severity of leaf blight of wheat, wheat growers of this region should be advised to practice growing Nepal-297 or similar genotypes of wheat with application of relatively high dose of nitrogen fertilizer and late sowing. These will help in lowering the severity of leaf blight in eastern Tarai.

ACKNOWLEDGEMENT

The authors are very much thankful to Regional Directors, RARS, Tarahara for providing support in conducting the trial and also very much thankful to P Khatri and Balkumari Chhetri for their help in conducting the experiment.

REFERENCES

Bimb HP. 1979. Effect of DM-45 for control of leaf blight of wheat caused by *Helminthosporium spp.* **In:** *Annual Report 1978-1979*. National Wheat Research Program, Nepal Agricultural Research Council, Bhairahawa, Rupandehi, Nepal. Pp. 80-85.

Chaurasia PCP. 1997. Determination of a relationship between disease severity of leaf blight of wheat and grain yield loss. **In:** *Proceedings of Wheat Crops Research Paper Seminar* held at Wheat Research Program Bhairahawa, Sept. 7-10, 1975..

Duveiller E, I Garcia, J France, J Toledo, J Crossa and F. Lopez. 1998. Evaluating spot blotch resistance of wheat improving disease assessment under controlled condition and field. **In:** *Helminthosporium blights of wheat spot blotch and tan spot* (E Duveiller, HJ Dubin, J Reeves and A Mchab, eds). CIMMYT, Mexico, D.F.

Duveiller E. 2000. *Instruction sheet of 9th helminthosporium monitoring nursery 2000*. CIMMYT.

Karki CB and M Horsford. 1986. Epidemic of wheat blight in Nepal caused by *Pyrenophora tritici*- repentis. *Nepalese J. Agric.* 17-69-74.

Mahato BN and GP Sedhai. 1994. Loss assessment of wheat due to foliar blight. **In:** *Wheat Proceedings*. National Wheat Research Program, Nepal Agriculture Research Council, Bhiarahawa, Rupendehi, Nepal. Pp. 100-105.

NWRP 1996. Wheat disease report. **In:** *Annual Report 1995-1996*. National wheat Research Program (NWRP), Nepal Agricultural Research Council, Bhairahawa, Rupendehi, Nepal. Pp. 78-81.

NWRP 1977. Wheat disease report. **In:** *Annual Report 1976-1977*. National Wheat Research Program (NWRP), Nepal Agricultural Research Council, Bhairahawa, Rupandehi, Nepal. Pp. 70-80.

Ruckstuhl M. 1998. Population structure and epidemic of *Bipolaris sorakiniana* in rice-wheat cropping pattern in Nepal. **In:** *Helminthosporium blights of wheat spot blotch and tan spot* (E Duveiller, HJ Dubin, J Reeves and A Mchab, eds). CIMMYT, Mexico, D.F.

Shanner G and RE Finney. 1998. The effect of nitrogen fertilizer on the expression of slow mildwing resistancee in Knox wheat. *Phytopatholpgy* 67:1051-1056.

Sharma RC and E Duveiller. 2004. Effect of Helminthosporium leaf blight on performance of timely and late-seeded wheat under optimal and stresses levels of soil fertility and moisture. *Field Crop Research* 89:205-218.

Shrestha KK, RD Timla, BN Mahato and HB Bim 1998. Disease incidence and yield loss due to foliar blight of wheat in Nepal. **In:** *Helminthosporium blights of wheat spot blotch and tan spot* (E Duveiller, HJ Dubin, J Reeves and A Mchab, eds). CIMMYT, Mexico, D.F.

Singh RV, AK Singh, R Ahmad and SP Singh. 1998. Influencee of agronomic practices on foliar blight and identification of alternate hosts in the rice-wheat cropping systems. **In:** *Helmonthosporium blights of wheat spot blotch and tan spot* (E Duveiller, E, HJ Dubin, J Reeves and A Mchab, eds). CIMMYT, Mexico, D.F.

Effect of Supplementation of Soybean Cake and Fishmeal with Lysine and Methionine in Broiler Diets on the Growth Performance of Turkey Poults

Mukesh Karki

Regional Agricultural Research Station-NARC, Parwanipur

ABSTRACT

The study was carried out during June to August 2003, using one hundred and eight day old turkey poults which were randomly divided into twelve groups, 9 birds in each. Three replicate were allocated to each four dietary treatments. Commercially available broiler feed (Ratna feed) was considered as basal diet (Diet-1), Diet-2 was prepared by addition of lysine (0.3%) + methionine (0.1%) to Diet-1, Diet-3 was prepared by supplementation of soybean cake (15%) + lysine (0.2%) + methionine (0.1%) to Diet-1and Diet-4 was formulated by addition of soybean cake (10%) + fishmeal (5%) in Diet-1. Each diet was offered ad lib. from one week to 10 weeks of age. Observation on weekly body weight, weekly and cumulative feed consumed was accessed. Weekly body weight gain and feed conversion ratio was calculated. Economics of dietary treatments in terms of income over chicks and feed cost was also calculated. Significantly higher body weight ($P < 0.01$) was observed in birds fed with Diet-3 (1881.5 ± 17 g), followed by Diet-4 (1745.3 ± 33 g) and Diet-2 (1460.8 ± 51 g) as compared to Diet-1 (1125.2 ± 20 g) up to 10 weeks of age. The birds fed with supplemented diet consumed significantly ($P < 0.01$) higher feed than that of basal diet. The average additional profit per bird fed with supplemented diets over basal diet was found to be Rs 31.21, Rs 29.4 and Rs 9.92 for Diet-3, followed by Diet-4 and Diet-2, respectively. The results showed that supplemented diets were more economical than that of basal diet. It may be concluded that supplementation of either soybean cake (15%) along with lysine (0.2%) and methionine (0.1%) or soybean cake (10%) and fishmeal (5%) in commercial broiler ration could be beneficial for enhancing higher body weight of turkey poults and resulted higher gross income as compared to basal diet (broiler ration).

Key words: Fishmeal, lysine, methionine, soybean cake, turkey

INTRODUCTION

Turkey is an important poultry species reared for meat production. In Nepal, Turkey was introduced on January 2001 for research with an aim to diversify meat production from different avian species. In Nepal, this bird is not fully exploited commercially; hence the balance feed formulated for turkey is not available commercially. Although the feed ingredients for rations formulation are the same as chicken, the feed requirement differs from those of chicken. However, experienced farmers may easily prepared turkey feed either self or in consultation with poultry nutritionists. Tyagi (2001) suggested that turkey diet needs a narrower energy to protein ratio as compared to chicken diet. Bhanja and Majumdar (2001) and Sell et al (1994) reported that turkey need high protein diet at early stage i.e. 28% protein and 2800 Kcal ME with lysine (1.6%) and methionine (0.55%) up to 4 weeks of age, 25% protein and 2900 Kcal ME with lysine (1.5%) and methionine (0.45%) for 5-8 weeks, 22% protein with 3000 Kcal ME for 9-12 weeks and then slowly the protein content is decreased and dietary metabolic energy is increased with age. Karki (2004) observed in Parwanipur Nepal that poor feed efficiency was associated in turkey poults fed in broilers diet as compared to standard formulated diet ie 28% protein with 2800 Kcal ME up to 5 weeks and 24% protein with 2900 Kcal ME for 6-10 weeks. This indicated that commercially available broiler ration may not able to sustain rapid growth of turkey particularly at early age due to having low protein contain and have a wider energy to protein ratio along with lower percent of lysine and methionine. In general commercial broiler starter ration have 23% protein and 2900 Kcal ME with

lysine (1.22%) and methionine (0.83%) (Panda et al 1997). Sell et al (1994) reported that reduced level of protein can decrease early growth in turkey. Protein requirements of turkey poults could be reduced by supplementation with lysine, methionine and theronine (Waibel et al 2000). He further addressed that lysine and methionine are first and second limiting amino acid in soybean-corn meal diets for turkey. Presently balance feed of turkey is not commercially available, in this context improving the quality of broiler feed by addition of protein containing ingredients like soybean cake and fishmeal with lysine and methionine could be the possible alternative to achieve rapid growth of turkey poults. So, this experiment was conducted to find out the growth performance of turkey poults on broiler diet supplementing with soybean cake, fishmeal with lysine and methionine.

MATERIALS AND METHODS

The study was conducted at Poultry Research Unit of Regional Agricultural Research Station, Parwanipur during June 2003 to August 2003. The study comprised of a day old one hundred and eight turkey poults which were randomly divided into twelve groups. Nine birds were allocated to each group. Three replicate groups were allotted to each four dietary treatments. Commercial available broiler feed (Ratna feed) was considered as basal diet (Diet-1), Diet-2 was prepared by addition of lysine (0.3%) + methionine (0.1%) to Diet-1, Diet-3 was prepared by supplementation of soybean cake (15%) + lysine (0.2%) + methionine (0.1%) to Diet-1 and Diet-4 was formulated by addition of soybean cake (10%) + fishmeal (5%) in Diet-1. Each diet was offered ad lib. from one week to 10 weeks of age. Adequate fresh water and uniform standard management were provided to all the birds throughout the experimental period. Observation on weekly body weight, weekly and cumulative feed consumed was accessed. Weekly and cumulative body weight gain and feed conversion ratio was calculated. The data were analyzed statistically by using MSTAT-C statistical package. Economics of dietary treatments was also calculated.

RESULTS AND DISCUSSION

Body weight gain

The mean weekly body weights of turkey poults fed with four different dietary levels from 1 to 10 weeks of age is presented in Table 1. Table clearly showed that supplemented diet have significantly positive influence on weekly body weight gain ($P < 0.01$). Average body weight of 1881.5 ± 17 g, 1745.3 ± 33 g, 1460.8 ± 51 g and 1125.2 ± 20 g was observed in birds fed with Diet-3, followed by Diet-4, Diet-2 and Diet-1, respectively. The body weight recorded in this trial are lower as compared to the reported by Karki (2004) who recorded 2.225 kg with the ration containing 28% protein and 2800 Kcal ME as starter, and 24% protein with 2900 Kcal ME up to 10 weeks of age. Similarly, average body weight of 5.2 kg (Sell et al 1994) and 3.17 kg (Panda et al 1997) was recorded at 10 weeks of age in large-type turkey. Lowered body weight of turkey recorded in this experiment might be due to the result of small variety, lack of standard ration and inadequate housing management.

Table 1. Weekly body weight (average ± SE) of turkey poults fed with four dietary treatments, g

Diets	1week	2 week	3 week	4 week	5 week	6 week	7 week	8 week	9 week	10 week
1	92.97 ± 0.81	131.63 ± 0.54	203.43^{c} ± 1.02	276.2^{c} ± 3.13	379.04^{c} ± 11.73	499.5^{c} ± 15.53	610.71^{c} ± 10.31	757.15^{d} ± 22.96	908.33^{d} ± 6.29	1125.2^{d} ± 20.89
2	97.53 ± 1.51	137.03 ± 2.75	218.10^{b} ± 2.63	310.5^{b} ± 5.29	459.52^{b} ± 9.56	641.9^{b} ± 13.66	804.77^{b} ± 7.25	1005.9^{c} ± 14.63	1199.8^{c} ± 9.13	1460.8^{c} ± 51.16
3	93.67 ± 2.55	141.67 ± 2.87	249.13^{a} ± 4.71	369.4^{a} ± 5.51	547.54^{a} ± 11.89	766.9^{a} ± 21.66	1009.5^{a} ± 20.24	1284.7^{a} ± 37.6	1528.2^{a} ± 44.28	1881.5^{a} ± 17.09
4	95.8 ± 2.68	141.37 ± 3.15	240.47^{a} ± 5.29	367.1^{a} ± 1.1	530.64^{a} ± 14.08	763.9^{a} ±	967.86^{a} ± 25.75	1191.6^{b} ± 28.89	1446.4^{b} ± 14.43	1745.3^{b} ± 33.08

						15.35				
P-value	0.2545	0.1258	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LSD (0.05)	6.35	9.59	13.68	13.69	32.19	48	52.68	79.76	3.09	128.83

Means bearing different superscripts in same column different significantly.

Table 2. Weekly net weight gain (average) of turkeys poults fed with four dietary treatments, g

Diets	2 week	3 week	4 week	5 week	6 week	7 week	8 week	9 week	10 week
1	39.7	71.81	72.76	102.87	120.48	111.08	146.44	151.18	216.91
	(43.2)†	(54.55)	(35.78)	(37.24)	(31.78)	(22.23)	(23.92)	(19.97)	(23.87)
2	39.4	81.06	92.38	149.06	182.38	162.86	201.19	193.81	261.07
	(40.41)	(59.15)	(42.34)	(48.01)	(39.79)	(25.37)	(24.99)	(19.27)	(21.71)
3	48	107.43	120.27	178.2	218.7	242.62	275.19	243.45	353.33
	(51.38)	(75.83)	(48.29)	(48.24)	(40.02)	(31.64)	(27.23)	(18.95)	(23.26)
4	45.6	99.08	116.67	173.37	233.41	203.97	223.81	254.76	298.84
	(47.85)	(70.08)	(48.49)	(47.23)	(44.06)	(26.7)	(23.14)	(21.38)	(20.64)
P-value	0.2169	0.0000	0.0000	0.0006	0.0012	0.0038	0.0017	0.0047	0.1025
LSD (0.05)	10.55	6.57	5.36	22.16	37.10	51.49	41.89	45.5	111.22

† *Relative growth rate percentages are given in parenthesis.*

Weekly net weight gain

The Table 2 revealed a significant difference ($P < 0.01$) among the four dietary treatments for weekly weight gain of turkey poults for all weeks except 2nd and 10th weeks of age. Higher relative growth rate percentage was observed in birds fed with Diet-3 and Diet-4 than that of Diet-1 and Diet-2, which was mainly distinct during 3rd weeks of age.

Feed consumption

The weekly and cumulative feed consumption of turkey poults are given in Table 3. The Table clearly indicated that the dietary treatment have significant influence on feed consumption ($P < 0.01$) with the birds fed with supplemented diet exhibiting more feed intake than that of basal diet. Cumulative feed consumption was found to be higher in Diet-3 (5562 g), followed by Diet-4 (5296 g), which were significantly higher ($P < 0.01$) than others treatment but non significant difference was exist to each other. The data observed in this experiment was lower than that of reported by Karki (2004), Panda et al (1997) and Sell et al (1994) who reported 6.33 kg, 6.8 kg and 9.37 kg feed, respectively. It is reported that an inverse relationship exists between the ME concentration of the diet and feed consumption of turkeys (Sell et al 1994). Turkey diet needs a narrower energy to protein ratio as compared to chicken diet. Lowered feed intake of turkey birds fed with Diet-1 and Diet-2 in this experiment might be due to the cause of wider energy to protein ratio.

Table 3. Weekly and cumulative feed intake (average, SE) of turkeys poults, g

Diets	2 week	3 week	4 week	5 week	6 week	7 week	8 week	9 week	10 week	Cumulative
1	156.9	231.3b†	274b	289b	339.3c	323.6c	472.5c	527.1c	634.62c	3248c
	± 1.77	± 7.14	± 13.7	± 22.4	± 3.34	± 23.4	± 17.2	± 30.9	± 14.83	± 112
2	160.6	269.7a	369.5a	365.1a	474.1b	525b	612b	708.9b	897.17b	4382b
	± 4.67	± 3.02	± 13.6	± 6.49	± 2.51	± 25.8	± 21.6	± 25.7	± 48.09	± 122
3	167.9	289.9a	387.6a	409.7a	533.9a	711.3a	884.2a	962.5a	1214.9a	5562a
	± 2.05	± 14.6	± 17.1	± 27.48	± 23.9	± 37.9	± 42.61	± 31.5	± 25.27	± 199
4	165.3	275.2a	403.8a	404.1a	563.6a	687.4a	796.8a	887.7a	1111.6a	5296a
	± 4.67	± 2.07	± 12.5	± 10.52	± 23.8	± 30.01	± 36.7	± 40.5	± 44.15	± 169
P-value	0.213	0.0068	0.0024	0.0137	0.0001	0.0003	0.0001	0.0002	0.0002	0.0001
LSD (0.05)	11.85	25.58	48.73	65.8	48.96	99.53	93.52	105.14	134.77	510.95

† *Means bearing different alphabet in the same column differs significantly.*

Table 4. Weekly and cumulative feed conversion ratio

Diets	2 week	3 week	4 week	5 week	6 week	7 week	8week	9 week	10 week	Cumulative
1	3.96	3.22a	3.76ab	2.82a	2.82	2.93	4.593	3.607	2.97	3.144

2		4.08	3.33a	4.01a	2.46b	2.633	3.307	3.043	3.673	3.557	3.218
3		3.48	2.69b	3.22c	2.29b	2.44	2.93	3.227	4.013	3.503	3.11
4		3.68	2.78b	3.48bc	2.33b	2.42	3.373	3.557	3.857	3.737	3.21
P-value		0.2158	0.007	0.0238	0.0075	0.3605	0.3292	0.4744	0.8527	0.4547	0.596
LSD (0.05)		0.667	0.323	0.456	0.25	0.572	0.695	2.459	1.251	1.142	0.218

Means bearing different alphabet in a column differ significantly.

Feed conservation ratio (FCR)

The weekly and cumulative feed conservation ratio of turkey poults assign to four dietary treatments are presented in Table 4. The data indicated that Diet-3 and Diet-4 have significantly better ($P < 0.01$) FCR than that of Diet-1 and Diet-2 at 3rd weeks of age. Similarly, better FCR was observed in Diet-3 followed by Diet-4 at 4th weeks and significantly poor feed efficiency ($P < 0.01$) was associated in basal diet as compared to others during 5th weeks of age. However, non significant difference among four dietary treatments was observed for weekly FCR during 6th to 10th weeks of age. At 9th and 10th weeks of age slightly better weekly feed efficiency was recorded in birds of basal diet that might be due to lower feed consumed of the birds as compared to supplemented diet. This reflected the possibility of using broiler diet to turkey poults after 8th weeks of age. Though, non significant difference was observed among the different dietary levels for cumulative FCR, lower value was found in Diet-3 (3.11), followed by Diet-1 (3.14), Diet-4 (3.21) and Diet-2 (3.22); which all are higher than reported by Karki (2004) ie 2.98 and Panda et al. (1997) ie 2.2. Similarly, Osti (2002) observed higher body weight gain, better feed efficiency, better feed consumption and higher gross income per bird of quail fed on layer starter ration supplemented with 5% fishmeal with 0.25% lysine and 0.125% methionine than that of basal ration.

Mortality

During entire experimental period, higher mortality was observed in Diet-1 (7.4%), followed by Diet-3 (3.7%) but no mortality was observed in other treatments. After 5 weeks of age lameness was observed in birds fed with Diet-1 (26.85%) and Diet-2 (14.81%), which was recovered by liquid feed supplementation. Incrustation in the corner of mouthparts was also appeared in birds of Diet-1 and Diet-2, which was disappeared with advancement of age by feeding of liquid multivitamins. Similar problems were also observed in turkey poults reared under farmers' ordinary feed and management condition (personal experience). The appearance of lameness and incrustation might be due to lack of adequate balance nutrition required for sustaining rapid growth of turkey.

Table 5. Economics of different feed treatments of Turkey rearing up to 10 weeks age

SN	Parameter	Diet-1	Diet-2	Diet-3	Diet-4
1	Initial cost of bird, Rs	40	40	40	40
2	Selling price of bird, Rs/kg live weight	110	110	110	110
3	Price of feed, Rs/kg	17	18.9	19.04	17.87
4	Feed consumed per bird, kg	3.284	4.382	5.562	5.296
5	Total feed cost per bird, Rs	55.83	82.82	107.8	94.63
6	Final weight per bird (up to 10 weeks of age), kg	1.125	1.461	1.882	1.745
7	Selling income per bird, Rs	123.75	160.71	207.02	191.97
8	Average profit per bird over chicks and feed cost, Rs	27.95	37.87	59.16	57.35
9	Additional profit per bird of supplemented diets over Diet-1		Rs 9.92	Rs 31.21	Rs 29.4

Economics of feeding

The detail of economics of four dietary treatments for turkey rearing up to 10 weeks of age is given in Table-5. The table clearly revealed that higher net income over feed and chicks cost was found in bird fed with Diet-3 (Rs 59.16), followed by Diet-4 (Rs 57.35) and Diet-2 (Rs 37.87) than that of birds reared on basal diet (Rs 27.95). The net income obtained in this experiment was lower than reported by Karki (2004). Similarly the average additional profit per bird fed with supplemented diets over basal diet was found to be Rs 31.21, Rs 29.4 and Rs 9.92 for Diet-3, followed by Diet-4 and Diet-2, respectively. The results showed that supplemented diets were more economical than that of basal diet.

The experiment clearly indicated that supplementation of either soybean cake (15%) along with lysine (0.2%) and methionine (0.1%) or soybean cake (10%) and fishmeal (5%) in commercial broiler ration could be beneficial for enhancing higher body weight of turkey poults up to 10 weeks of rearing and resulted higher gross income as compared to basal diet (broiler ration). As no published report on this aspect is appear to available, it is obligatory to verify the results through conducting comprehensive experimentations in future.

REFERENCES

Bhanja SK and S Majumdar. 2001. Formulation of turkey feed. **In:** *Modern turkey production and management* (AKD Roy, ed). Turkey Research Unit, Central Avian Research Institute, Izatnager, India. Pp. 49-52.

Karki M. 2004. Comparative performance of turkey poults on broilers ration versus formulated ration. **In:** *Paper presented in Sixth National Workshop on Livestock and Fisheries Research in Nepal*, 1-2 July, Khumaltar, Lalitpur, Nepal.

Osti NP. 2002. Layers starter ration with methionine and lysine supplements an ideal approach of rearing quails. **In:** *Proceeding of 5th National Workshop on Livestock and Fisheries Research in Nepal* (AK Rai and AP Nepal, eds), 10-11th July 2002, Khumaltar, Lalitpur, Nepal. Pp. 44-50.

Panda B, VR Reddy, VR Sadagopan and AV Shrivastav. 1997. *Feeding of poultry* (1st Edition). Publication and Information Division, Indian Council of Agricultural Research, New Delhi. 85 pp.

Sell JL, FH Kratzer, JD Latshaw, SL Leeson, ET Moran, CM Parsons and PW Waldroup. 1994. *Nutrient requirements of poultry* (9th Edition). National Academy Press, Washington, D.C. 155 pp.

Tyagi PK. 2001. The nutritional requirement of commercial turkeys. **In:** *Modern turkey production and management* (AKD Roy, ed). Turkey Research Unit, Central Avian Research Institute, Izatnager, India. Pp. 18-24.

Waibel PE, CW Carlson, JA Brannon and SL Noll. 2000. Limiting amino acids after methionine and lysine with growing turkeys fed low-protein diets. *Poultry* 79:1290-1298.

Nutritional Variation of Different Feed Ingredients and Compound Feed Found in Different Parts of Nepal

Megh R. Tiwari[1], Shreekrishna Khanal[2], Basanta Shrestha[2] and Raj K. Jha[2]

[1]Regional Agricultural Research Station, Lumle, Kaski
[2]Animal Nutrition Division, Kumaltar, Lalitpur

ABSTRACT

Many feed industries in various parts of the country have been producing and marketing different types of compound feeds. The source of feed ingredients also varies greatly which will ultimately lead to the variation in the quality of finished products. Altogether 493 samples of 50 different feed ingredients and compound feed were collected from Baglung, Baitadi, Banke, Chitwan, Darchula, Dolakha, Dolpa, Gorkha, Ilam, Jhapa, Kathmandu, Kaski, Lalitpur, Lamjung, Morang, Mahottary, Makwanpur, Myagdi, Nawal Parasi, Parbat, Parsa, Rasuwa, Rupandehi, Sankhuwasava, Sunsari, Saptari, Sarlahi, Sindhupalchok, Siraha, Syangja and Tanahun districts. Highest content of dry matter (99.51%), organic matter (98.45%), total ash (98.14%) and crude protein (67.85%) was recorded for oyster cell, white maize grain, oyster cell and meat meal respectively. Similarly, the rice husk was found to be superior in crude fibre content (34.46%) In terms of mineral oyster cell was found to be superior in calcium content (35.94%) and bone meal in phosphorous content (1.59%) as compared to other feed ingredients.

Key words: Crude fibre, crude protein, dry matter, feed ingredients, organic matter, total ash

INTRODUCTION

Many feed industries in various parts of the country have been producing and marketing different types of compound feeds. Feed supplements and other feed materials intended for feeding different species of livestock and poultry birds. The source of feed ingredients also varies greatly which will ultimately lead to the variation in the quality of finished products. Quality of these feed materials produced by various feed manufacturers should be required of standard before and after reaching to the farmers for a certain period of time so that farmers get their intended benefit from their animals by feeding these feeds or feed ingredients. Due to the lack of knowledge on nutritive value of feed and feed ingredients farmers are unable to formulate the balance diet for their animals. As a result quality status of these feed ingredients and their effect on animal performance is not known properly. Scientific study on the evaluation of the quality of such feeds and feed ingredients thus becomes necessary to satisfy the farmers, scientists and the feed manufacturers for various purposes. Determining the quality of these feed ingredients will help to address this problem.

Determining the quality of feed ingredients will help select feed industries the appropriate ingredients in maintaining the quality of their product. Both these information will also be useful for the researchers and scientists for preparing suitable feed formulae according to the demand of the farmers.

METHODOLOGY

Sample collection

A household survey with semi structured questionnaire was carried out in 31 districts of Nepal during past 12 years (1990-2001) by Animal Nutrition Division, Khumaltar, Lalitpur for identifying the different feed ingredients which farmers use to feed their animals. Samples of both feed ingredients and

compound feed were taken from the farmer's households during survey period. As per expression of the farmers, generally they used compound feed manufactured by Cattle Feed Industry of Hetauda. The name and number of samples taken from the districts is given in Table 1.

Table 1. District-wise sample collection

SN	District	Number of observation	SN	District	Number of observation
1	Baglung	3	17	Makwanpur	2
2	Baitadi	2	18	Myagdi	7
3	Banke	25	19	Nawal Parasi	13
4	Chitwan	16	20	Parbat	3
5	Darchula	4	21	Parsa	1
6	Dolakha	7	22	Rasuwa	2
7	Dolpa	8	23	Rupendehi	36
8	Gorakha	1	24	Sankhuwasava	9
9	Illam	7	25	Sunsari	12
10	Jhapa	5	26	Saptari	74
11	Kathmandu	21	27	Sarlahi	11
12	Kaski	3	28	Sindhupalchok	5
13	Lalitpur	19	29	Siraha	48
14	Lamjung	13	30	Syangja	2
15	Morang	29	31	Tanahun	2
16	Mahottary	20		Total	493

Chemical and data analysis

The samples were dried to a constant weight under laboratory condition (Aman and Hesselmen 1984) and were grinded approximately 2-mm size as revealed by Wu et al (1994) and Luhaloo et al (1996). Sample were subjected to laboratory analysis for proximate components (AOAC 1980) and mineral (Ca and P). Calcium content was determined by titrimetric method and Phosphorous by photospectrometer. SPSS software was used to analyze data.

RESULTS AND DISCUSSION

Proximate components

Dry matter, organic matter, total ash, crude protein and crude fibre (proximate component) content of different feed ingredients and compound feed is given in Annex 1.

Dry matter (DM)

Annex 1 revealed that altogether 30 types of feed ingredients were evaluated for their dry matter content, however, 43 types were collected. Dry matter content of 14 feed ingredients was found in the range of 85-90 % followed by 90-95 and 80-85%. There were only 2 feed ingredients that had dry matter content above 95%, however it varied between 82.31 to 99.51%. Highest dry matter content was recorded for oyster cell (99.51%) followed by rice husk and bone meal (96.3 and 94.19% respectively). Similarly, the lowest amount of dry matter content was noted in millet grain (82.31%). In case of compound feed, it was noted that feed for broiler 1,2 and 3 had dry matter content almost similar (92. %). Similarly, dry matter content of layer mash 1and 2 was found to be similar (87%) whereas in the feed for layer mash 3 it was higher (90.27%). Likewise, dry matter content of compound feed produced by Cattle Feed Industry, Hetauda for cattle was found to be 84.17%. In general, dry matter content of different feed ingredients and compound feed was observed to be satisfactory.

Organic matter (OM)

Organic matter content of most of the feed ingredient was recorded in the range of more than 95% followed by 90-95%. There were 5 feed ingredients that organic matter content ranged from 85-90% whereas 5 feed ingredient had organic matter in its constituent below 85%. The organic matter content of different feed ingredients varied between 1.86 –98.45%. Highest organic matter content was noted for white maize grain (98.45%) followed by wheat flour and lentil grain (98.34 and 97.93% respectively). Similarly, the least amount of organic matter was observed in oyster cell (1.86%). In case of compound feed, broiler feed for 1,2 and 3 (starter, grower and finisher respectively) contained organic matter 86.88, 87.26 and 92% respectively. Similarly, organic matter content of layer mash 1 and 2 was recorded almost uniform (87.77 and 87.82% respectively) whereas in the feed of layer mash 3 it was 85.16%. Compound feed for cattle of Cattle Feed Industry, Hetauda had organic matter content 90.80 %.

Total ash (TA)

Most of the feed ingredient contained total ash below 5% followed by 5-10% and 10-15%. There were 5 feed ingredients which total ash content above 15%. The total ash content of different feed ingredients was found to vary between 1.55 to 98.14%. The highest total ash content was noted for oyster cell (98.14%) followed by fish meal and bone meal (66.07 and 60.12% respectively). Likewise, least amount of total ash was found in maize white grain (1.55%). In case of compound feed, total ash content of layer mash 1 and 2 was similar (12.23 and 12.18% respectively) whereas for layer mash 3 it was recorded 14.84%. Similarly, total ash content of broiler 1, 2 and 3 was observed 13.12, 12.74 and 8% respectively. The compound feed for cattle prepared by Cattle Feed Industry, Hetauda had 9.2% total ash in its constituent.

Crude protein (CP)

A total of 50 samples were evaluated for crude protein content. Among them, there were 12 samples in which protein content was recorded less than 10% in their constituent. There were 9 samples with crude protein content between 10-15%. Similarly, there were 8 samples each that had crude protein content between 15-20, 20-25 and more than 30% respectively. Likewise, there were only 5 samples of which crude protein content was recorded 25-30%. Highest crude protein content was recorded for meat meal (57.85 %) followed by soybean cake and groundnut cake (45.07 and 41.61% respectively), however it varied from 2.44 to 67.85%. The least amount of crude protein content was found in oyster cell (2.44%). In case of compound feed made by Cattle Feed Hetauda, crude protein content of feed for broiler 3, 1 and layer mash 3 was noted almost similar (20.7, 20.22 and 20.06% respectively). Similarly, in the feed of layer mash 2 and broiler 2 crude protein content was recorded 19.42 and 19.17 respectively. The crude protein content of feed for layer mash 3 and cattle was observed 17.91 and 16.58 respectively.

Crude fibre (CF)

Crude fibre content of 32 samples were evaluated from the collected 50 samples. Crude fibre content of 17 samples was found to be less than 10%. There were 10 samples, which had crude fibre content in the range of 10-15%. Similarly, there were few samples in which crude fibre content ranged between 15-20 and more than 20% respectively. Crude fibre content of different feed ingredients and compound feed was found to vary 2.4-34.46%. The rice husk was found to be superior in crude fibre content (34.46%) followed by pigeon pea, bran and husk (28.33 and 27.31% respectively). The least amount of crude fibre content was recorded for white maize flour (2.4%). Analysis for crude fibre content of Cattle Feed Hetauda revealed that in the feed for broiler 3 had highest crude fibre in their constituent (10.65%). The crude fibre content of feed for cattle, layer mash 1 and broiler 1 was noted similar (8.66, 8.6 and 8.5% respectively). Similarly, crude fibre in the feed for layer mash 2, broiler 2 and layer mash 3 was also found to be similar (7.75, 7.63 and 7.05% respectively).

Mineral content

Mineral (Ca and P) content of feeds and feed ingredients is given in Annex 2.

Calcium (Ca)

Both calcium and phosphorous are important macro elements for animals. Altogether 44 samples were subjected for evaluation of calcium in its constituent. Most of the samples were rich in calcium content (more than 0.6%) followed by 0.2-0.4 and less than 0.2% respectively. There were only 8 samples which had calcium in the range of 0.4-0.6%. Calcium content of different feed ingredients and feed was recorded in the range of 0.02-35.94%. Highest amount of calcium was observed in the oyster cell (35.94%) followed by bone meal and fish meal (22.03 and 3.42% respectively). Similarly, maize bran was found as a poor source of calcium (0.02%) among the collected samples. In case of compound feed manufactured by Cattle Feed Plant of Hetauda, feed for broiler was not evaluated for their calcium content. But feed for layer mash 1, 2 and 3 was rich in calcium content (1.17, 1.83 and 1.45% respectively) than that of feed for cattle (0.46%).

Phosphorous (P)

Among the 44 samples only 42 samples were evaluated for their phosphorous content. Evaluation result showed that there were 15 feed samples, with phosphorous content ranging in between 0.2-0.4% followed by 14 and 10 samples in which phosphorous content was found in the range of more than 0.6% and in between 0.4-0.6% respectively. Phosphorous content of different feed ingredients and compound feed was noted in the range of 0.11-1.88%. Highest amount of phosphorous was found in bone meal (1.59%) followed by rice polish and sunflower cake in which phosphorous content was found to be 1.18 and 1.13% respectively whereas meat meal was recorded with least phosphorous (0.11%). Similarly, feed for cattle and layer mash made by Hetauda Cattle Feed plant contained phosphorous in their constituent in 0.46 and 1.17% respectively.

DISCUSSION

In order to increase the livestock production and productivity, feed is the most important thing. Supplying adequate amount of feed for various livestock species involves the formulation of diet. Good quality feeds are produced from good quality feed ingredients. Feed ingredients are selected on the basis of their nutrient content as determined by chemical analysis. Oyster cells, was found to be superior in dry matter, total ash and calcium content (99.51, 98.14 and 35.94 %) respectively whereas it had least amount of crude protein and organic matter (2.44 and 1.86% respectively). Meat meal was recorded as good source of crude protein (57.85%). In case of crude fibre, rice husk was better (34.46%) than that of other feed ingredients. Similarly, white maize grain was found better for organic matter content (98.45%). Likewise, bone meal is noted as good source of phosphorous (1.59%). All these feed ingredients are easily available in the market and could be used by farmers to formulate the balance ration for their animals. Compound feed made by Cattle Feed Hetauda were found to be satisfactory in dry matter, organic matter, total ash and crude protein content, but it varied between batches. So, it was felt that there was necessity to check the quality of compound feed made by Cattle Feed Hetauda time to time.

Bista and Shrestha (2000) evaluated different feed ingredients from five development regions and reported that soybean found in eastern development region was significantly ($P < 0.05$) rich in protein content (40.3%) than that of central development region (39.9%). Further, they noted that protein content (12.65%) of maize of central development region was significantly higher ($P < 0.05$) than that of other regions (average 6.5%). Devkota et al (1995) analyzed nutrient content of feed mixtures prepared by different farmers and some fodder trees of Chitwan district and found that crude protein content of those feed mixtures was as low as 13.75% which was even lower than that of some fodder trees (Badahar, Kimbu, Dabdabe, Bakaino, Tanki and Dabdabe) found in Chitwan district. Further, they suggested for regular to evaluate the status and quality of concentrates or feeding mixture.

CONCLUSION

The nutrient content of feed ingredients greatly depends upon the soil fertility, time of harvest, cultivation practices, application of fertilizer, frequency of irrigation, agroecological zones and etc**.** Therefore, it is concluded that, the knowledge of the nutrient content of the feed ingredients and compound feed available in Nepal would be useful to formulate ration that are cost efficient, sustainable and increase production performances of the animals.

REFERENCES

Aman P and K Hesselmen. 1984. Analysis of starch and other main constituents of cereal grains. *Swedish J. Agric. Res.*1:135-139.

AOAC. 1980. *Official methods of analysis*. 13th Association of Analytical Chemists. Washington D.C.

Bista JD and RK Shrestha. 2000. Nutritional value and digestibility of fish feed stuffs of Nepal. **In:** *Proceedings of the 4th National Workshop on Livestock and Fisheries Research in Nepal*, 24-26 April. ARS, Pakhribas, Dhankuta Nepal. Pp. 30-38.

Devkota NR, M Sapkota, JL Yadav, SS Pant and KR Pande. 1995. *Indigenous management and nutrient analysis of fodder trees and feed mixtures in Chitwan*. Institute of Agriculture and Animal Science Research Report, 1993-94 (FP Neopane, ed). Pp. 105-116.

Luhallo M, C Tilly and P Aman. 1996. Chemical Composition of air classified and stock sieved fractions of a high fibre rye milling steam. *Swedish J. Agric. Res.* 2:3-10.

Wu Y, AC Strigfellow and GC Inglett. 1994. Protein and α- glucan enriched fractions from high protein, high α-glucan barley's by sieving air classification. *Cereal Chem.* 71:220-223.

Annex 1. Dry matter, organic matter, total ash, crude protein and crude fibre content of feed ingredients and compound feed

SN	Name	Scientific name	Dry matter	Organic matter	Total ash	Crude protein	Crude fibre	No of samples
	Feed ingredients							
1	Bakula bran	*Vicia fava*	-	75.32	24.68	16.42	NA	1
2	Blackgram	*Vigna mungo*	90.01	95.80	4.20	25.25	6.17	6
3	Blackgram bran	*Vigna mungo*	89.20	92.40	7.60	16.35	NA	2
4	Bone meal	-	94.19	39.11	60.12	30.41	NA	3
5	Buckwheat	*Fagopyrum tataricum*	86.77	92.72	7.28	9.31	15.25	5
6	Chick pea	*Cicer arietinum*	91.0	95.98	4.02	17.48	12.56	5
7	Cowpea	*Vigna stnensis*	89.0	95.11	4.89	26.50	8.01	9
8	Fishmeal	-	91.20	33.93	66.07	30.55	2.96	6
9	Horse gram	*Dolichos sps.*	82.80	95.35	4.65	25.0	7.90	2
10	Groundnut cake	*Arachis hypogaea*	-	93.61	6.39	41.61	NA	12
11	Lentil	*Lens culinaris*	-	97.93	2.07	10.28	NA	1
12	Lentil bran	*Lens culinaris Medic*	-	90.58	9.42	13.27	10.40	10
13	Lentil husk	*Lens culinaris*	-	89.07	10.93	9.71	NA	1
14	Maize flour, white	*Zea mays*	84.50	96.36	2.64	9.18	2.40	14
15	Maize flour, yellow	*Zea mays*	87.39	96.82	3.08	9.77	3.03	8
16	Maize, red	*Zea mays*	89.34	97.14	2.86	9.96	4.24	19
17	Maize, white	*Zea mays*	88.98	98.45	1.55	10.97	3.02	13
18	Maize, yellow	*Zea mays*	-	96.09	3.91	9.16	NA	3
19	Maize bran	*Zea mays*	84.50	94.61	5.39	8.26	16.90	2
20	Masyang	*Vigna umbellata*	85.27	96.40	3.60	23.36	7.36	3
21	Meat meal	-	88.89	81.86	18.14	57.85	NA	1
22	Millet	*Eleusine coracana*	82.31	96.71	3.29	7.65	8.64	9
23	Millet bran	*Eleusine coracana*	89.20	92.40	7.60	16.35	NA	1
24	Mung bran	*Vigna radiata*	90.66	94.50	5.50	21.50	NA	3
25	Mustard cake	*Brassica campestris*	91.88	91.28	8.72	27.48	11.60	34
26	Oat	*Avena sativa*	93.11	93.25	6.75	11.40	NA	2
27	Oyster shell	-	99.51	1.86	98.14	2.44	NA	1
28	Pegeon pea	*Cajanus cajan*	87.25	95.48	4.52	23.18	10.82	5
29	Pegeon pea bran	*Cajanus cajan*	86.96	95.46	4.54	13.20	28.33	3
30	Pegeon pea husk	*Cajanus cajan*	-	96.20	3.80	13.32	27.31	2
31	Rice bran	*Oriza sativa*	83.69	86.42	13.38	9.52	12.61	77
32	Rice husk	*Oriza sativa*	96.30	85.19	14.81	6.60	34.46	3
33	Rice polish	*Oriza sativa*	-	89.81	10.19	12.77	11.64	2
34	Sesame cake	*Minum usitatissimum*	90.21	93.57	6.43	24.51	11.30	4
35	Soybean	*Glycine max*	86.74	92.99	7.01	32.0	NA	15
36	Soybean cake	*Glycine max*	92.04	92.34	7.64	45.07	NA	34
37	Sunflower	*Helianthus annus*	-	91.63	8.37	30.03	NA	1
38	Sunflower cake	*Helianthus annus*	-	90.99	9.01	37.29	NA	1
39	Til cake	*Daesamum indicum*	-	88.98	11.02	28.26	12.07	3
40	Wheat	*Triticum astivum*	86.70	96.24	3.76	14.57	2.95	3
41	Wheat bran	*Triticum astivum*	86.75	93.59	6.41	12.65	11.64	36
42	Wheat flour	*Triticum astivum*	-	98.34	1.66	8.40	NA	1
	Compound feed							
1	Broiler 1	-	92.37	86.88	13.12	20.22	8.50	9
2	Broiler 2	-	92.18	87.26	12.74	19.17	7.63	9
3	Broiler 3	-	92.90	92.0	8.0	20.70	10.65	2
4	Cattle feed	-	84.17	90.80	9.20	16.58	8.66	75
5	Layer mash 1	-	87.87	87.77	12.23	20.06	8.60	22
6	Layer mash 2	-	87.74	87.82	12.18	19.42	7.75	17
7	Layer mash 3	-	90.27	85.16	14.84	17.91	7.05	15

Annex 2. Mineral content of feed ingredients and compound feed

SN	Name	Scientific name	Mineral, %	
			Calcium	Phosphorous
Feed ingredient				
1	Bakula bran	*Vicia faba*	1.12	0.29
2	Blackgram	*Vigna mungo*	0.13	0.43
3	Blackgram bran	*Vigna mungo*	0.56	0.38
4	Bone meal	-	22.03	1.59
5	Buckwheat	*Fagopyrum tataicum*	1.15	0.28
6	Chick pea	*Cicer arietinum*	0.23	0.19
7	Cowpea	*Vigna sinensis*	0.22	0.44
8	Fishmeal	-	3.42	0.94
9	Horse gram	*Dolichos* sps	0.29	0.39
10	Groundnut cake	*Arachis hypogaea*	0.30	1.04
11	Lentil	*Lens culinaris*	0.42	0.58
12	Lentil bran	*Lens culinaris*	0.58	0.31
13	Lentil husk	*Lens culinaris*	1.23	0.18
14	Maize flour, white	*Zea mays*	0.11	0.35
15	Maize flour, yellow	*Zea mays*	0.15	0.45
16	Maize, red	*Zea mays*	0.15	0.39
17	Maize, white	*Zea mays*	0.10	0.34
18	Maize, yellow	*Zea mays*	1.80	0.69
19	Maize bran	*Zea mays*	0.02	0.20
20	Masyang	*Vigna unbellanta*	0.26	0.42
21	Meat meal	-	1.64	0.11
22	Millet	*Eleusine coracana*	0.30	0.31
23	Millet bran	*Eleusine coracana*	0.64	0.30
24	Mung bran	*Vigna radiata*	0.38	0.37
25	Mustard cake	*Brassica campestris*	1.25	0.97
26	Oat grain	*Avena sativa*	0.25	0.48
27	Oyster meal	-	35.94	0.80
28	Pigeon pea	*Cajanus cajan*	0.24	0.35
29	Pigeon pea bran	*Cajanus cajan*	0.43	0.21
30	Rice bran	*Oriza sativa*	0.32	0.66
31	Rice husk	*Oriza sativa*	0.11	0.73
32	Rice polish	*Oriza sativa*	0.14	1.18
33	Soybean	*Glycine max*	0.43	0.59
34	Soybean cake	*Glycine max*	1.61	0.67
35	Sunflower	*Helianthus annus*	0.60	1.13
36	Sunflower cake	*Helianthus annus*	0.64	0.98
37	Wheat	*Triticum astivum*	0.12	0.52
38	Wheat bran	*Triticum astivum*	0.55	0.55
39	Wheat flour	*Triticum astivum*	0.64	0.30
Compound feed				
1	Cattle feed	-	0.46	0.82
2	Layer mash 1	-	1.17	0.54
3	Layer mash 2	-	1.83	-
4	Layer mash 3	-	1.45	-

A Survey on Marketing Potential of Maize Seed Production in the Western Hill of Nepal

Kiran R. Joshi

Agriculture Research Station-NARC, Lumle

ABSTRACT

A Marketing Rural Rapid Appraisal Survey (MRRA) was conducted from 12-16 June 2002 in Bhakimli (1725 masl), Myagdi district. Two factors namely gender (male and female) and wealth category rich, medium and poor were considered in accessible area of Bhakimli. Semi-structured questionnaires and checklist were used to collect information on maize seed production, marketing opportunities and marketing system for producers, traders and consumers. The objectives of the study were to understand existing maize seed production, demand and supply; to identify the problems associated with the seed marketing system and policy options for sustainable maize seed production. Farmers groups in Bhakimli were involved in maize seed production and management of marketing. Successful seed production for long-term would ensure a continuous supply of open pollinated variety (OPV) seed in farmers' level. Seed production as a new commercial enterprise created employment opportunities as well as income generating in the Western hills of Nepal.

Keywords: Commercial enterprises, community seed production, employment, income generating, marketing potential

INTRODUCTION

Maize is the second important crop in Nepal. It is a staple crop of the hill people that occupies 825000 ha and contributes 78.3% to the total maize production (14,84,112 ton) in the country (MOAC 2001). Nearly 69% of the maize area in the hills is under local varieties. An improved variety has higher productivity over local by 42% and 39% in the high hills and hills, respectively (MOAC 2001). Although a number of composite varieties have been released for cultivation, their larger spread is impeded by non-accessibility of seeds to the farmers. In Myagdi district, maize occupies 8750 hectare of land with the production of 14350 ton (MOAC 2001). Increasing the access to improved maize seeds for farmers can be an important step towards increasing productivity of maize in the farmer's field. Marketing research on seed is the systematic gathering of information concerning the consumers' need, buying habits and availability of seed for farmers (LARC 1997). A study conducted in Nepal (Seeley 1998) revealed that farmers using regulated OPV seeds noticed significant changes in maize plant and it was stressed that there is a need to develop a long term strategy that would ensure continuing supply of open pollinated variety (OPV) seeds. Initially, Agriculture Research Station, Lumle provided inputs like fertilisers and foundation maize seed as well as seed production training to each community group. Community managed on farm maize seed production program was implemented in Bhakimli, which helped toward establishing a new enterprise for employment, income generation (Joshi et al 2002). In the western hills of Myagdi district, seed production has been initiated jointly by the Agricultural Research Station Lumle, Agricultural Development Office (Myagdi) and Seed Sector Support Project as a partnership program.

METHODOLOGY

A survey on identification of marketing potential of maize seed production was conducted from 12-16 June 2002 at accessible area of Bhakimli ward No 5 of Myagdi district, MRRA was the basic technique

applied. Semi-structured questionnaire was developed for marketing survey. A total of twenty-two questions in relation to seed production systems, supply and demand were considered and asked to the concerned farmers of the village at maize cultivated area for improved and local maize during 2001 and 2002. The questionnaire survey covered 15 farmers 5 in each of three categories viz. farmers with food sufficiency for more than 12 months (A), for 6-12 months (B) and less than 6 months (C). The questionnaire raised to households was both male headed and female headed. After completion of field survey, group discussion was held with farmers, who managed community maize seed production and faced some problems of marketing system of maize associated with improved and local maize seed production. Secondary data was also collected from ADO, Myagdi, SSSP, Beni and Agrovet centres of Beni and Pokhara.

RESULTS AND DISSCUSSION

In the survey area, farmers were growing maize and finger millet as relay crop in *Bari* land. Maize growing period is March – August and millet growing period is July – November. Farmers in category A had total cultivated (*Khet* and *Bari* land) of 1.18 ha, farmers of category B had 0.46 ha and farmers of category C had 0.26 ha. Total maize cultivated area of category A was higher (0.62 ha.) as compared to category B (0.35 ha) and category C (0.22 ha). Farmers grow improved varieties such as Manakamana 3, White hill pool, Yellow hill pool and Rampur Composite and local maize were Seto Makai, Pahenlo Makai and Khairo Makai. Category A produced maize grain yield of 3.2 t/ha, category B produced 3.5 t/ha and category C produced 3.7 t/ha in Bari land of Bhakimli in 2001/2002. Table 1 shows a pattern of land use in survey site.

Table 1. Existing maize production system at accessible Bhakimli ward No. 5 area, western hill, Myagdi district, 2001/02

SN	Farmers categories	A, Mean		Total	B, Mean		Total	C, Mean		Total
		Khet	Bari	area, ha	Khet	Bari	area, ha	Khet	Bari	area, ha
1	Cultivated area, ha	0.62	0.56	1.18	0.19	0.27	0.46	0.10	0.16	0.26
2	Maize cultivated area, ha	0.16	0.46	0.62	0.10	0.25	0.35	0.08	0.14	0.22
3	Maize covered area, ha									
	A) Improved	0.16	0.45	0.61	0.01	0.24	0.25	0.03	0.11	0.14
	B) Local	0.00	0.01	0.01	0.09	0.01	0.10	0.05	0.03	0.08
4	Maize production (improved), t/ha									
	2000/01	-	3.0	3.0	-	3.5	3.5	-	3.5	3.5
	2001/02	-	3.2	3.2	-	3.5	3.5	-	3.7	3.7

There is opportunity for maize seed production in Western hills of Nepal. Community based maize seed production program has been started from 2000/2001 in Bhakimli, Myagdi. Farmers' categories A, B and C require seed of 14.0 kg for 0.46 ha, 7.3 kg for 0.25.ha and 6.0 kg for 0.14 ha respectively. Category A, B and C produced 484.0kg, 280.0 kg and 170.0 kg maize seed respectively for selling purposes to different agencies. Improved seed demand from the neighbour was about 12.2 kg for 0.46 ha. Similarly, farmers households categories of A, B and C in total required 12.4 for 0.54 ha, 7.5 kg for 0.33 ha and 4.2 kg for 0.20 ha respectively. It was found that Bhakimli farmers' demand for improved maize seed was very low (Table 2).

Out of the total amount of seed sold to different agencies, ARS, Lumle purchased 1000 kg of Manakamana 3, 500 kg of White hill pool and 500 kg of Arun 1 from community based seed of 3.05 ha produced at Bhakimli and Dhudhekhola from 17 farmers. Remaining maize seed was exchanged with neighbour farmers as barter system. Community based farmers group sold their maize seed to different agrovets and agencies. 33% of the total cost included for seed sheller, drying, storage losses, grading and transportation cost is only Rs 1-1.50/kg for (Beni) market. The cost of maize seed was Rs 11.60/kg in Myagdi.

Table 2. Opportunities of maize seed production demand and supply system of Bhakimli area, western hill, Myagdi district, 2001/02

SN	Farmers categories	A, Mean	B, Mean	C, Mean
1	Maize varietal grown by farmers, ha			
	a) Improved	0.46	0.25	0.14
	b) Local	-	-	-
2	Total house hold seed required, kg	14.0	7.3	6.0
3	Local price for improved maize seed, kg	17.6	19.4	19.0
4	Local price of maize grain for home consumption, kg	10.0	10.5	10.5
4	Maize seed required for cultivation, kg	246.0	142.0	114.0
5	Maize seed sell, kg	484	280	170
6	Source of seed	ARS, Lumle	ARS, Lumle	ARS, Lumle
7	Utilization of selected source seed for different area, ha			
	a) From selected grain before planting, ha	0.37	0.24	0.10
	b) Ear selection at planting, ha	0.07	0.03	0.15
	c) Selected ears from the field and store separately, ha	0.18	0.06	0.13
	d) Obtain from neighbours, ha	0.03	-	-
8	Seed demand from neighbours, kg	12.2	5.75	3.5
9	Membership of community based managed seed production	Yes	Yes	Yes

Agrovets purchased maize seed @ Rs 18/kg from the seed growers and sell at retail price of about Rs. 26-28/kg. Generally, agrovets received marginal profit of Rs. 7-8/kg. However, ARS, Lumle was adding 25% cost for seed losses, seed treatment and transportation cost. Seed Support Sector Project is however subsidizing these extra costs to the farmers and selling seed at prices actually bought (Table 3).

Table 3. Marketing of maize seed enterprises for different institutions, 2001/02

SN	Particular	Agencies/Institutions				
		ARS, Lumle	ADO, Myagdi	SSSP	Beni	Agrovet Pokhra
1	Amount of seed sold to different agencies, kg					
	a) Manakamana -1	1000	500	500	82	100
	b) Arun-1	500	500	275	27	50
	c) White hill pool	500	250	100	10	50
	Cost of production of maize, Rs/kg	-	7.63	-	-	-
	Cost of maize seed production, Rs/kg	-	11.60*	-	-	-
2	Buying price, Rs/kg	18	18	18	18	18
3	Selling price, Rs/kg	23	23	18	25	26
4	Marginal profit	5	5	0	7	8

It takes 8 hrs for the farmers to go up and down and finally reached at central market of Beni for marketing purpose. Group discussion was held with community based maize seed/grain producers. Indicated that lack of high yielding varieties was a major problem (rank 1), followed by storage pest and lack of storage structure for seed grain problems (ranked second and third) (Table 4).

In terms of problems of marketing system, it was indicated that lack of awareness in selecting the quality seed and availability of poor quality seed ranked as numbers one problem. Lack of proper marketing system and information on marketing system ranked second and third problems respectively (Table 5).

Figures for marketing function at different levels indicate that grain prices in the local markets were less than in the near by markets. The average grain price at local level was Rs 12/kg and the average seed price was Rs 26/kg in nearby market. Retail prices were reported at marginal profit of Rs 2-8. Majority of the farmers preferred to sell seed in Beni Bazar (market) and Baglung Bazar. Seed Sector Support Project (SSSP) is playing vital role as a mediator for seed marketing mechanism as well as it coordinates between seed producer groups and traders (Figure 1).

Table 4. Problems of improved maize seed growers at accessible area, Bhakimli VDC (martix ranking), 2001/02

SN	Indicator	1	2	3	4	5	6	7	8	9	Total	Rank
1	Lack of high yielding varieties	X	1	1	1	1	1	1	1	1	8	1
2	Non effective group mobilization	X	X	3	4	5	6	7	8	9	0	6
3	Timely unavailability of input (chemical fertilizer)	X	X	X	4	5	6	7	8	9	1	5
4	Pest problem (army worm and white grub)	X	X	X	X	5	6	7	4	9	3	4
5	Disease problem (cob smut and head smut)	X	X	X	X	X	6	7	8	9	3	4
6	Tarpaulin for seed drying	X	X	X	X	X	X	7	8	6	5	3
7	Lack of storage structure for seed/rain	X	X	X	X	X	X	X	8	9	5	3
8	Lack of corn sheller	X	X	X	X	X	X	X	X	9	5	3
9	Storage pest problems (weevil and moth)	X	X	X	X	X	X	X	X	X	6	2

Table 5. Problems of marketing system of maize seed production at accessible area, Bhakimli VDC (matrix ranking), 2001/02

SN	Indicator	1	2	3	4	5	6	7	8	Total	Ranking
1	Lack of proper marketing system	X	1	3	4	5	6	7	8	1	3
2	Transportation problem for seed	X	X	3	4	5	6	7	8	0	4
3	Lack of seed traders	X	X	X	4	5	3	7	8	3	2
4	Lack of support price for seed production	X	X	X	X	5	6	7	8	3	2
5	Seed storage problem	X	X	X	X	X	5	7	5	6	1
6	Lack of information on marketing system	X	X	X	X	X	X	7	8	3	2
7	Availability of poor quality seed	X	X	X	X	X	X	X	8	6	1
8	Lack of awareness in selecting the quality seed	X	X	X	X	X	X	X	X	6	1

Problem of lack of markets: Markets for maize seed are very thinly spread. Due to inadequately developed markets for maize, farmers usually received less prices in the local (village) markets than in the organized markets, which were located at some distance from the village. The loss due to lack of maize market in village is computed as follow:

$$Lm = \{(PRM_m - PRM_v) - TC_{m\cdot v}\} * MQV$$
$$= \{(18 - 14) - 1.50\} * 500$$
$$= \{4 - 1.50\} * 500$$
$$= 2.50 * 500 = 1250$$

Where, Lm is the loss due to lack of market in the village, PRMm is the price received by the farmers in the approachable near by market; PRMv is the price received by the farmers in the village; TCm.v is the transportation cost differential between organized market and MQV is the quantity of maize sold in the village (Joshi and Sing 2001). The local market price of maize seed was Rs 14.0 at Bhakimli and Rs 18.0 at Beni. Transportation cost from Bhakimli to Beni market was Rs 1.50/kg. The farmers of Bhakimili can obtain at least NRs 1.50/kg seed if sold to the retailers at NRs 17.00/kg at Beni. So, market of Beni is less profitable for farmers of Bhakimli.

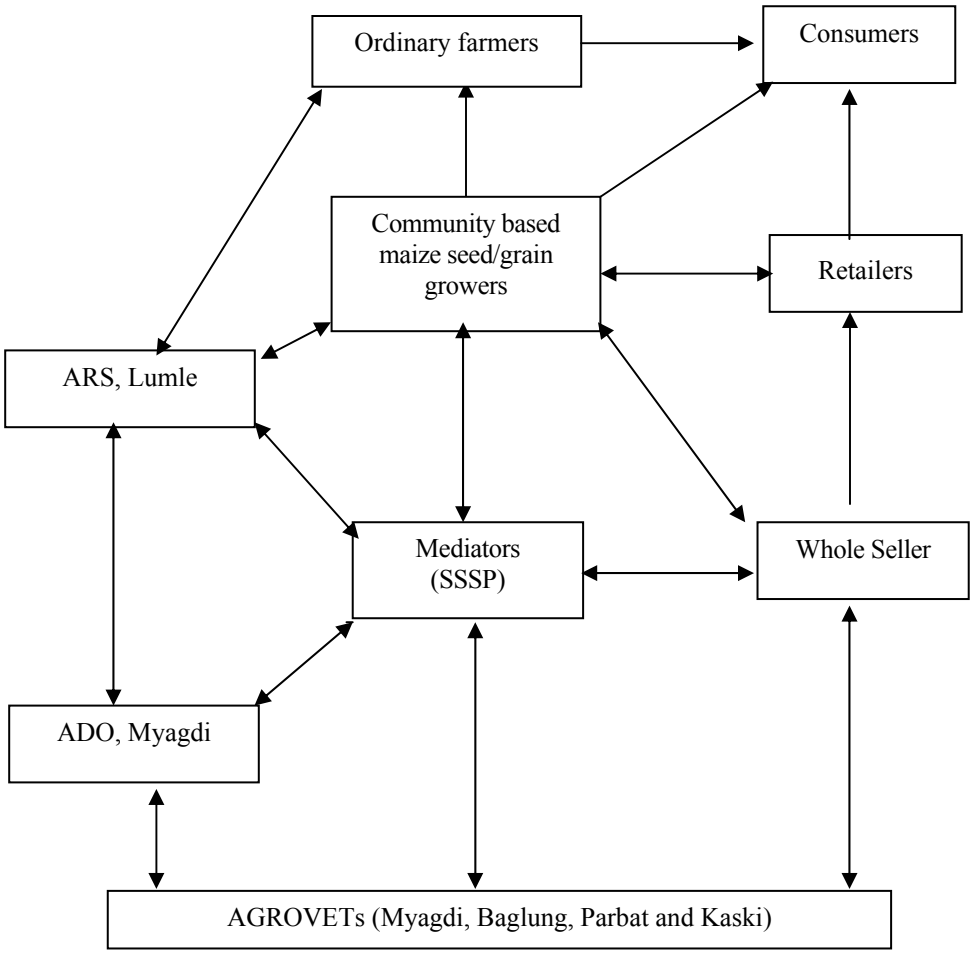


Figure 1. Marketing system of community based maize seed growers.

CONCLUSION

Farmers are more demanding high yielding variety of maize seed. Community based maize seed production program should be implemented in inaccessible areas and minimum support price should be announced for maize seed/grain growers before planting season. Agricultural Development Bank should provide loan at minimum interest rate for community based seed producers in inaccessible or remote areas of hills. Researchers and extensionists should conduct combine training on post harvest technologies for seed growers. Agricultural Development Offices, NGOs/INGOs should explore marketing enterprises.

ACKNOWLEDGEMENTS

I wish to express their gratitude to Dr RP Sah, Station chief, ARS, and Lumle for his encouragement in implementing this study project successfully. The authors are pleased to acknowledge the considerable technical and financial support of Dr Joel Ransom, Dr N Rajbhandari, Dr K Paudyal and Dr TP Tiwari and staff members of CIMMYT, Kathmandu and support staff members of ARS, Lumle. Collaboration of District Agricultural Development Office, Myagdi is highly acknowledged. The authors are also thankful to the staff members of Seed Sector Support Project, District Office, Myagdi for their valuable co-operation in implementing the study project.

REFERENCES

Joshi KR, TB Karki and S Paudel. 2002. Community managed maize seed production program. An experience of ARS, Lumle. *LARC Working Paper No. 2002/03*. ARS, Lumle, Kaski..

Joshi PK and NP Sing. 2001. Intensification of maize production in upland area of India, prioritisation for research and development plans. The paper presented in the 4th workshop held from 4-8 June at Kathmandu.

LARC. 1997. The strategy for maize research. *LARC Strategy Paper* No. 97/7. Lumle Agricultural Research Center, Kaski.

MOAC. 2001. *Statistical information on Nepalese agriculture-2000/2001*. Agribusiness Promotion and Statistical Information Division, Ministry of Agriculture and Cooperatives. HMG/N, Singha Durbar, Kathmandu, Nepal.

Seeley J. 1998. Household maize variety selection in Lumle Agricultural Centre extension command area. LARC *Technical Paper No. 88/24*. ARS, Lumle, Kaski.

Estimation of Production Function of Hiunde (Boro) Rice

Ram B. Bhujel[1*] and Surya P. Ghimire[1]

[1]Regional Agriculture Research Station, Tarahara, Sunsari, Nepal

ABSTRACT

Hiunde (Boro) rice has not been popularized due to least attention given to this crop in Nepal. In order to estimate the production function of this crop, a field survey in Morang district during 2002/2003 was carried out using a semi-structured questionnaire. The primary information was collected through face to face interview. The result of the empirical model of Cobb-Douglas production function revealed the model significant at 1% level and defined 95% variation in Hiunde rice production due to variation in independent variables included in the model. The coefficient of area, nitrogen, phosphorous, and tractor hour were found significant at 1% level while the dummy for more than 10 times of irrigation was significant at 5% level and up to 10 times of irrigation and potash was significant at 10% level. The effect of human and bullock labor was found non-significant. Among the sampled farmers the average cropping intensity was 194% and average yield of Hiunde rice was 4802.50 kg/ha. On an average 131 kg of nitrogen, phosphorous and potash was applied for one ha and 15 irrigations in average. The net benefit from Hiunde rice was found to be Rs. 14507.41/ha with 1.73 benefit cost ratio. About 31% cost was incurred in land preparation and transplanting which was highest among the operations. It was followed by the costs incurred in fertilizers and agrochemicals which counted 23%.

Key words: Estimate, Hiunde rice, production function

INTRODUCTION

Agriculture is the mainstay of Nepalese economy which is continued to be dependent upon monsoon rainfall due to lack of sufficient irrigation facilities. The average annual economic growth rate of agriculture sector was estimated to be 3.3% as against the target of 4% during the period of Ninth Plan while this target is 4.1% per annum during Tenth Plan (MoF 2003). The average annual growth rate of paddy production during Ninth Plan was 2.34% while for yield it was 2.26% (ABPSD 2003). Rice is a major staple food crop which contributes more than 50% to total edible cereal production and about 20% to agriculture domestic product (AGDP) in the country. During 2003/2004, the preliminary estimation has predicted 50.15% contribution of rice to total edible cereal grain requirement (ABPSD 2004). The surplus production was in eastern and western region while other three regions were in food deficit status.

Paddy during 2003/2004 was grown in 1559436 ha which produced 4455722 mt with an average yield of 2857 kg/ha (ABPSD 2004). The improved varieties covered about 83% area which was about 46% under irrigated and about 37% under unirrigated environment. The net profit from one ha of rice cultivation during 2002/2003 under improved and irrigated condition in Tarai belt was Rs 9524.00/ha while it was Rs 10500.00 for hills (DoEAS 2004).

Rice in Nepal is mostly grown in two distinct seasons; main/summer season (June/July-October/November) and early/Chaite/Autumn rice (March/April-May/June). Except these two season crops, farmers are also growing rice as *Hiunde Dhan* (Boro) on winter in certain parts of the country. They had started rice cultivation in winter (November/December-May/June) season in Kawasoti Village Development Committee (VDC) of Nawalparasi district since 1968 (Joshi 2004). Other VDCs growing Hiunde rice in Nawalparasi district are Angeli and Pithauli. The winter rice cultivation has been

introduced in Benauli and Sira Ineruwa VDC of Bara district; Biruwaguthi, Madhuwan (Auraha) VDC of Parsa district (Personal communication with KP Bhurer, RARS, Parwanipur, Bara); Parwaha, Nikal (Sapahi), and Sakhuwa Mahendranagar (Pakadia) VDC of Dhanusa district (Personal communication with Dr N Adhikari and RB Yadav, NRRP, Hardinath, Dhanusha). Despite theses areas, Morang is a leading district in winter rice cultivation where Rangeli, Aampgachhi, Takuwa and neighboring VDCs are major pocket areas. It is also grown in Mahabhara VDC of Jhapa district. Though the official statistics on area of winter rice is not available, the area covered by this crop is estimated to be more than 400 ha in Nepal (Bhujel 2004).

Winter rice in Nepal is generally called as Hiunde *Dhan* while in India and Bangladesh it is popularly known as 'Boro Rice'. Boro - a Bengali term originated from the Sanskrit word 'BOROB'. It refers to a special cultivation of rice in low land pockets during November-May; taking advantage of the residual water in the field after harvest of *Kharif* season paddy, longer moisture retentivity of the soil and surface water stored in the near by ditches (Singh et al 2003a). Thakur et al (2003) reported Boro in Shivapuran as one of the offerings to the God. In Bangladesh rice is grown in three distinct seasons; *boro* (January to June), *aus* (April to August), and *amon* (August to December). Modern rice varieties were introduced for the *boro* and *aus* seasons in 1967 and for the *amon* seasons in 1970 (Hossain et al 1994). In Bangladesh *boro* rice occupied nearly 35% of the 10.80 million ha of rice harvested area, and contributed 50% of the 38.7 million tons of rice produced in 2001/2002. The yield in 2001/2002 was 4.9 ton/ha (Singh et al 2003b).

In India it is commonly grown in the deeply flooded areas of North East Bihar, West Bengal, Assam and Eastern Uttar Pradesh. Pusa 2-21, IR 8, Jaya etc. became popular varieties (Thakur et al 2003). In Madhubani District, substantial increase in farm income was observed due to *boro* farming which made the distribution more equitable particularly on small farm households. *Boro* rice production helped in increasing employment, particularly in slack agricultural season. It has brought about a change in socio-economic status of rural households (Nilanjali and Singh 2003). The net return to the farmers from the cultivation of *boro* in Bangladesh during 2000 was about US $ 433/ha, almost eight times higher than that from *aus* and about three times compared to the return from wheat (Hossain 2003).

The estimation of production function of winter rice in eastern region of the country has not been found sufficiently studied and its socio-economics study is also lacking. Considering these facts a primary level study on winter rice was carried out during 2059/2060 (2002/2003). The main objective of this study was to estimate production function.

METHODOLOGY

Morang being a leading district in winter rice cultivation was selected for the study. The popular VDCs for winter rice cultivation in Morang district like Rangeli, Aampgachhi and Takuwa were purposively selected as these are the major pocket areas of this crop. A sampling frame of winter rice growers was prepared and 35 farmers were selected randomly without replacement. The primary information was collected from sample farmers through face to face interview schedule. A standardized semi-structured questionnaire was finalized after pre-testing and interview carried out. The secondary data were collected from published documents and personal communication with related agencies.

Empirical model

The empirical model used in this study was the Cobb-Douglas production function and other simple statistical tools like mean, total count and percent. This model was selected because; among the production functions, the power production function is a new linear production function which is also known as Cobb-Douglas production function after the name of the persons who first applied it in empirical works (Debertin 1986, Sankhayan 1988). This function has been widely used in agricultural

studies because of its simplicity. Furthermore, this function allows either constant, increasing or decreasing marginal productivity, or not all the three and even any two at the same time.

The model specified was:

$$Y = AX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}X_7^{b7}D_1^{b8}D_2^{b9}\ \mu$$

Where,
Y = Production of winter rice (kg), A = Intercept, X_1 = Area of winter rice (ha), X_2 = Human labor (Man days), X_3 = Bullock labor (Labor days), X_4 = Nitrogen (kg), X_5 = Phosphorous (kg), X_6 = Potash (kg), X_7 = Tractor hour, D_1 = Dummy for number of irrigation (1 for up to 10 irrigations, and 0 for otherwise), D_2 = Dummy for number of irrigation (1 for more than 10 irrigations, and 0 for otherwise), b_1 to b_9 = Elasticities coefficients, μ = Error term

Above model can be estimated by using Ordinary Least Square (OLS) method. The Cobb-Douglas Production Function was transferred into log-linear form as:

$$\ln Y = \ln A + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7\ln X_7 + b_8 D_1 + b_9 D_2 + \mu$$

The values of the input coefficients imply their contribution to the production of winter rice or the coefficients are the level of determination to winter rice production.

RESULTS AND DISCUSSION

The primary information was collected from 35 farmers and only 33 were valid for final analysis due to outlier nature of certain information. The calculation was done for farm size, cropping intensity, yield, labor (human and bullock), quantity of inputs and cost incurred in different operations for the cultivation of winter rice. Similarly, the share of inputs for different operations was also calculated.

Sowing and harvesting time

The response of sample farmers revealed the popular sowing time for winter rice as *Kartik-Mangsir* (November-December) for seeding, *Magh* (January/February) and latest by first week of *Falgun* was the suitable time for transplanting, while *Jestha* (May/June) and latest by the first week of *Ashadh* was the period when most of the farmers harvested the crop. The most popular variety grown by the farmers was *Jaya* which was supposed to be introduced from neighboring part of Bihar, India. The variety was not replaced and continued to be used from generation to generation.

Farm size

Among the sample farmers the average operational holding was 5.08 ha and the distribution of more than 0.67 ha to 3 ha holding was high showing the 40% farmers within this status (Table 1).

Table 1. Average farm size of winter rice growers in Morang District

SN	Operational hectare	Number of farmers	Percent
1	Up to 0.67	1	3
2	> 0.67-3	13	40
3	> 3-5	9	27
4	> 5-7	6	18
5	> 7	4	12

Cropping intensity

Farmers were not much interested to grow wheat or early rice during this season and very few were found growing wheat and *Chaite* rice along with winter rice during a period of one year. However, the cropping intensity was found to be 194% in average. More than 48% farmers were found to have more than 150 to 200% cropping intensity (Table 2).

Table 2. Average cropping intensity of winter rice growers in Morang District

SN	Cropping intensity, %	Number of farmers	Percent
1	Up to 150	5	15
2	> 150-200	16	48.5
3	> 200-250	7	21
4	> 250	5	15.5

Yield

The farmers were very much enthusiastic to achieve high yield from winter rice, however, the average yield recorded from sample farmers was 4802.5 kg/ha. The majorities of the sample farmers (21.21%) produced 3700-4200 kg/ha, while more than 18% farmers were found producing more than 5700 kg/ha average yield (Table 3). Only 3% farmers produced up to 2700 kg/ha.

Table 3. Average yield of winter rice among the sample farmers in Morang District

SN	Average yield, kg/ha	Number of farmers	Percent
1	Up to 2700	1	3.03
2	> 2700 - 3700	3	9.09
3	> 3700 - 4200	7	21.21
4	> 4200 - 4700	1	3.03
5	> 4700 - 5200	5	15.15
6	> 5700	6	18.18

Seed rate

Among the sample farmers 85 kg/ha seed rate was adopted which varied from 72 to more than 157 kg/ha (Table 4). The seed rate being high in winter rice is due to high chances of seedling mortality and injury due to cold and slow growth as it has to tolerate natural cold during seeding to seedling stage. Therefore farmers use high seed rate to compensate the anticipated damage of seedlings. Majority of sample farmers were found applying more than 72 to 115 kg seed/ha and very few were found to sowing more than 157 kg seed for one ha (Table 4).

Table 4. Average seed rate of winter rice applied by the sample farmers in Morang District

SN	Seed rate, kg/ha	Number of farmers	Percent
1	Up to 72	10	30.30
2	> 72 - 115	18	54.54
3	> 115 - 157	4	12.12
4	> 157	1	3.04

Use of nitrogen

Dia-Ammonium Phosphate (DAP) and urea were found as major sources of nitrogen. The average rate of nitrogen used by sample farmers in survey area was 74.52 kg/ha. Some of the farmers were also using even more than 100 kg nitrogen/ha. However, the range between more than 70-90 kg/ha application of nitrogen was dominant among the sample households (Table 5). The range of more than 90 to 100 kg nitrogen/ha was lowest among the sample farmers which was only 6%.

Use of phosphorous

Dia-ammonium phosphate (DAP) was the main source of phosphorous which provides 46% nutrient phosphorous. The average quantity of phosphorous applied by the farmers was 38 kg/ha while the range of its application from more than 30-50 kg/ha was applied by 61% of the sample farmers (Table 6). Quantity ranging from more than 30-40 kg P_2O_5/ha was applied by 42% of the sample farmers.

Table 5. Average dose of nitrogen applied by the sample farmers for winter rice in Morang District

SN	Nitrogen, kg/ha	Number of farmers	Percent
1	Up to 50 kg	6	18.18
2	> 50-70	9	27.27
3	> 70-90	12	36.36
4	> 90-100	2	6.06
5	> 100	4	12.12

Table 6. Average dose of phosphorous applied by the sample farmers for winter rice in Morang District

SN	Phosphorous, kg/ha	Number of farmers	Percent
1	Up to 30	8	24.24
2	> 30-40	14	42.42
3	> 40-50	6	18.18
4	> 50-60	1	3.03
5	> 60	4	12.12

Use of potash

Farmers were applying Muriate of Potash as a main source of potash. The average nutrient potash used by the sample farmers was found 18.58 kg/ha and the majority of the farmers applied up to 30 kg of potash/ha (Table 7). Only 3 per cent farmers applied more than 40 kg potash/ha.

Table 7. Average dose of potash (K_2O) applied by the sample farmers for winter rice in Morang District

SN	Potash, kg/ha	Number of farmers	Percent
1	Up to 30	30	90.90
2	> 30-40	2	6.06
3	> 40	1	3.03

The above figure of nitrogen (N), phosphorous (P) and potash (K) made the ratio of 74:38:19 kg NPK/ha counting whole NPK as 131 kg/ha on an average. However, the dose of more than 100-130 kg/ha was applied by the majority of the farmers counting more than 30% followed by 27.28% who were found applying more than 145 kg NPK/ha (Table 8).

Table 8. Average dose of NPK applied by the sample farmers for winter rice in Morang District

SN	NPK, kg/ha	Number of farmers	Percent
1	Up to 100	5	15.16
2	> 100-130	10	30.31
3	> 130-145	7	21.22
4	> 145	9	27.28

Irrigation

The winter rice is irrigation intensive crop as it needs whole winter season to medium summer season for its life cycle. Without assured irrigation, the production cannot be expected high for this crop. Therefore, the number of irrigation for this crop was found very high in comparison with other winter crops. The average number of irrigation supplied by sample farmers was 15 times while the majority of the farmers were found irrigating winter rice more than 16 to 20 times for whole crop season (Table 9). The high number of irrigation is due to its long period that crosses whole winter season and also the spring season where the crop has to be faced moisture stress condition. To overcome this situation, the irrigation needs to be frequent and regular. More than 9% of farmers were found irrigating more than 20 times.

Table 9. Average number of irrigation applied by the sample farmers for winter rice in Morang District

SN	Irrigation number	Number of farmers	Percent
1	Up to 4	2	6.06
2	> 4-8	5	15.15
3	> 8-12	5	15.15
4	> 12-16	6	18.18
5	> 16-20	12	36.36
6	> 20	3	9.10

Human and bullock labor

The human and bullock labor in average used by sample farmers of winter rice growers was found 84 man days and 16 bullock pairs/ha, respectively. More than 35 to 70 human labor/ha was used by more than 33% of sample farmers while more than 14-20 pairs of bullock was used by more than 51% of sample farmers at survey site (Table 10). The number of human and bullock labor was also determined by the use of tractors by the farmers. Farmers also used/hired tractor for land preparation which determined the number of labors (human and bullock).

Table 10. Average number of human and bullock labor/ha used by sample farmers for winter rice cultivation in Morang district

SN	Number of human labor/ha	Number of farmers	Percent	Number of bullock pair/ha	Number of farmers	Percent
1	Up to 35	6	18.18	Up to 8	7	21.21
2	> 35-70	11	33.33	> 8-14	6	18.18
3	> 70-105	9	27.27	> 14-20	17	51.51
4	> 105	7	21.22	> 20	3	9.10

Use of tractor

The sample farmers were also using tractor for land preparation of winter rice which was 1.69 hour/ha on an average. Majority of them used at least for one hour (Table 11). Farmers also used tractor for more than 5 hours/ha. Tractor is generally used by most of the farmers at least for first plowing after which they used bullocks.

Table 11. Average tractor hour used by the sample farmers for winter rice in Morang district

SN	Tractor hour/ha	Number of farmers	Percent
1	Up to 1	19	57.57
2	> 1-3	8	24.23
3	> 3-5	3	9.10
4	> 5	3	9.10

Estimation of production function

The share of input variables to winter rice production was estimated by using OLS technique. The value of F test in OLS estimation indicated that the model is significant at 1%. The value of adjusted R^2 is 0.95 which reveals that the model has explained 95% of total variation in winter rice production due to the variation in area, human and bullock labor, nitrogen, phosphorous, potash, use of tractor and number of irrigations (Table 12). According to Gujrati (1995), the coefficient of determination (adjusted R^2) is a summary measure that tells how well the sample regression line fits the data. The fit of the model is said to be better the closer is R^2 to 1. Therefore, in this model 95% variation in winter rice production has been defined by independent variables included in the model. The intercept is significant at 1% level which implies the level of output when the value of all independent variables is zero. The coefficient of winter rice area is positive and significant at 1% level which implies that, other factors keeping constant, one per cent increase in area would result in 0.91% increase in winter rice production. Similarly, *ceteris paribus*, one per cent increase in phosphorous, potash, tractor use would result into 0.33, 0.02 and 0.02% increase in production from the use of respective variables. Similarly, irrigation for up to 10 and more than 10 are significant at 10 and 5% level, which reveals that other factors keeping constant, when

one per cent irrigation for 10 is increased, the production would be increased by 0.36% and when it is applied to more than 10 number of irrigation it would result in increasing 0.42% winter rice production.

The nitrogen effect on production is significant at 1% level and has negative value which indicates the excess application and the variety which is not much responsive to higher dose of nitrogen, however the dose of phosphorous and potash can be increased. Similarly, the human and bullock labor has not any significant effect in production, but the tractor hour can be increased which can further reduce these labors and make the cultivation cost effective.

Table 12. Estimates of ordinary least square (OLS) technique

Explanatory variables	Elasticities	Standard errors	t statistics
Intercept	8.09***	0.47	17.24
Area, ha	0.91***	0.11	8.14
Human labor, days	0.05	0.05	0.97
Bullock labor, days	0.01	0.03	0.48
Nitrogen, kg	-0.33***	0.12	-2.64
Phosphorous, kg	0.33***	0.10	3.13
Potash, kg	0.02*	0.01	1.93
Tractor use, hour	0.02***	0.009	2.68
Dummy for number of irrigation up to 10†	0.36*	0.19	1.84
Dummy for number of irrigation > 10‡	0.42**	0.18	2.26
Adjusted R^2	0.95		
F value (9, 23)	75.63***		
Observations	33		

****, **, * Significant at 1, 5, and 10% respectively. † 1 for up to 10 irrigations and 0 for otherwise. ‡ 1 for more than 10 irrigations and 0 for otherwise.*

Analysis of gross margin

Application of different inputs was taken as variables and their cost as variable costs. The total variable cost incurred in winter rice cultivation was found Rs 19878.49/ha in average while the gross income from the grain production was found Rs 34385.90, which counted 1.73 as benefit cost ratio. It provided Rs 14507.41 as net benefit from one hectare of winter rice cultivation (Table 13). The scenario of gross margin was as follows:

Average production of winter rice, kg/ha	:	4802.50
Average price of winter rice, Rs/kg	:	7.16
Gross revenue from grain production, Rs	:	34385.90
Total variable cost, Rs	:	19878.49
Benefit cost ratio	:	1.73

Table 13. Gross margin of winter rice cultivation in Morang District

SN	Operations and items	Expenditure, Rs/ha	Percent of total expenditure
	Input costs		
1.	Seed	919.47	4.62
2.	Chemical fertilizers and agrochemicals	4613.29	23.20
3.	Land preparation and transplanting	6095.41	30.66
4.	Weeding and harvesting	4261.641	21.44
5.	Irrigation	3856.69	19.41
6.	Land tax and interest	132.53	0.66
	Total variable costs	19878.49	100
	Gross revenue from grain production	34385.90	
	Net profit	14507.41	

The highest cost incurred was found by land preparation and transplanting which was more than 30% followed by the costs for chemical fertilizers and agrochemicals (Figure 1) which counted more than 23%.

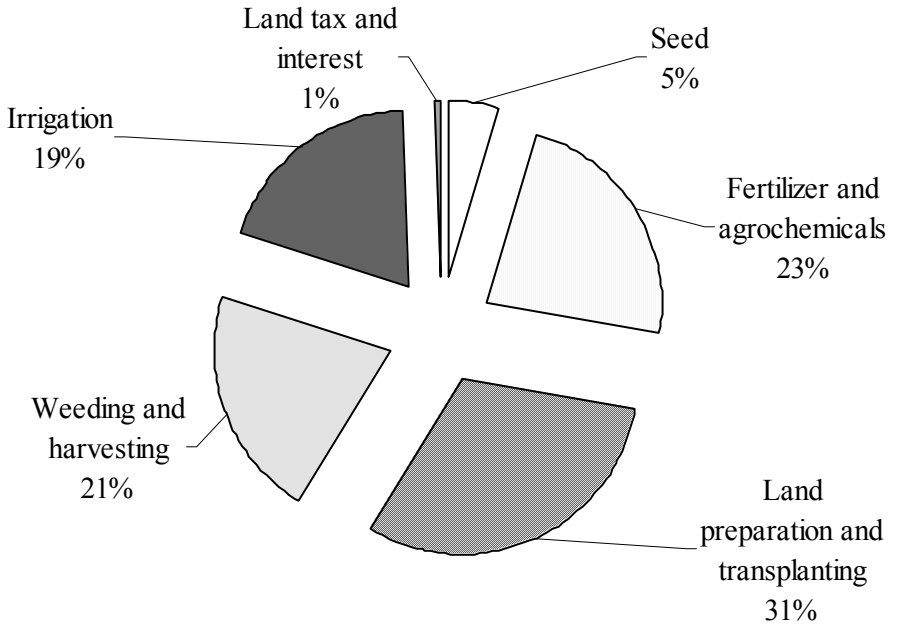


Figure 1. Cost incurred in winter rice cultivation in Morang.

The hypothesis tested was found true that the farmers received more net profit from winter rice in the survey area as benefit cost ratio for this crop was found 1.73. The net profit of Rs 14507.41 is far higher than normal/early rice or wheat crop in the district. It was only Rs 10500.00 and Rs 9524.00/ha from normal rice under irrigated and improved variety in hills and Tarai in 2002/2003.

Why farmers grow winter rice

On the basis of farmer responses followings are the reasons:

- The production of winter rice is higher than chaite rice and wheat.
- It is harvested before monsoon rainfall and thus it makes the farmer easy to thresh and get rid of disturbance from rainfall as it happens with C*haite* rice.
- Due to early harvest, summer rice can be planted in time.
- Majority of the farmers let the straws into the field which adds humus to soil and improve soil health.
- To the date the market problem has not been experienced seriously as the product is sold immediately after threshing (even from the threshing flour) and the fresh grains weigh more due to high moisture content and fetch more money through satisfactory market price. The rice mill owners also get fresh product which is generally used for flat/beaten rice so called *Chyura*.
- The essence of this crop is that it provides hard cash at the period of *Jestha*/*Ashadh* which is/are month/s of crisis for both cash and kind in rural farm households. They are in dire need of resources at this period as there is no any crop to harvest and fetch money. They get relief by earning cash money from winter rice which substantially helps cultivate summer crops, pay school/admission fee of their children and run household activities. Thus winter rice is not only a cereal crop but is 'A hard Cash in Crisis' too (*Hiunde Dhan Aapatma Bardan* = Winter Rice - Boon in Crisis).

Problems

Since the market is available and product is sold out, farmers are satisfied but are in need of high yielding variety that can produce more than presently cultivated *Jaya* variety. Some of the farmers raised problems on availability and quality of chemical fertilizers and fuels, irregular supply of electricity, and sometimes electric poles/pillars were damaged by storm and were not timely corrected by concerning agencies. They expect encouragement in installing irrigation facilities by government through some subsidy program. Because it is an irrigation-intensive crop and needs more irrigations than any other crop. Quality of inputs was found as a matter of more concerns of the farmers in the survey site.

The cash income earned by the farmers improves their socio-economic status and grows rural economy which can substantially help reduce poverty. The water logged area and the area where excess moisture is exerted in winter season causing unfit for other winter crop can be well utilized by growing winter rice for which a campaign needs to be organized to its extension with package of practices. Migration of rural youth, unemployment and food deficit can be minimized by encouraging winter rice production in the area where it is still not practiced but has its scope and potentiality. Since this was a primary survey, it needs to be carried out in more detail in other rice growing area of the country so as to formulate a proper policy of winter rice in the future.

ACKNOWLEDGMENTS

Authors are thankful to CR Yadav, RARS, Tarahara for providing facilities to carry out the field survey work. The cooperation extended by the officials of District Agriculture Development Office, Jhapa and Morang is highly acknowledged. KP Bhurer of RARS, Parwanipur Bara, Dr N Adhikari and RB Yadav of National Rice Research Program, Hardinath, Dhanusa are highly appreciated for providing information on winter rice in Nepal. The members of survey team including HK Prasai, AB Thapa, K Mandal and B Yadav deserve special thanks for their cooperation in carrying out survey study in rural villages.

REFERENCES

ABPSD. 2003. *Agriculture sector in the ninth plan*. Agri-Business Promotion and Statistics Division, Ministry and Agriculture and Cooperatives, His Majesty's Government of Nepal, Kathmandu. Pp. 6-8.

ABPSD. 2004. *Statistical information on Nepalese agriculture, 2003/2004*. Agri-Business Promotion and Statistics Division, Ministry and Agriculture and Cooperatives, His Majesty's Government of Nepal, Kathmandu. Nepal. Pp. 4-8.

Bhujel RB. 2004. Rice production challenges in Nepal. *NARC News Letter, A special issue on International Year of Rice 2004* (May 2004). CPDD/NARC, Khumaltar, Lalitpur, Nepal.

Debertin DL. 1986. *Agriculture production economics*. Macmillan Publishing Company, New York, USA. Pp. 166-182.

DoEAS. 2004. *Cost of production of cereal crops, Nepal 2059/20600 (2002/2003)*. MoAC/DoA/Directorate of Economic Analysis and Statistics, His Majesty's Government of Nepal, Harihar Bhawan, Lalitpur. Pp. vii-viii.

Gujrati DN. 1995. *Basic econometrics*. Third edition. McGraw-Hill Inc. Pp. 237.

Hossain M, MA Quasem, MA Jabbar and MM Akash. 1994. Production environment, modern variety adoption and income distribution in Bangladesh. **In:** *Modern rice technology and income distribution in Asia* (David and Otsuka, eds). IRRI, Philippines. Pp. 221-279.

Hossain M. 2003. Development of boro rice cultivation in Bangladesh: Trends and policies. **In:** *Boro rice* (RK Singh, M Hossain and R Thakur, eds). IRRI-India Office. Pp 25-49.

Joshi BK. 2004. Hiunde Rice: 35 years old practice in Nepal. *NARC News Letter, A special issue on International Year of Rice 2004* (May 2004). CPDD/NARC, Khumaltar, Lalitpur, Nepal.

MoF. 2003. *Economic survey, Fiscal Year 2002/2003*. Ministry of Finance, His Majesty's Government of Nepal. Pp. 113.

Nilanjali and RKP Singh. 2003. Impact of boro rice cultivation on socio-economic status of farm households in Bihar. **In:** *Boro rice* (RK Singh, M Hossain and R Thakur, eds). IRRI-India Office. Pp. 207-220

Sankhayan. 1988. *Introduction to the economics of agricultural production*. Prentice Hall of India, Pvt. Ltd. New Delhi. Pp. 135.

Singh PK, M Hossain and R Thakur. 2003a. **In:** *Boro rice* (RK Singh, M Hossain and R Thakur, eds). IRRI-India Office.

Singh RK, R Thakur and SD Chatarjee. 2003b. Harnessing boro rice potential for increasing rice production in deepwater areas of Eastern India, An overview. **In:** *Boro rice* (RK Singh, M Hossain and R Thakur, eds). IRRI-India Office. Pp. 51-72.

Thakur R, NK Singh, VK Chaudhary. 2003. Recent advances in boro rice research in Bihar. **In:** *Boro rice* (RK Singh, M Hossain and R Thakur, eds). IRRI-India Office. Pp. 99-116.

RESEARCH NOTE

Access to and Control Over Household Resources: A Consistency Check Using Gender Analysis and Household Survey Data

Durga Devkota

Institute of Agriculture and Animal Science, Tribhuvan University, Rampur
<dnaba@wlink.com.np>

ABSTRACT

A study was conducted during 1998 covering three Village Development Committees (VDCs) of Chitwan district, Nepal, to examine the consistency of results if carried out independently using formal and informal methods of information collection. Gender analysis (access and control profiles), and a face-to-face household survey (n = 123 households) were employed for this purpose. Gender differences in access to and control over household resources was studied. Results showed a consistent response from both household survey and gender analysis for most of the parameters studied, such as access to agriculture extension and veterinary services, participation in training, and community work. Gender response for control over resources, such as income from small animals was also similar from both methods. However, some of the parameters were not consistent in response. For example, there was no participation of women in control over income from cash crops and cereal crops and large animals as strongly indicated by gender analysis, which was not visible in the case of household survey. This raises a question about the reliability of using only one approach of information collection for rural development research. On the basis of these results, we suggest a combine approach of quantitative and qualitative methods of data collection, which could be more reliable, informative and appropriate. The use of multiple methods also allows the researcher to cross-reference in order to validate the trustworthiness of information.

Key words: Gender analysis, household survey, triangulation

INTRODUCTION

Sociological research, particularly in agricultural development and planning are mostly carried out with questionnaire or personal interview. Usually clear instructions and unambiguous question design is required for the questionnaire (Sharma and Sharma 1981), while personal interview gives researcher the greatest level of control over the data collected (Gordon 1975).

Participatory approaches of information collection for sociological research are also increasingly in use mainly after the decades of 80s and are being popular (Chambers 1994). Techniques such as Participatory Rural Appraisal (PRA), which can be also described as a method to enable local people to express, share and analyse their knowledge of life and conditions, to plan themselves, supports analysis of rural resources and socio-economic conditions in different communities. Approaches such as gender analysis (GA) (Shrestha 1994), group discussion and key informants interview are practically common for sociological research (Bajracharya 1994).

Either questionnaire survey method (quantitative) or participatory approaches (mostly qualitative) are usually used independently without considering the usefulness of using both approaches simultaneously to collect information related to sociological research, also for rural development planning and policy

formulation. However, use of only quantitative or qualitative approach may not be always applicable to get actual information about rural people, particularly in the developing world where people are mostly uneducated, and are with subsistence or poor economic situation (William and Charles 1997). It is also because some of the information associated with rural people having small-scale farming is difficult to address by the use of any single approach. Consistency checking about results obtained from household survey, and other participatory methods such as gender analysis could give practical insights about the methods used for information collection related to the agriculture and rural development planning. The use of multiple methods also allows the researcher to cross-reference in order to validate the trustworthiness of data (Robson 1993).

A research was carried out in Chitwan, Nepal, a country of an ethnically diverse, with many different languages and dialects and associated different cultures. The objective of the research was to examine the consistency on the results obtained from both household survey and gender analysis in identifying gender roles of access to and control over household resources.

METHODOLOGY

The fieldwork for this research was carried out between April and June 1998 in Chitwan. The Chitwan district, in the Tarai region of Nepal had a population of 354,488 during the time of study (CBS 1997). Three Village Development Committees (VDCs) were purposively selected for the study based on their concentrations of the ethnic population of research interest. Four different data collection methods were used: PRA (social maps and seasonal calendars), gender analysis (activity profiles, access and control profiles, and time use charts), key informant interviews (n = 14) and a face-to-face household survey (n = 123 households). The household survey was administered separately to a male and female from 123 households representing the three chosen ethnic groups (Devkota 1999). The household survey data were analysed using statistical software for descriptive analyses (SAS 1997), whereas information obtained from qualitative approach were organised into the tabular forms (Gordon 1975). Results from both face-to-face survey with female members and the group exercises (gender analysis) which were conducted in an endeavour to understand the roles of gender in access to services and control over household resources are mainly incorporated for the brevity reason.

RESULTS

Gender roles in access to resources

Survey results in relation to access of men and women to three types of services: agricultural extension, community activities and training, and finance are presented in Table 1. Males overwhelmingly dominated in gaining access to agricultural and veterinary services than women among the researched communities. Likewise, gender differences was common in the level of participation in community activities. The community activities examined were the opportunity to participate in community meetings, training and study tours. The category in which women fared best was access to skill development training (Table 1). In relation to study tours, however, involving travel away from home, male domination was found common in the society.

Similarly, access to finance was also dominated by men (Table 1). Women were largely illiterate and thus were not involved in financial activities, which need specific knowledge and skills, and require information. The gender analysis concurred with most of the parameters of survey results. However, some differences were found while comparing the results of gender analysis and household survey data (Table 2).

Table 1. Gender roles in access to resources in the Chitwan district, Nepal: Household survey approach (Percent respondents reporting)

Access to resources	Gender roles		
	Male	Female	Joint
Agricultural extension			
Agricultural extension worker (n = 119)	79	12	9
Veterinary services (n = 119)	74	9	17
Community activities and training			
Community meetings (n = 122)	58	16	26
Skill development training (n = 101)	35	31	34
Farming study tour (n = 93)	69	17	14
Finance			
Banking facility (n = 85)	75	15	10
Private money lender (n = 117)	66	20	14
Savings (n = 97)	65	27	8

Table 2. Gender roles in access to resources in the Chitwan district, Nepal: Gender analysis approach

Access to resources	Gender role		
	Male	Female	Joint
Agricultural extension			
Agricultural extension worker	✓✓		
Veterinary services	✓✓		
Community activities and training			
Community meetings	✓✓	✓	✓
Skill development training	✓✓		
Farming study tour	✓✓		
Finance			
Banking facility	✓✓	✓	✓
Private money lender	✓✓	✓	✓
Savings	✓✓	✓	✓

✓✓ Denotes strong and ✓ weaker gender participation for access to resources.

Access to skilled development training, agricultural extension, veterinary services, farming study tour all had a strong male domination, while other activities such as access to finance, and participation in community meetings had although, men domination, but also had women's involvement at a low level. These all activities also had low level of joint participation of both men and women (Table 2).

Gender roles in control over household resources

The survey result revealed the information about men's and women's control over household income from the three main sources: crops, livestock, and off-farm employment are presented in Table 3. There was not strong gender domination in the income generation from crops, livestock and off-farm employment. However, relative male domination was found in crops and off-farm related income while female relatively dominated for small animal income (Table 3). Off-farm income typically comes from household members working for government and non-governmental services, running small businesses or casual farm-work. Off-farm income provides a valuable source of cash to many rural Nepalese households.

The gender analysis result on control over household resources is summarised in Table 4. Income generated from off-farm employment was strongly controlled by males only. Women's participation to control income generated from cereal crops, cash crops, and large animals were almost none. However, there was a weaker level of participation of both men and women for the same (Table 4).

Table 3. Gender roles in control over household income in the Chitwan district, Nepal: Household survey approach (Percent respondents reporting)

Control over income	Gender roles		
	Male	Female	Joint
Cereal crops (n = 102)	41	27	32
Cash crops (n = 102)	40	29	31
Large animals (n = 98)	47	30	23
Small animals (n = 77)	36	46	18
Off-farm (n = 100)	43	29	28

Table 4. Gender roles in control over household income in the Chitwan district, Nepal: Gender analysis approach

Control over income	Gender role		
	Male	Female	Joint
Cereal crops	✓✓		✓
Cash crops	✓✓		✓
Large animals	✓✓		✓
Small animals	✓✓	✓	✓
Off-farm	✓✓		

✓✓Denotes strong and ✓ weaker gender participation for control over household resources.

DISCUSSION

Both household survey and gender analysis revealed consistency for most of the parameters studied. However, there was a contradiction on some of the parameters. For example, household survey results reported overwhelming domination of male in gaining access to agricultural and veterinary services, community activities and training, and finances than women, which was not seen in gender analysis. Likewise, level of gender participation in access of skill development training, agricultural extension, veterinary services and farming study tour was found more or less similar for both men and women as indicated by the household survey results, while gender analysis results showed a complete male domination for those services.

Similarly, survey results did not report about the strong gender domination in control over household resources in relation to income generation from off-farm employment, while gender analysis results supported strong male domination for off-farm employment income. However, there was a weaker level of participation of both men and women for crops and livestock income as revealed by the gender analysis results.

This raises a question about the validity of the methods used, and the reliability of the results obtained. There are some grounds to rely on the results obtained from gender analysis than the household survey since gender analysis results was based on thorough discussion on the topic and the general consensus of the participants. Still, it is difficult to underestimate the results obtained from household survey since individual member's perception was considered in the results. What we can understand from such inconsistency in the result is that, there is a possibility of contradiction in results obtained from household survey and participation methods.

The results from this study clearly revealed that some of the issues related to rural household decision-making, mainly that of sociological research associated to the agriculture and rural development planning are difficult to identify just on the basis of only one method of information collection. While the other are very much specific to the participatory methods of data collection only.

REFERENCES

Bajracharya B. 1994. Gender issues in Nepali agriculture: A review. *Winrock Research Report Series*, No. 25. HMG, Ministry of Agriculture/ Winrock International, Kathmandu.

CBS. 1997. *Statistical year book of Nepal 1997*. Central Bureau of Statistics. National Planning Commission Secretariat. His Majesty's Government, Nepal.

Chambers R. 1994. Participatory rural appraisal (PRA): Challenges, potentials and paradigm. *World Development* 22 (10):1437-1454.

Devkota D. 1999. Household decision making in rural Nepal: A study of the effects of gender roles and ethnicity. *Master Thesis*. Massey University, New Zealand, 180 p. (Unpublished)

Gordon RL. 1975. *Interviewing: Strategy, techniques and tactics*. Illinois: Dorsey Press.

Robson C. 1993. *Real world research: A resource for social scientists and practitioner-researchers*. Oxford: Blackwell Publishers.

SAS. 1997. *SAS/STAT User's Guide*. Version 6.12. SAS Institute. Cary: NC.

Sharma PN and VK Sharma. 1981. *Elements of farm management*. Prentice-Hall Inc. New Dehli.

Shrestha SL. 1994. *Gender sensitive planning what, why and how in Nepal*. Women Awareness Centre Nepal (WACN), Kathmandu.

William MA and CM Charles. 1997. Researchers and the rural poor: Asking questions in the third world. *Journal of Geography in Higher Education* 21(1):215-229.