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ERRATUM Volume 4, 2000

The Second author of the paper,
Response of rice varieties to age of
seedlings and transplanting dates is
Ramji Yadav not Rambaran Yadav.

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Abstract: Every manuscript (article) must have a short abstract (not more than 250 words), which should be complete itself but it should be concise and clear without any cited references. Abstract should highlight objectives, materials and methods, important results and conclusion written in a manner so that it is suitable for direct reproduction in some abstracting journals. Key words (not more than 5 words) should be written below the abstract in alphabetical order.

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Journal

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Book

Cochran WG and GM Cox. 1968. *Experimental designs*. 2nd ed. John Wiley and Sons, Inc., New York, 490pp.

Contribution to Book/Proceedings

Yuan LP, ZY Yang and JB Yang. 1994. Hybrid rice in China. *In: Hybrid rice technology: New development and future prospects*. SS Virmani, ed. IRRI, the Philippines. Pp.143-147.

Annual Report

NWRP. 1980. Rice-wheat system: Opportunities and constraints. *In: Annual Report-1980*, National Wheat Research Program (NWRP), Nepal Agricultural Research Council, Bhairahawa, Rupandehi, Nepal. Pp.60-65.

Serials

Hodges EM, WG Kirk, FM Peacock and JR Neller. 1964. Forage and animal response to different phosphatic fertilizers on pangobgrass pastures. *Fla. Agric. Expt. Sta. Bull.* 6(8):28.

Thesis/ Dissertation

Joshi BK. 2000. Assessment of the potential of Nepalese rice cultivars and landraces for hybrid production. Master Thesis. Institute of Agriculture and Animal Science, Rampur Nepal. 104pp.

Paper presented in workshop or seminar

Upadhyay MP, BK Baniya, RB Rana, J Bajrachayraya, A Subedi, A Mudwari, S Gyawali, DK Rijal, BK Joshi, HB KC, D Gauchan, BR Sthapit. 2003. On farm management of agrobiodiversity: Experiences of Nepal. Paper presented in: International conference on Himalayan biodiversity (ICHB 2003), 26-28 Feb 2003, Kathmandu.

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STATISTICAL METHODS

Report enough details of their experimental design so that the results can be judged for validating and so that previous experiments may serve as a basis for the design of future experiments. A multiple comparison procedure may be useful when treatments consists of a set of unrelated materials (such as cultivars or chemicals), but may be inappropriate in other cases. When treatments are factorial their effects may be classified by partitioning into main effects and interactions. Specific relationships among treatments may be elucidated with single-degree-of-freedom contrasts (for details see Joshi et al 2002 J. Institute Sci. Tech. 12:69-81). Regression analyses are appropriate when treatments form a progressive series of an experimental factor.

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Agronomic Performances of Rice and Potato in Different Cropping Patterns

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ABSTRACT

Cropping sequence affects grain crop yields. Nine different cropping patterns (CPs) were analyzed to know the effect of cropping sequences on rice grain and potato tuber yields, to study the role of legumes as green manure crop and to relate the biomass incorporated in soil with rice and tuber yields. Four cropping patterns such as vetch-fallow-rice, rice-bean-fallow-rice, berseem-fallow-rice and dhaincha-rice-potato gave higher rice yields than the CPs with chemical fertilizers. In tuber yield, dhaincha-rice-potato sequence gave the highest response among the CPs with no fertilizers. There were increment in both rice grain and potato tuber yields as biomass incorporated in soil was increased. Rotation on crops with legumes at least once in a year can be considered as important factor in sustaining production system.

Key words: Biomass, cropping patterns, cropping sequence, legumes, tuber yield, grain yield

INTRODUCTION

Rice (*Oryza sativa* L.) and potato (*Solanum tuberosum* L.) are important crops in Nepal. Crop yields depend upon the climate, application of organic manure, fertilizer rate and also cropping patterns. Rice-wheat system are practiced on 0.5 million ha in Nepal (IRRI 1992). The problem of decreasing land fertility, use of high doses of inorganic fertilizer and increasing the cost of inorganic fertilizers are factors considered harmful for sustainability of production systems. Increase in production of rice grain and potato tuber yields can be achieved by increasing productivity per unit area and time for the scope of increasing land under cultivation is limited. Modern researches have shown that legumes improve soil primarily through symbiotic N₂ fixation (Sutherland et al 1961, Baldock and Musgrave 1980). Legumes in Asia have been used as nitrogen source in rice-based cropping systems since ancient time (Watanabe and Lines 1992). Green manure was an important source of nutrient for rice in China, India and Japan (Bin 1983). Soybean green manure gave higher rice yield than farmyard manure and chemical fertilizers (Tripathi and Suwal 1999). Incorporation of 10 t ha⁻¹ of green leaves of

Asuro (Malabar-nut, *Justicia adhatoda* L) before transplanting rice produced 19 to 49 percent yield increase over 60 N:30 P₂O₅: 30 K₂O kg ha⁻¹ (Sthapit et al 1988). Garrity and Flinn (1987) estimated yield increases of 15 to 25 percent with the use of green leaf manure. Rice-potato-sunflower cropping sequence gave the highest total production followed by rice-potato-wheat (15.9 t ha⁻¹ year⁻¹) and potato-mentha (15.3 t ha⁻¹ year⁻¹) (Jaiswal et al 1993). Most of the earlier studies have been related to harnessing the yield potential through fertilizer application. Little information is available on the effects of cropping sequence on rice and potato yields. Study was, therefore, carried out to know the effect of cropping patterns on grain and tuber yields of rice and potato, to assess the effects of legumes on rice and potato production, and to determine the relationship between biomass (not considering the type) incorporated into the soil and grain and tuber yields.

MATERIALS AND METHODS

The experiment was performed during 1996 at the field of Regional Agricultural Research Station (RARS), Khajura, Nepalgunj (180 masl,

26° 06' N, 81° 37' E). The cropping patterns and cultivars used in the experiment are listed in Table 1.

The most common patterns, fallow-rice-wheat and lentil-fallow-rice were selected and compared with other seven modified cropping patterns. Seeds of all crops were obtained from RARS, Nepalgunj. In one of the okra-rice-potato

lentil (*Lens culinaris* L.) each of 120 days old plants were incorporated in the soil. Fresh biomass of cowpea, dhaincha, okra, berseem, rice bean, vetch and lentil; grain yields of rice, wheat (*Triticum aestivum* L.), cowpea, rice bean, and lentil; green pods of okra and tuber yields of potato were recorded from each plot. Some agronomic characters of rice were recorded as described by IRRI (1980).

Table 1. Cropping patterns and cultivars used in the experiment and remarks of each crop included in the experiment, 1996

Treatment	Cropping pattern	Crop	Cultivar/genotype	Remarks
1	Okra-rice-potato (ORP-1)	Rice	Radha-4	Early, drought and blast resistant
2	Okra-rice-potato (ORP-2)	Potato	Kufri Sinduri	Most popular, red skin
3	Dhaincha-rice-potato (DRP)	Dhaincha	Sesbania canabina	Higher germination rate
4	Cowpea-rice-potato (CRP)	Okra	Pravani Kranti	Yellow vein mosaic virus resistant
5	Wheat-fallow-rice (WFR)	Wheat	BL1135	Rust resistant, bold grains
6	Berseem-fallow-rice (BFR)	Cowpea	Prakash	Short duration, determinate type
7	Rice bean-fallow-rice (RbFR)	Berseem	Trifolium alexandrianum	Nutritious forage
8	Vetch-fallow-rice (VFR)	Rice bean	Nang dang	Determinate type
9	Lentil-fallow-rice (LFR)	Vetch	Common vetch	Dense ground coverage
		Lentil	Simal	Wide adaptation

(ORP-1) systems, fertilizers were applied @ 60:40:30 kg N:P₂O₅:K₂O ha⁻¹ to each crop but in other cropping patterns, rice was not fertilized and all others crops except legumes were fertilized @ 30:20:15 kg N:P₂O₅:K₂O ha⁻¹. The field was fertilized pre-plant with a half of N and full rate of P₂O₅ and K₂O and the remaining half of N was top dressed later on. The chemical fertilizers applied were urea, diammonium phosphate and muriate of potash. The experiment was laid out in RCB design with four replications. The plot size was 5- × 3-m.

Standard agronomic practices were followed. Dhaincha (*Sesbania cannabina*) of 90 days old; cowpea (*Vigna unguiculata*) of 70 days old; berseem (*Trifolium alexandrianum*) of 150 days and rice bean (*Phaseolus calcarus*), vetch (*Vicia sativa*), okra (*Abelmoschus esculentus* L.) and

Data on different cropping patterns were analyzed. Statistical procedures were followed as described by Gomez and Gomez (1984). The analyses were performed with MSTATC software (MSTATC 1990) and Microsoft Excel (version 6.0). Least significant difference (LSD) test was used to determine differences between means of grain and tuber yields of each treatment. Similarly, annual total grain, tubers, and okra yield, from each experimental unit were also analyzed. Trend comparisons were made to determine the relationship between biomass incorporated in the soil, and grain and tuber yields.

Orthogonal comparisons were made on grain and tuber yields between: i) cropping patterns having legumes vs non legumes, ii) cropping patterns having potato vs. non potato, iii) cropping

patterns receiving 60:40:30 kg N:P₂O₅:K₂O ha⁻¹ vs. legumes, iv) cropping patterns receiving 60:40:30 kg N:P₂O₅:K₂O ha⁻¹ vs. non legumes, and v) chemical fertilizers applied vs. without chemical fertilizers.

RESULTS AND DISCUSSION

Analysis of variance of rice yield and other agronomic characters were not significantly different (Table 2a, 2b). The cropping patterns: i) legumes vs non legumes, ii) potato vs non potato, and iii) 60:40:30 kg N:P₂O₅:K₂O ha⁻¹ vs legumes gave similar yields (Table 3a). Similar results were observed in plant height, panicle length, straw yield and harvest index (HI) (Table 3b). The highest rice yield was obtained from the vetch-fallow-rice cropping system followed by berseem-fallow-rice and rice bean-fallow-rice system. Dhaincha-rice-potato sequence was placed in the 4th position. The lowest fresh yield was in okra-rice-potato with fertilizers. In all sequences whether the chemical fertilizers were used or not, yield was not significantly different (Table 4). Higher rice yields were obtained from legume based sequences.

Potato tuber yield was significantly different in these cropping sequences (Table 2a). Tuber yield from legumes and non legumes based-CPs was

not significant but CPs receiving the chemical fertilizers were highly significantly different from others legumes or non legumes based (Table 3a). Among the three CPs receiving no fertilizers, dhaincha-rice-potato cropping sequence gave the highest tuber yield followed by okra-rice-potato (Table 4). Singh (1993) obtained the highest tuber yield from the plot where green manure was incorporated before potato planting. Khatri and Wells (1998) reported that potato grown after legumes produced more yields than where no legumes were included in CPs. Here the results were not similar to those obtained by Singh (1993). This may be due to the less biomass of legumes incorporated in soil in this study. Because amount of biomass incorporated in soil was very important (Figure 1) for tuber yield. Even ignoring the types of biomass there was certain change in tuber yield with increasing levels of biomass incorporated in the soil. Rice grown immediately after green manure incorporation might have taken up nutrients and this might have reflected in the less effectiveness of legumes in tuber yield. It is indicated that the amount of biomass buried in the soil should be considered an important factor to increase tuber yield.

Total rice and tuber yields over the years were significantly different (Table 2b). Orthogonal

Table 2a. Analysis of variance of rice and potato tuber yields from different cropping patterns, 1996

Source	Rice grain yield			Potato tuber yield		
	df	MS	F	df	MS	F
Replication	3	4.113	6.51	3	14.83	2.73
Cropping patterns	8	0.37	0.60	3	86.98	16.01**
Error	24			9	5.43	
CV, %	15.60%			13.62%		

** Significant at 1%.

Table 2b. Analysis of variance for different agronomic characteristics of rice grown in different cropping patterns, Khajura, Nepalgunj, 1996

Source†	Plant height		Panicle length		Straw yield		HI		Grain + tuber yield	
	MS	F	MS	F	MS	F	MS	F	MS	F
Replication	62.96	3.03	1.73	0.42	3.14	1.6	10.60	0.55	5.43	0.95
Cropping patterns	12.67	0.61	3.60	0.87	1.84	0.44	18.64	0.46	381.5	66.8**
Error	20.78		4.13		1.96		14.36		5.71	
CV, %	5.1		10.17		28.2		8.6		18.39	

** Significant at 1%. HI, Harvest index.

Table 3a. Contrast information for rice and potato yields, Nepalgunj, 1996

Contrast†	Grain yield		Contrast	Tuber yield	
	MS	F		MS	F
(2+5) vs. (3+4+6+7+8+9)	1.72	2.72	2 vs. (3+4)	1.60	0.29
(2+3+4) vs. (5+6+7+8+9)	0.48	0.75	1 vs. (2+3+4)	245.07	45.12**
1 vs. (2+3+4+5+6+7+8+9)	0.09	0.15	1 vs. (3+4)	205.57	37.84**
1 vs. (2+5)	0.003	0.005			
1 vs. (3+4+6+7+8+9)	0.85	1.35			

** Significant at 1%. † Number in parenthesis indicates treatment numbers.

Table 3b. Contrast information for some agronomic characters of rice grown in different cropping patterns, Nepalgunj, 1996

Con†	Plant height		Panicle length		Straw yield		HI		Grain + tuber yield	
	MS	F	MS	F	MS	F	MS	F	MS	F
1	6.51	0.47	3.01	0.73	7.37	3.77	13.4	0.69	8.50	1.48
2	4.02	0.14	0.29	0.07	1.04	0.56	0.11	0.01	1806.8	316.4**
3	2.17	0.10	4.75	1.15	0.52	0.26	4.06	0.21	1171.2	205.1**
4	3.72	0.18	6.09	1.48	0.04	0.02	1.65	0.09	1166.7	204.3**
5	0.00	0.00	1.04	0.25	3.9	2.0	12.8	0.66	796.1	139.0**

** Significant at 1%. HI, Harvest index.

† Con, Contrast. 1, Cropping patterns having legumes vs non legumes. 2, Cropping patterns having potato vs non potato. 3, Cropping patterns receiving 60:40:30 kg N, P₂O₅, K₂O ha⁻¹ vs legumes. 4, Cropping patterns receiving 60:40:30 kg N:P₂O₅:K₂O ha⁻¹ vs non legumes. 5, Cropping patterns with chemical fertilizers vs without chemical fertilizer.

contrast information indicated that there were highly significant differences on total rice and tuber yields between CPs having potato vs non potato, and chemical fertilizer applied vs. without chemicals (Table 3b). The highest total rice and tuber yields were obtained from okra-rice-potato (with chemical fertilizers) cropping system followed by dhaincha-rice-potato (Table 4). Two crops based CPs yielded more than single crop based CPs. Sikka et al (1974) reported that three crops based rotations such as maize-potato-onion, maize-potato-tomato were more profitable than the two crop maize-wheat rotation. Dhaincha-rice-potato based cropping pattern yielded maximum yield among CPs receiving no chemical fertilizers. There was no significant difference between okra-rice-potato (without fertilizers) and cowpea-rice-potato CPs. It is indicated that rice and potato planted after dhaincha gave the highest total production per year. Jaisawal et al (1993) obtained the highest total production from rice-potato-sunflower followed by rice-potato-wheat.

Rice grown after dhaincha, rice bean, berseem or vetch gave higher yields than the cropping

sequences: okra-rice-potato receiving 60:40:30 kg N:P₂O₅:K₂O ha⁻¹. Therefore, dhaincha, berseem, rice bean or vetch could be used as a substitute of chemical fertilizer. There was no effect on rice plant height, panicle lengths but significant difference on straw yield and HI was observed. The highest straw yield was on berseem-fallow-rice sequence, which resulted in the lowest HI. The lowest straw yield was observed in okra-rice-potato and lentil-fallow-rice sequences gave the highest HI. Straw and HI are equally important characters to be considered for rice grower. Straw is also very important component because it is used for livestock. Traditional varieties generally have lower HI as a result of taller culms. Yoshida et al (1972) observed the close association of HI and yielding potential of rice varieties. Lentil-fallow-rice sequence had the highest HI. Rice yield was also higher in this cropping pattern. An additional beneficial effects of legumes on the succeeding crop yield has been observed by Khatri and Wells (1996), Barker (1972). Sthapit (1991) reported an increment of rice yield by 19 to 49% with the use of green leaf manure over chemical fertilizers. Results indicated that legumes should be inter-

Table 4. Rice and potato yield and some agronomic characters obtained in different cropping patterns, Nepalgunj, 1996

Cropping pattern	Rice					Potato tuber yield, t ha ⁻¹	Rice grain + potato tuber, t ha ⁻¹ yr ⁻¹
	GrYld, t ha ⁻¹	StrYld, t ha ⁻¹	Plant height, cm	Panicle length, cm	HI‡, %		
Okra-rice-potato	3.49a†	3.53ab	89a	21a	50.1ab	15.93a	19.42a
Okra-rice-potato	3.11a	2.60b	86a	21a	52.4ab	9.55b	12.71c
Dhaincha-rice-potato	3.51a	3.40ab	91a	19a	51.7ab	10.96b	16.30b
Cowpea-rice-potato	3.18a	3.47ab	90a	19a	48.8ab	9.18b	12.26c
Wheat-fallow-rice	3.12a	2.82ab	91a	20a	52.4ab		3.11d
Berseem-fallow-rice	3.57a	4.06a	89a	20a	47.3b		3.57d
Rice bean-fallow-rice	3.56a	3.44ab	88a	21a	51.1ab		3.57d
Vetch-fallow-rice	3.63a	3.53ab	90a	19a	52.2ab		3.63d
Lentil-fallow-rice	3.40a	2.87ab	91a	21a	54.5a		3.40d

† Means within a column followed by a common letter/s don't differ significantly at the 0.05 probability level according to least significance difference test. GrYld, Grain yield. StrYld, Straw yield. ‡ HI, Harvest index.

cropped at least once in a year to get as much yield as indicated by CPs. Application of N fertilizers not only increases the cost of production but also creates soil and water pollution problem. On the other hand, legumes had positive effects as compared to chemical fertilizers.

Cropping sequences are important factors to be considered for the sustainability of production system. Some crops are to be planted not only for the immediate yield but also for improving soil fertility. Legumes can be used as green manure equivalently with 60:40:30 kg N:P₂O₅:K₂O ha⁻¹ in terms of rice yield in the rice based cropping pattern. Amounts of biomass incorporated in soil are also important factors to increase rice and potato yield.

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Genetic Diversity in Nepalese Wheat Cultivars Based on Agro-Morphological Traits and Coefficients of Parentage

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ABSTRACT

Genetic diversity between parents is necessary to derive transgenic segregants from a cross. Coefficient of parentage (COP) and agromorphological traits (AMT) can be used to estimate diversity among cultivars. The pedigrees of 26 bread wheat cultivars were traced back to 77 ancestors and computed coefficient of parentage for all pair-wise combinations. All the cultivars used in the pedigree analysis were evaluated for six agromorphological traits in the National Wheat Research Programme (NWRP), Bhairahawa, Nepal in 1996. Six quantitative variables were used to compute dissimilarity distance matrix. Cluster and principal components analyses were performed on the matrix of COP and AMT values. COP matrix and the matrix based on agromorphological traits were compared. Mexico, India and Nepal were countries of the origin for 26 cultivars. A total of 77 ancestors originated from 22 different countries were used to develop these cultivars. Most of the ancestors were aestivum (80.52%) and spring growth habit (64.94%). Maximum dissimilarity was between RR 21 and Annapurna 3 and the most closely related pair was Rohini and BL 1022 based on the AMT. The mean of COP for all cultivars was 0.159 ± 0.256 . The highest COP was between Annapurna 3 and Annapurna 2. Other more closely related pairs based on COP were Kalyansona and Annapurna 2, Pasang Lhamu and Annapurna 3, UP 262 and RR 21, Vaskar and Kalyansona, NL 297 and BL 1473, Pasang Lhamu and Annapurna 1. Completely unrelated pairs were L 52 and HD 1982, L 52 and Kalyansona, LR 64 and Kalyansona, Kalyansona and HD 1982, PI and Kalyansona, PI and L 52, RR 21 and HD 1982, RR 21 and Kalyansona, RR 21 and PI. Fifteen ancestors were present in at least about 65% of the cultivars. 17 ancestors had been used more frequently. Five and six clusters were formed based on AMT and COP, respectively. Correlation coefficient between COP and AMT was 0.18 ($P = 0.0168$). Cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic variation may be useful for further improvement of wheat and it is necessary to conserve them.

Key words: Agromorphological traits, coefficient of parentage, genetic diversity, Nepalese wheat cultivars

INTRODUCTION

Wheat is the third most important crop after rice and maize in Nepal. During mid 1960s, the yield potential of dwarf high yielding varieties initiated scopes 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 the development works on wheat as a

commodity. Since then, there have been a 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).

Parental selection is the first step in any plant breeding programme. Genetic diversity between parents is necessary to derive transgenic

segregants from a cross. One would like to detect genetic diversity among phenotypically superior breeding materials so that appropriate crosses could be produced. 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 genetic diversity depends on the number and the diversity of the original ancestors involved in the development of a germplasm pool. Coefficient of parentage (COP) and agromorphological traits (AMT) can estimate diversity among cultivars. COP has also been used to predict breeding behavior of the progeny of crosses (Cowen and Frey 1987), to summarize regional crop diversity (Souza et al 1994) and to identify parents that have contributed to yield improvements (Beer et al 1995). Diversity in wheat breeding programme based on morphological traits and pedigree information was measured by Autrique et al (1996) in durum wheat, Gerdes and Tracy (1994) in sweet corn, Schut et al (1997) in barley. Morphological markers often do not reliably portray genetic relationships because of environmental interactions, epistatic interactions and largely unknown genetic control of the traits (Smith and Smith 1989). The objective of this research was to study the level of diversity present in the Nepalese bread wheat cultivars. Diversity based on agromorphological traits and coefficient of parentage was measured and compared.

MATERIALS AND METHODS

Coefficient of parentage

We examined the pedigrees of 26 cultivars (Table 1) out of 35 released cultivars in Nepal. Due to unavailability of seeds of seven cultivars, these were excluded both in pedigree and agromorphological analyses. 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 26 bread wheat cultivars were traced back to 77 ancestors (Figure 1, Table 2),

that had no known relationship each other and computed coefficient of parentage for all pair wise combinations. The source of pedigrees and release dates for cultivars were Jain (1994), NARC (1997), Bland (2001), Skovmand et al (1997), Joshi and Mudwari (2003) and Skovmand et al (2000). The coefficient of parentage between two individuals is defined as the probability that a random allele at a locus in one individual is identical by descent to a random allele at the same locus in other individual. The following assumptions were made in computing coefficients of parentage: a) ancestors are unrelated, b) all cultivars, ancestors and parental lines are homozygous and homogenous, c) a cultivar derived from a cross obtains one-half of its genes from each parent, d) the COP between cultivar or ancestor and a direct selection from that cultivar or ancestor is 0.75, e) the COP between two selections from the same cultivar or ancestor is $(0.75)^2 = 0.56$ and f) the COP between a cultivar and itself is 1.0. Origin and growth habit of ancestors were also reported.

Agromorphological traits

All the cultivars used in pedigree analysis were evaluated for six agromorphological traits in National Wheat Research Programme (NWRP), Bhairahawa, Nepal in 1996. These traits were days to heading, days to maturity, plant height, 1000-grain weight, grain number per spike and grain yield (Table 3).

Data analysis

Six quantitative variables measured were used to compute dissimilarity distance matrix. The data was transferred with the STAND procedure from NTSYS-pc. The standardization procedure reduced the effect of different scales of measurement of different characters. In this transformation, the mean is subtracted from the original value and divided by the standard deviation. The standardized values were used in the SIMINT subroutine of NTSYS-pc to compute a matrix of dissimilarities among all pairs of cultivars with the average taxonomic distance. The computer programme, KIN was used to calculate the COP (Tinker and Mathur 1993).

Table 1. Nepalese bread wheat cultivars used in this study

SN	Variety	Abb [†]	Pedigree	Origin	Year released	Area of adaptation
1.	Achyut	ACH	CPAN1687/HD2204	India	1997	Terai
2.	Annapurna 1	ANNA1	KVZ/BUHO//KAL/BB	Mexico	1988	Hills
3.	Annapurna 2	ANNA2	NAPO/TOB//8156/3/KAL/BB	India	1988	Hills
4.	Annapurna 3	ANNA3	KVZ/BUHO//KAL/BB	Mexico	1991	Hills
5.	Annapurna 4	ANNA4	KVZ/3/CC/INIA/CNO/ELGAU/4/SN64	Mexico	1994	Hills
6.	Bhrikuti	BK	CMT/COC75/3/PLO//FURY/ANA	Mexico	1994	Terai
7.	BL 1022	BL1022	PVN/ALD	Nepal	1991	Western Terai
8.	BL 1135	BL1135	QTZ/TAN	Nepal	1994	Terai
9.	BL 1473	BL1473	NL297/NL352	Nepal	1999	Terai & Hills
10.	HD 1982	HD1982	E5557/HD845	India	1975	Western Plains
11.	Kalyansona	KAL	PJ/GB55	Mexico	1968	Terai
12.	Kanti	KANTI	LIRA/FFN//VEE	Mexico	1997	Hills
13.	Lerma 52	L52	MTA/K324	Mexico	1960	Hills
14.	Lerma Rojo 64	LR64	Y50/N10B//L52/3/2*LR	Mexico	1967	Hills
15.	Lumbini	LUM	E4871/PJ	India	1981	Terai
16.	NL 251	NL251	WH147/HD2160//2*WH147	India	1988	Terai
17.	NL 297	NL297	HD2137/HD2186//HD2160	India	1985	Terai
18.	NL 30	NL30	HD832/BB	India	1975	Western Plains
19.	Pasang Lhamu	PAL	PGO/SERI	Mexico	1997	Hills
20.	Pitic 62‡	PI	YT54/N10B 26.1C	Mexico	1967	Hills
21.	Rohini	ROH	PRL/TONI//CHIL	Nepal	1997	Terai
22.	RR 21 (Sonalika)	RR21	I153.388/AN/3/YT54/N10B/3/LR/4/B49 46.A.4.18.2.IY/Y53//3*Y50	Mexico	1971	Hills & Plains
23.	Siddhartha	SID	HD2092/HD1962//E4870/3/K65	India	1983	Terai
24.	Triveni	TRI	HD1963/HD1931	India	1982	Terai
25.	UP 262	UP262	S 308/BAJIO 66	India	1978	Terai
26.	Vaskar	VKR	TZPP/PL//7C	Mexico	1983	Mid-western Terai

[†] Abb, Abbreviation. [‡] PI was not formally released but reported by many authors (Bland 2001). BL, Bhairahawa Line. HD, Hybrid Delhi. NL, Nepal Line. RR, Rust Resistant, UP, Uttar Pradesh.

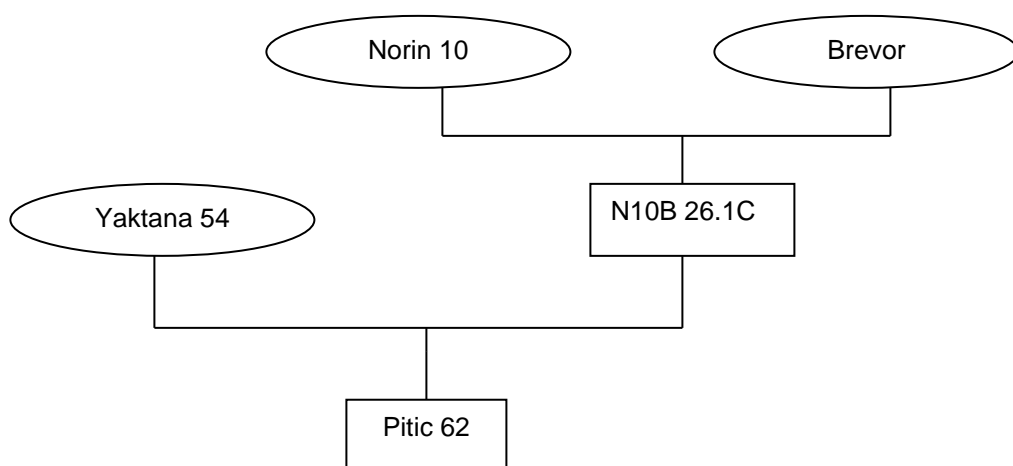


Figure 1. Pedigree tree of Pitic 62 wheat cultivar (Ancestors are kept in oval shape. For pedigree trees of all Nepalese improved wheat cultivars, contact author)

Table 2. Ancestors of 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.	8B	8B	INDIA	IND	-	-
4.	9D	9D	INDIA	IND	-	AESTIVUM
5.	AKAGOMUGHI	AGA	JAPAN	JPN	WINTER	AESTIVUM
6.	ALFREDO CHAVES 6.21	AC	BRAZIL	BRA	SPRING	AESTIVUM
7.	B4946.A.4.18.2.IY	B4946	-	-	-	-
8.	BONZA	BZA	COLOMBIA	COL	SPRING	AESTIVUM
9.	BREVOR	BVR	USA	USA	WINTER	AESTIVUM
10.	BUTTON	BUTTON	-	-	-	AESTIVUM
11.	C13	C13	INDIA	IND	SPRING	AESTIVUM
12.	C209	C209	INDIA	IND	SPRING	AESTIVUM
13.	CARIANCA422	CAR422	CHILE	CHL	WINTER	AESTIVUM
14.	CENTENARIO	CTR	BRAZIL	BRA	SPRING	AESTIVUM
15.	CHRIS	CHR	USA	USA	SPRING	AESTIVUM
16.	CLEMENT	CMT	NETHERLANDS	NLD	WINTER	AESTIVUM
17.	CPAN1687	CPAN1687	INDIA	IND	SPRING	AESTIVUM
18.	DAVIS6301	D6301	USA	USA	-	AESTIVUM
19.	EL GAUCHO	ELGAU	ARGENTINA	ARG	SPRING	AESTIVUM
20.	FEDERATION	FR	AUSTRALIA	AUS	SPRING	AESTIVUM
21.	FROCOR	FCR	BRAZIL	BRA	SPRING	AESTIVUM
22.	FUFAN17	FFN	CHINA	CHN	SPRING	AESTIVUM
23.	FURY	FURY	KENYA	KEN	SPRING	AESTIVUM
24.	GAZA	GAZA	EGYPT	EGY	SPRING	DURUM
25.	GABO-AUS	GB	AUSTRALIA	AUS	SPRING	AESTIVUM
26.	GENERAL URQUIZA	GU	ARGENTINA	ARG	SPRING	AESTIVUM
27.	HARD FEDERATION	HF	AUSTRALIA	AUS	SPRING	AESTIVUM
28.	HARDRED CALCATTA	HRC	INDIA	IND	SPRING	AESTIVUM
29.	HOPE	H44	USA	USA	-	AESTIVUM
30.	HYBRID DELHI845	HD845	INDIA	IND	SPRING	AESTIVUM
31.	IUMILLO	IU	USA	USA	SPRING	DURUM
32.	KANRED	KR	USA	USA	WINTER	AESTIVUM
33.	KAVKAZ	KVZ	RUSSIA	RSA	WINTER	AESTIVUM
34.	KENTANA48	KT48	MEXICO	MEX	SPRING	AESTIVUM
35.	KENYA GOVERNER	KGV	KENYA	KEN	SPRING	AESTIVUM
36.	KENYA STANDARD	KS	KENYA	KEN	SPRING	-
37.	KENYA117A	K117A	KENYA	KEN	SPRING	AESTIVUM
38.	KENYA256	K256	KENYA	KEN	SPRING	-
39.	KENYA324	K324	KENYA	KEN	SPRING	-
40.	KENYA350-A-D9-C-2	KAD	KENYA	KEN	SPRING	-
41.	KENYA58	K58	KENYA	KEN	SPRING	AESTIVUM
42.	KHAPLI	KHP	INDIA	IND	SPRING	DURUM
43.	KLEIN ATLAS	KLAT	ARGENTINA	ARG	SPRING	AESTIVUM
44.	KLEIN RENDIDOR	KLRE	ARGENTINA	ARG	SPRING	AESTIVUM
45.	LA ESTANZUELA2787C	LAEST	-	-	-	-
46.	LERMA ROJO	LR	MEXICO	MEX	SPRING	AESTIVUM
47.	MARNE DESPREZ	MD	FRANCE	FRA	WINTER	AESTIVUM
48.	MARROQUI	MRQ	MOROCCO	MAR	SPRING	AESTIVUM
49.	MCMURACHY	MCM	CANADA	CAN	SPRING	AESTIVUM
50.	MIDA-U	MIDA	USA	USA	SPRING	AESTIVUM
51.	MUNDIA	MUNDIA	INDIA	IND	-	-
52.	NAPO	NAPO	COLOMBIA	COL	SPRING	AESTIVUM
53.	NARINO59	NAR59	COLOMBIA	COL	SPRING	AESTIVUM
54.	NAINARI60	NAI60	MEXICO	MEX	-	AESTIVUM
55.	NORIN10	N10	JAPAN	JPN	WINTER	AESTIVUM
56.	NEW PUSA773	NP773	INDIA	IND	SPRING	AESTIVUM
57.	OLESSEN'S DWARF	ON	ZIMBABWE	ZIM	SPRING	AESTIVUM
58.	P4160E	P4160E	MEXICO	MEX	SPRING	AESTIVUM
59.	POLYSSU	PSSU	BRAZIL	BRA	SPRING	AESTIVUM
60.	QUINTZEL	QTZ	-	-	-	-

SN	Name	Abb†	Origin		Growth habit	Species
			Name	Abb		
61.	RED FIFE	RF	CANADA	CAN	SPRING	AESTIVUM
62.	RED MACE	RM	GREAT BRITAIN	GBR	WINTER	AESTIVUM
63.	REITI	REITI	-	-	-	-
64.	S339	S339	INDIA	IND	SPRING	AESTIVUM
65.	SANTA ELENA	SE	USA	USA	SPRING	AESTIVUM
66.	SINVALOCHO MA	SCHOMA	ARGENTINA	ARG	SPRING	AESTIVUM
67.	STEINWEDEL	SWD	AUSTRALIA	AUS	SPRING	AESTIVUM
68.	TEZANOS PINTOS PRECOZ	TZPP	ARGENTINA	ARG	SPRING	AESTIVUM
69.	THEW	THEW	AUSTRALIA	AUS	WINTER	AESTIVUM
70.	TIMESTEIN	T	AUSTRALIA	AUS	SPRING	AESTIVUM
71.	TYPE1	TYPE1	PAKISTAN	PAK	-	DURUM
72.	TYPE9	TYPE9	PAKISTAN	PAK	-	AESTIVUM
73.	VERNAL EMMER	VN	RUSSIA	RSA	SPRING	DURUM
74.	WEIQUE	WEIQUE	DUETSCHLAND	DEU	WINTER	AESTIVUM
75.	WILHELMINE	WHM	NETHERLANDS	NLD	WINTER	AESTIVUM
76.	WILLET ERONO	WTE	USA	USA	SPRING	AESTIVUM
77.	YAKTANA54	YT54	MEXICO	MEX	SPRING	AESTIVUM

† Abb, Abbreviation.

Table 3. Agromorphological traits of Nepalese bread wheat cultivars†

SN	Cultivar	DH	DM	Plant height, cm	TGW, g	G SPK ⁻¹ , N	Grain yield, t/ha
1.	Achyut	89	123	104	42.5	34.8	4.6
2.	Annapurna 1	86	121	97	42.2	61.5	7.6
3.	Annapurna 2	79	118	102	40	54	5.8
4.	Annapurna 3	87	123	98	38.3	64.2	6.2
5.	Annapurna 4	78	116	102	46.2	55.8	5
6.	Bhrikuti	86	123	92	46	50.4	4
7.	BL 1022	77	116	97	45.3	51.2	6.4
8.	BL 1135	72	116	101	43.7	49.4	6.2
9.	BL 1473	68	115	99	50	40	5.8
10.	HD 1982	77	119	91	43.9	41.5	4.6
11.	Kalyansona	86	123	96	36.5	35.9	5.8
12.	Kanti	88	122	122	52.7	59.2	6.2
13.	Lerma 52	88	120	135	41.3	50.8	3.4
14.	Lerma Rojo 64	86	122	108	38.3	46	3.4
15.	Lumbini	77	120	90	47.6	40.1	6.4
16.	Nepal Line 251	77	118	99	46.4	52.6	8
17.	Nepal Line 297	67	116	90	54.7	46.8	5
18.	Nepal Line 30	85	120	106	40.6	56.2	6.4
19.	Pasang Lhamu	81	118	111	38	42	3.5
20.	Pitic 62	90	125	102	43	48	4.5
21.	Rohini	75	115	104	46.9	51.6	6.6
22.	RR 21 (Sonalika)	68	115	91	56.1	37.8	4.4
23.	Siddhartha	74	120	86	44.4	45	7.6
24.	Triveni	79	116	101	47.1	59	4
25.	UP 262	81	119	99	49.9	36.5	5.2
26.	Vaskar	82	119	93	40	59.8	6.2
	Mean	80.11	119.15	100.61	44.67	48.85	5.49
	SD	6.80	2.97	10.35	5.12	8.51	1.30

† DH, Days to heading. DM, Days to maturity. TGW, 1000-grain weight. G SPK⁻¹, Grain number per spike. SD, Standard deviation.

Cluster analysis was performed on the matrix of COP and AMT values using the computer programme NTSYS-pc (Rohlf 1994), which employed the unweighted pair group method of clustering. A dendrograph was drawn based on the cluster analysis. The hierarchical dendrogram of pedigree clusters was formed by successively joining groups with the highest coefficient of parentage. Principal component analysis was performed upon the matrix of relationships among cultivars for reduction of dimensions for analysis of cultivar relationship. This procedure permits the representation of the cultivars as points in Euclidean space.

COP matrix and the matrix based on agromorphological traits were compared by the MXCOMP routine of NTSYS-pc (Rohlf 1994) that uses the normalized Mantel Z statistics. The statistical consideration for these analyses were discussed by Beer et al (1993).

RESULTS AND DISCUSSION

Mexico, India and Nepal are countries of origin for 26 cultivars. In Nepal four cultivars had been originated and the maximum number of cultivars was originated from Mexico. 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. Shuttleing of generation lines during the off-season help to develop wheat cultivars within a short period of time. Due to the varied agroecological diversity of the country, it is possible to plant the same cultivar in both winter and summer seasons.

Most of the recommended cultivars are adapted to plains but there is lack of climatic information in defining plains. Site-specific adapted cultivars are necessary because of diverse climate in Nepal. The trend of releasing many cultivars in the same year for the same domain is not strong strategy of breeding programme. Strategy is better to adopt a system of releasing a cultivar for some specific domain regularly. Cultivars

performance may be affected by origin of ancestors, number of ancestors used and times of crossing considered for developing them. Nine parents with 7 times crosses were used for developing Sonalika, which has been a popular cultivar in the country. Therefore, study on origin of ancestors, number of ancestors and crossing frequency may be useful for crop improvement programme and gene conservation.

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. Relatively more number of ancestors has been used in developing Nepalese wheat cultivars. A total of 77 ancestors originated in 22 different countries were used to develop 26 cultivars. Highest number of ancestors was from India (Table 2). 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 (80.52%) and spring growth habit (64.94%). CIMMYT (1987) reported that crosses between winter and spring wheat gene pools are far more common and offer a new source of diversity. Landraces from Nepal were not used in developing these cultivars, though 150 landraces have been maintained by National Wheat Research Programme, Bhairahawa. Cultivated landraces of spring and winter type, wild landraces and diploid species of wheat are found in Nepal (Bland 2001) (Mudwari 1999). Gene pool from these landraces along with international gene pool could make to success in developing high yielding cultivars with wide adaptability.

We assumed here that ancestors are not related but some of genes may be similar. Therefore, ancestors' dissimilarity at molecular level, if we could add on COP analysis may be better way of diversity assessment of ancestors used in

developing cultivar. If more number of ancestors is used, more genes are conserved in a single cultivar. The number of ancestors used to develop a cultivar ranged from 3 to 23. Diversity on ancestors with respect to growth habit and species was low, it indicates that these 26 cultivars may have also narrow diversity on these aspects. However, there are possibility of increasing diversity through mutation and transgressive segregation,. Similarly, the number of origin country may not be good indicator of diversity rather geographic differences among these countries may be better way to discuss about variation present in released cultivars.

Agromorphological traits (AMT)

The AMT showed great variation among these cultivars (Table 3). Annapurna-1 was the highest grain yielder followed by Siddhartha and Lerma 52 and LR 64 were lower yielder. Siddhartha was also the most dwarf genotype. PI matured late and BL 1473, Rohini and RR 21 were early maturing cultivars. Developing cultivars possessing desired period of maturity, height and yield seemed possible using these gene pools. Relative genetic dissimilarities based on AMT are given in Table 4. These values were the standardized relative genetic dissimilarity coefficients. Maximum dissimilarity was observed between RR 21 and Lerma 52. Other more distantly related cultivars were RR 21 with Annapurna 2, Kanti and Siddhartha with L 52; NL 297 with Annapurna 3 and L 52, and L 52 with BL 1477. The most closely related pair was Rohini and BL 1022. Others closely related pairs were Triveni and Annapurna 4, Rohini and BL 1135 and BL 1135 and BL 1022. Clustering by AMT largely reflected the differences in days to maturity, plant height and grain yield. Souza and Sorrells (1991a) showed that relationships based on quantitative traits of oats revealed a distribution of genotypes based on days to heading. Five distinctive clusters were identified (Figure 1). Clusters 1 and 2 included all the cultivars except Kanti, L 52, RR 21, BL 1473 and NL 297. Cluster 1 included mostly late maturing and medium grain yielding cultivars. Tall were grouped in clusters 4 and 5.

Variation in days to heading and days to maturity was low in compared to other agromorphological traits. These six traits are agronomically important and we can relate these traits to other findings. Because of environment sensitive traits, addition of other single gene governed traits ie morphological markers in such study may be more appropriate and easy to interpret. Dissimilarity value ranged from 0.361 to 2.607 based on AMT. The highest value between RR 21 and L 52 was attributed due to variation in plant height, 1000-grain weight and grain number. Similarly, the least value between Rohini and BL 1022 was due to similarity in days to heading, maturity, 1000-grain weight, grain number and grain yield. Diversity values (Table 4) and cluster groups (Figure 2) may be useful for selecting parental materials from these cultivars and developing conservation strategy.

Coefficient of parentage (COP)

The COP for all cultivars is given in Table 5. The mean of COP for all cultivars was 0.159 ± 0.256 and ranged from 0.000 to 0.603. The highest COP was between Annapurna 3 and Annapurna 1 ie these are the most closely related. Other more closely related pairs based on COP were Kalyansona and Annapurna 2, NL 297 and BL 1473, Pasang Lhamu and Annapurna 1, Pasang Lhamu and Annapurna 3, UP 262 and RR 21, and Vaskar and Kalyansona. Completely unrelated pairs were Kalyansona and HD 1982, L 52 and HD 1982, Kalyansona and HD 1982, L 52 and Kalyansona, Lerma Rojo 64 and Kalynasona, PI and Kalyansona, PI and L 52, RR 21 and HD 1982, RR 21 and Kalyansoan, RR 21 and PI. Fifteen ancestors were present at least in about 65% of the cultivars. Most commonly used ancestors were N 10, BE, YT 54, T, MRQ, K 324, HRC, RF, GB, KVZ, TZPP, NAR 59, WTE, SE, PJ, PISSU and LR. The COP mean across these cultivars is similar to those reported for oat and barley (Souza and Sorrells 1989, Martin et al 1991), but lower that those reported by Dilday (1990) and Autrique et al (1996). In barley, only five ancestors contributed more than 50% of the genetic make up of released cultivars (Martin et al 1991).

Table 4. Relative genetic dissimilarities of 26 Nepalese bread wheat cultivars estimated from six agromorphological traits

SN	Cultivar	1 15	2 16	3 17	4 18	5 19	6 20	7 21	8 22	9 23	10 24	11 25	12 26	13	14
1.	ACH†	0.000													
2.	ANNA1	1.644	0.000												
3.	ANNA2	1.366	0.928	0.000											
4.	ANNA3	1.556	0.620	1.000	0.000										
5.	ANNA4	1.575	1.255	0.626	1.392	0.000									
6.	BK	0.964	1.325	1.173	1.160	1.214	0.000								
7.	BL1022	1.582	1.099	0.600	1.410	0.536	1.349	0.000							
8.	BL1135	1.651	1.321	0.636	1.561	0.637	1.504	0.378	0.000						
9.	BL1473	1.842	1.902	1.305	2.176	1.059	1.765	0.883	0.744	0.000					
10.	HD1982	1.095	1.497	0.904	1.540	0.939	0.916	0.878	0.899	1.036	0.000				
11.	KAL	0.710	1.451	1.239	1.374	1.667	1.182	1.510	1.559	1.892	1.092	0.000			
12.	KANTI	1.675	1.381	1.522	1.513	1.447	1.539	1.607	1.738	2.024	1.887	2.003	0.000		
13.	L52	1.551	2.067	1.630	1.881	1.678	1.799	1.991	1.957	2.289	1.962	1.941	1.446	0.000	
14.	LR64	0.786	1.606	1.123	1.306	1.353	0.934	1.552	1.561	1.931	1.139	1.030	1.673	1.155	0.000
15.	LUM	1.241	1.329	1.077	1.587	1.140	1.136	0.833	0.937	0.980	0.654	1.172	1.764	2.232	1.542
16.	NL251	1.727	0.882	0.875	1.369	0.998	1.553	0.586	0.747	1.175	1.253	1.585	1.493	2.183	1.817
17.	NL297	2.064	1.999	1.539	2.237	1.142	1.684	1.110	1.096	0.676	1.162	2.171	2.093	2.543	2.107
18.	NL30	1.275	0.608	0.528	0.684	0.945	1.141	0.925	1.058	1.669	1.217	1.191	1.208	1.513	1.112
19.	PAL	1.069	1.787	1.007	1.646	1.148	1.309	1.338	1.252	1.562	1.019	1.236	1.851	1.182	0.666
20.	PI	1.494	1.722	1.873	1.225	0.000									
21.	ROH	0.699	1.326	1.290	1.076	1.508	0.619	1.607	1.727	2.065	1.256	0.979	1.405	1.528	0.742
22.	RR21	1.391	1.692	2.133	1.063	1.296	0.000								
23.	SID	1.753	1.286	0.781	1.621	0.593	1.592	0.361	0.396	0.805	1.123	1.748	1.548	1.943	1.710
24.	TRI	1.049	0.647	1.115	1.068	1.424	1.804	0.000							
25.	UP262	2.062	2.327	1.798	2.551	1.403	1.844	1.382	1.354	0.733	1.254	2.246	2.302	2.607	2.191
26.	VKR	1.275	1.711	0.508	2.134	1.896	2.268	1.373	0.000						
		1.620	1.176	1.090	1.509	1.306	1.447	0.869	0.951	1.198	0.999	1.321	1.972	2.510	1.819
		0.564	0.738	1.357	1.257	1.774	1.662	1.103	1.620	0.000					
		1.677	1.450	0.878	1.481	0.363	1.184	0.873	0.967	1.289	1.070	1.842	1.525	1.672	1.358
		1.375	1.325	1.230	1.148	1.208	1.540	0.936	1.474	1.582	0.000				
		0.980	1.596	1.187	1.774	1.079	1.072	1.003	1.092	0.987	0.691	1.257	1.582	1.862	1.327
		0.638	1.231	1.181	1.317	1.221	1.280	1.115	1.149	1.174	1.243	0.000			
		1.547	0.622	0.520	0.702	0.880	1.124	0.798	0.982	1.617	1.101	1.334	1.622	1.964	1.341
		1.177	0.927	1.7007	0.592	1.412	1.301	1.067	2.021	1.069	1.046	1.424	0.000		

† Refer Table 1 for full description of cultivars.

The COP (0.603) between Annapurna 1 and Annapurna 3 was due to the same ancestors used in developing them (Table 5). Value of zero indicates the completely different ancestors were used for developing these cultivars. As the value increases, the ancestral similarity increases. Eight pairs of cultivars were developed using completely different ancestors.

Five and six clusters were formed based on AMT and COP, respectively (Figure 1). Kanti and L 52 formed a single individual cluster within AMT

and Lumbini and Achyut formed the single individual cluster based on COP. The maximum number of cultivars in a cluster were 15 and 13 based on AMT and COP, respectively. Plot of two dimension based on the multivariate analysis could help to locate cultivars responded with PC1 and PC2 (Figure 2). Cultivars scattered apart were RR 21 and Annapurna 3, L 52 and Siddhartha based on AMT and RR 21 and Annapurna 3, NL 251 and BL 1473 based on COP. First two PC accounted 55% and 85% of variation based on AMT and COP, respectively.

Cultivar pair, which has highest COP value, was not most diverse with respect to AMT. Probably this happens due to quantitative traits. Relatively cluster and scatter diagram drawn based on COP may be more reliable to pick the most diverse genotypes. This is also supported much by

accounting much more variations by first two PCs in COP analysis. Among the four cells in PC graph, there was not any cultivar in right top quarter and most of the cultivars has fallen within two cells. But equal distribution of cultivars in four cells was found in graph based on AMT.

Table 5. Coefficients of parentage for all pair wise combinations of 26 Nepalese bread wheat cultivars

SN	Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		15	16	17	18	19	20	21	22	23	24	25	26		
1	ACH†	1.000													
2	ANNA1	0.029	1.000												
3	ANNA2	0.027	0.394	1.000											
4	ANNA3	0.029	0.603	0.394	1.000										
5	ANNA4	0.067	0.157	0.086	0.157	1.000									
6	BK	0.040	0.122	0.113	0.122	0.126	1.000								
7	BL1022	0.031	0.221	0.230	0.221	0.134	0.095	1.000							
8	BL1135	0.020	0.170	0.173	0.170	0.087	0.072	0.199	1.000						
9	BL1473	0.051	0.141	0.148	0.141	0.126	0.078	0.129	0.084	1.000					
10	HD1982	0.007	0.016	0.012	0.016	0.041	0.018	0.030	0.016	0.038	1.000				
11	KAL	0.019	0.355	0.440	0.355	0.014	0.071	0.223	0.148	0.145	0.000	1.000			
12	KANTI	0.027	0.349	0.227	0.349	0.130	0.110	0.137	0.105	0.090	0.013	0.192	1.000		
13	L52	0.046	0.020	0.012	0.020	0.058	0.037	0.021	0.015	0.029	0.000	0.000	0.022	1.000	
14	LR64	0.100	0.069	0.006	0.069	0.058	0.150	0.042	0.023	0.066	0.016	0.000	0.092	0.125	1.000
15	LUM	0.023	0.014	0.013	0.014	0.049	0.020	0.018	0.013	0.043	0.016	0.004	0.013	0.063	0.021
16	NL251	0.026	0.084	0.106	0.084	0.022	0.025	0.056	0.038	0.078	0.010	0.215	0.048	0.034	0.017
17	NL297	0.067	0.046	0.047	0.046	0.120	0.060	0.052	0.034	0.527	0.046	0.023	0.041	0.040	0.120
18	NL30	0.027	0.248	0.235	0.248	0.105	0.113	0.148	0.135	0.109	0.078	0.128	0.152	0.012	0.022
19	PAL	0.033	0.434	0.339	0.434	0.146	0.117	0.287	0.192	0.145	0.027	0.320	0.355	0.021	0.056
20	PI	0.014	0.044	0.031	0.044	0.089	0.043	0.095	0.049	0.093	0.250	0.000	0.032	0.000	0.031
21	ROH	0.029	0.209	0.188	0.209	0.105	0.119	0.169	0.115	0.109	0.019	0.179	0.162	0.023	0.072
22	RR21	0.047	0.035	0.021	0.035	0.108	0.064	0.037	0.026	0.136	0.000	0.000	0.039	0.000	0.215
23	SID	0.089	0.044	0.044	0.044	0.078	0.051	0.041	0.028	0.070	0.009	0.042	0.038	0.094	0.136
24	TRI	0.049	0.052	0.046	0.052	0.154	0.074	0.059	0.041	0.072	0.023	0.017	0.049	0.039	0.158
25	UP262	0.098	0.055	0.053	0.055	0.201	0.094	0.077	0.047	0.133	0.016	0.006	0.053	0.023	0.118
26	VKR	0.028	0.189	0.255	0.189	0.045	0.055	0.130	0.085	0.097	0.004	0.501	0.109	0.010	0.034
		0.007	0.114	0.044	0.075	0.178	0.009	0.104	0.017	0.042	0.046	0.063	1.000		

† Refer Table 1 for full description of cultivars.

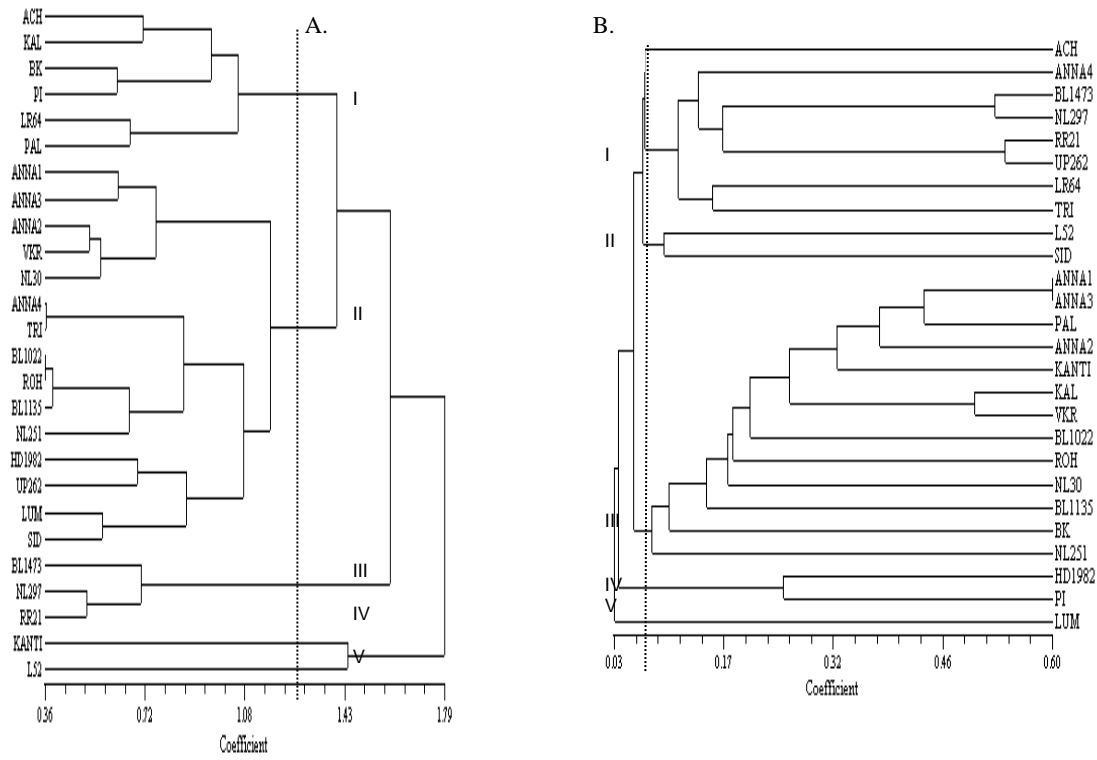


Figure 2. Dendrograph based on agromorphological traits (A) and coefficients of parentage (B) among 26 Nepalese bread wheat cultivars (Refer Table 1 for full description of cultivars).

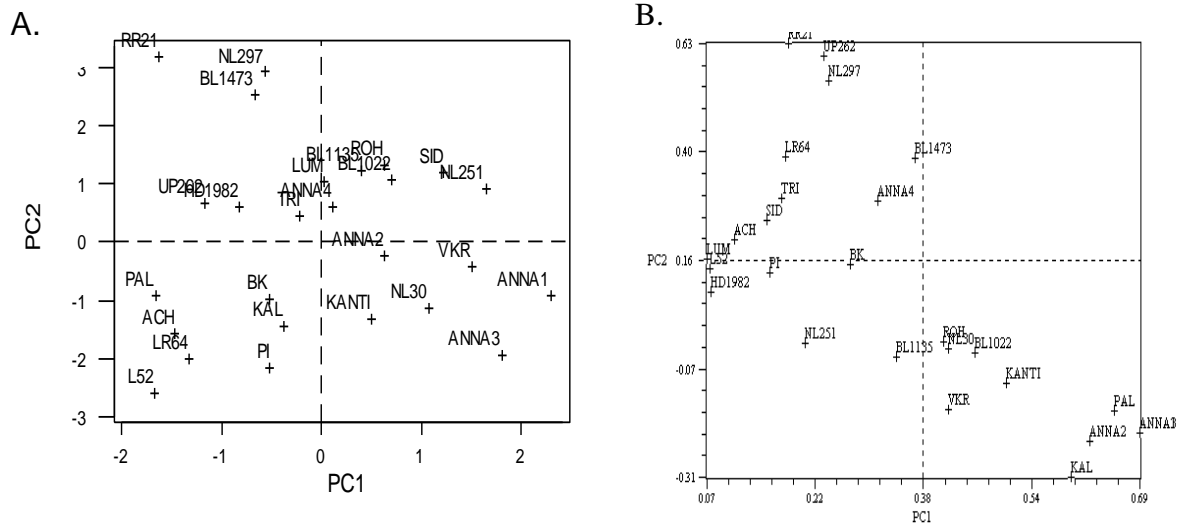


Figure 3. Plot of the first (PC1) and second (PC2) principal components from principal components analysis of agromorphological traits (A) and coefficients of parentage (B) among 26 Nepalese bread wheat cultivars (Refer Table 1 for full description of cultivars).

Comparison of different measures of similarity

The degree of relationship between the distance estimation based on COP and AMT was measured with the normalized Mantel Z statistics. Correlation coefficient between COP and AMT was 0.18 ($P = 0.0168$). The correlation coefficient was lower than the reported in durum wheat (Autrique et al 1996). Cox et al (1985a) found close agreement between modern soybean cultivars based on pedigree data and estimates based on biochemical and morphological markers.

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 improvement of wheat. The results of this study may help in the selection of the most diverse cultivars and greatly expand genetic variation for wheat improvement. Measures of genetic diversity can be used to maximize the level of variation in segregating populations by intermating cultivars with greater genetic distance. Contributions of different measures might be useful in the prediction of progeny performance, diversity or both. Prediction of progeny performance in winter wheat namely F_2

heterosis with morphological distance estimation was better predictors than COP (Cox and Murphy 1990). But COP was reported to be a better predictor than morphological traits of F_4 family performance in oats and a combined measure was a better estimator of specific combining ability in F_1 (Souza and Sorrells 1991b). If we can add the inheritance pattern of important traits in pedigree trees, it will be very useful in breeding programme.

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Some Local Potato Cultivars and their Reaction to Viruses

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ABSTRACT

Potato Research Programme (PRP) started initial studies of local potato cultivars since 1988/89 in Nepal, to understand the plant and yield characteristics of these cultivars and to explore potato cultivars diversity in the country. More activities on germplasm collection, characterization and performance evaluation were carried out at Khumaltar. Twenty-one local cultivars collected from different parts of the country were evaluated and compared with check varieties. The studies were carried out in the laboratory of PRP, Khumaltar for identification and rating of these cultivars for virus diseases. The presence of different viruses was observed in almost all cultivars tested. However, the degree of infection was different. The tuber yields of almost all tested stocks were found infected by virus diseases and as a result, a large number of small sized tubers per plant were produced. However, combined results of tuber characteristics showed that cultivars Farse White, Rosita, Khumbule and Lumle Red were superior to Kufri Jyoti in tuber yields over the years.

Key words: Local cultivars, potato, tuber yield, virus diseases

INTRODUCTION

Potato is not an indigenous crop of Nepal. Local cultivars, cover around 80 percent of the total potato growing area and are in highly degenerated condition. Rhodes (1985) recorded 18 land races only from eastern hills. Several local cultivars traditionally grown all over the country possess different desirable characters (Shrestha 1996). Due to these desirable characteristics, cultivars like Ilam Blue, Chisapani Red, Khumbule, Bhotange, Tharu Local, Kathmandu Local, Jumli Local and Sarkari Seto are still popular among farmers (Khatri et al 1998). Since potatoes are propagated vegetatively, the seed tubers are the major source of survival of different diseases (Akius and Kloos 1990). Farmer's practices further accelerated infection of seed stocks as they generally used smaller (Bhomi and Kloos 1991) and leftover tubers as seed.

Due to these reasons and severe degeneration on it, the so-called local cultivars are giving lesser yields but have greater scope of improvement.

Based on tuber yields, farmers' preference, area coverage and distribution pattern of these specific cultivars, Jumli Local, Kathmandu Local, Sarkari Seto, Syang Dorje and Tharu Local were selected and recommended for general cultivation and were cleaned against six potato viruses (A, X, M, Y, S and leaf roll) at Khumaltar (Khatri and Rai 2000). Yield performance of some of the important local cultivars cultivated in the country, the status of viral disease in those cultivars and status of degeneration are described and presented in this paper.

MATERIALS AND METHODS

Twenty-one different local cultivars collected from different parts of the country (Table 1) were evaluated and compared with the check varieties Cardinal and Kufri Jyoti at the Potato Research Farm, Hattiban, Lalitpur during 1996/97 and 1997/98. Most of the cultivars evaluated were of unknown origin but they were cultivated continuously in different parts of the country.

Table 1. Tuber characteristics of local potato germplasms at Khumaltar, Lalitpur, 1996/97 and 1997/98

SN	Variety	Collected site	Maturity	Tuber					Yield, t ha ⁻¹
				Size	Shape	Colour	Eye depth	Skin surface	
1	Kal Aankhe	Central hills	Late	Small-Medium	Round	Dark Purple	Deep	Rough	14.4
2	Farse White	Eastern hills	Early	Medium – Big	Oval	White	Shallow	Smooth	30.4
3	Rosita	Central hills	Late	Small-Medium	Round	Pink	Medium	Rough	25.1
4	Lamjunge	Western hills	Medium	Small-Medium	Oblong	White	Shallow	Smooth	8.5
5	Lumle Red	Western hills	Late	Small-Medium	Round	Pink	Medium	Rough	23.5
6	Sarkari Seto	Eastern hills	Medium	Small-Medium	Long	White	Shallow	Smooth	15.6
7	Musa	Central hills	Early	Medium-Big	Oval	White	Shallow	Rough	9.8
8	Jyalle	Eastern hills	Late	Medium	Oval	White	Shallow	Smooth	14.1
9	Old Nepali	Central hills	Medium	Medium	Oval	Pink	Medium	Rough	11.2
10	Farse Red	Eastern hills	Medium	Small-Medium	Round	Pink	Deep	Rough	10.9
11	Jumli Local	Mid-west hills	Medium	Medium-Big	Oblong	White	Medium	Smooth	18.2
12	Morange	Eastern terai	Late	Small	Round	White	Deep	Smooth	9.8
13	Ilam Blue	Eastern hills	Medium	Small	Round	Purple blue	Deep	Rough	14.8
14	Dolpa Local	Mid-west hills	Late	Small-Medium	Round	White	Medium	Smooth	8.8
15	Thakali Red	Western hills	Late	Small-Medium	Round	Pink	Medium	Smooth	12.4
16	Kalo	Central terai	Early	Small-Medium	Round	Purple black	Deep	Rough	15.2
17	Bhutange	Central hills	Late	Small-Medium	Round	White	Shallow	Smooth	6.8
18	Syangdorje	Central hills	Medium	Big	Oval	White	Medium	Smooth	12.5
19	Khumbule	Eastern hills	Medium	Medium	Oval	Red	Shallow	Smooth	21.3
20	Khodpeli	Far-west hills	Late	Medium	Oval	White	Medium	Smooth	6.6
21	KTM† Local	Central hills	Medium	Small-medium	Round	Red	Medium	Rough	11.8
22	Cardinal (chk)	Improved Variety	Early	Medium	Long	Red	Medium	Rough	17.6
23	K. Jyoti (chk)		Medium	Medium	Oval	White	Shallow	Smooth	20.4
	CV, %								25.6
	F test								**
	LSD (0.05)								2.64

† KTM, Kathmandu. chk, Check.

Potato cultivars including check cultivars were planted in 3.6 m² plot size in three replications. Chemical fertilizers were applied at the rate of 100:100:60 kg ha⁻¹ NPK and the compost at the rate of 20 t ha⁻¹. Spacing was maintained at 60 cm as row to row and 25 cm as plant to plant. Observations were made and the data on maturity days, tuber size, tuber shape, tuber color, eye depth, skin surface and tuber yield were recorded.

Fresh leaf samples were collected from each cultivar grown in the field for virus testing. Samples for this purpose were prepared according to the standard procedure (Ranjit et al 1994). The crude extract was obtained using buffer in the ratio of 1:15 w/v and tested against six potato viruses (PV), A, M, S, X, Y and potato leaf roll (PLR) by double antibody sand-witch enzyme-linked immunosorbent assay (DAS-ELISA) technique. For the purpose of virus

identification, samples containing A_{405} values of more than 0.200 were considered as positive and A_{405} values of less than 0.136 was not registered in any of the samples showing negative for virus presence.

RESULTS AND DISCUSSION

Among 21 cultivars evaluated in the studies, 19 were collected from the hills and 2 were from terai of Nepal (Table 1). In the agronomic studies, all cultivars except Farse White, Musa and Kalo were found medium to late maturing type. Most of the cultivars except Sarkari Seto and Lamjunge had round to oval tuber shape. There was a clear diversity in skin color from white to purple black in the tubers. Cultivars, Khumbule and Kathmandu Local were found to have red-skin. Nepalese consumers prefer shallow-eyed tubers and most of the cultivars have tubers with shallow to medium eye depth. Cultivars Kal Aankhe, Farse Red, Morange, Ilam Blue, and Kalo have deep eyes and seven have shallow and nine medium types. Skin surface of all harvested tubers were categorized either as rough or smooth type.

Highly significant differences were observed on potato tuber yields among landraces. Yield ranged from 6.6 t ha⁻¹ in Khodpeli Local to 30.4 t ha⁻¹ in Farse White. Rosita yielded 25.1 t ha⁻¹ and Lumle Red 23.5 t ha⁻¹. Result shows that most of the cultivars collected from the hills were high yielder as compared to the cultivars collected from terai or mid-hills. Combined results of tuber characteristics and yield over the years showed that cultivars Farse White, Rosita, Khumbule and Lumle Red were superior to Kufri Jyoti (Table 1). Cultivar Lamjunge, Musa, Morange, Dolpa Local, Bhotange and Khodpeli were the lowest yielder. In both the years, cultivars Farse White, Musa and Kalo were found early maturing and eight cultivars were late maturing and the rest were medium maturing type.

In the plant samples, virus PVA was not detected in any of the tested cultivars. Surprisingly, insect transmitted potato leaf roll virus was also not observed in any of the samples except in

Bhotange and Kathmandu Local but PVS was in almost all cultivars. Cultivar Bhotange was highly infected with PVM and PVX showing the A_{405} value of 0.959 and 0.640, respectively. PVY value was also found higher in almost all tested cultivars. Virus testing results showed that there were no any virus free cultivars obtained in the study. The mean absorbance at 405 nm corresponding to different potato viruses is presented in Table 2.

Results revealed the presence of viruses PVS, PVX, PVY in cultivar Khodpeli, whereas PVX and PVS in Thakali red, Lamjunge and Bhotange. PVS was found positive in almost all the local cultivars tested and PVY occurred relatively at high frequency in the samples. The result shows that there was a severe infection of PVY, PVS (mild) and PVX viruses. This was the case even in visually healthy looking plants in the fields. The test showed absence of PVA in all the tested cultivars. Although PVM was less common than PVS, PVX or PVY, it is also perpetuated in infected tubers and transmitted by physical contact and by aphids. PLRV, the most important aphid transmitted potato virus was found in cultivars Bhotange and Kathmandu Local only. Tuber yield in some local cultivars in the trials was equal or superior to check varieties.

Table 2. Mean absorbance at 405 nm to different potato viruses on some local cultivars

Variety	Mean absorbance at 405 nm				
	PVM	PVS	PVX	PVY	PLRV
Kal Aankhe	-	0.263	-	0.446	-
Farse White	-	0.247	-	-	-
Rosita	-	0.265	-	0.668	-
Lamjunge	-	0.276	0.322	-	-
Lumle Red	-	0.240	-	-	-
Sarkari Seto	-	-	-	0.698	-
Musa	-	0.276	-	0.668	-
Jyalle	-	0.271	-	0.609	-
Old Nepali	-	0.315	-	0.658	-
Farse Red	-	0.292	-	-	-
Jumli Local	-	0.275	-	0.617	-
Morange	-	0.236	-	-	-
Ilam Blue	-	0.236	-	0.622	-
Dolpa Local	-	0.276	-	0.459	-
Thakali Red	-	0.221	0.259	-	-
Kalo	-	0.277	-	0.406	-
Bhotange	0.959	0.245	0.640	-	0.230
Syangdorje	-	-	-	0.561	-
Khumbule Red	-	0.278	-	0.586	-
Khodpeli	-	0.294	0.221	0.424	-
KTM† Local	-	-	-	0.473	0.608
Cardinal (chk)	-	-	-	0.699	-

† KTM, Kathmandu. chk, Check.

Majority of local cultivars had high percentages of virus infection. However, the yields of these cultivars could be increased significantly through the use of better quality seed materials and improved cultural practices. These results further indicate that there are some high yielding virus resistant local cultivars. Diverse plant and tuber characteristics available in these cultivars might be the sources for further improvement of potato cultivars of desired characters.

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Use of Chemical Fertilizers on Potatoes in Sandy Loam Soil under Humid Sub-Tropical Condition of Chitwan¹

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ABSTRACT

An experiment was conducted at Rampur, Chitwan to study the effects of N, P₂O₅ and K₂O on tuber yield, quality and leaf nutrient status of potato cv. Kufri Sinduri and Desiree. The highest potato tuber yields (35.7 and 21.1 t ha⁻¹) were obtained with 150:100:100 and 100:100:100 of N:P₂O₅:K₂O kg ha⁻¹ respectively of Kufri Sinduri and Desiree. The optimum dose of N, P₂O₅ and K₂O was 100:50:50 kg ha⁻¹ for both cultivars. Regression of N, P₂O₅ and K₂O doses on Kufri Sinduri and Desiree explained 78 and 31% variation, respectively, in the tuber yield. Leaf N alone accounted for maximum variation (76% and 43% by linear in Kufri Sinduri and Desiree, respectively). Leaf N, P and K, respectively 5.04, 0.29 and 3.97% dry matter was critical for potato production under humid sub-tropical condition of Chitwan. Present findings suggest that Nitrogen, Phosphorous and Potassium fertilizers management should be based on leaf analysis for balanced application of mineral nutrients in potato crops.

Key words: Desiree, Kufri Sinduri, nutrients, potato, tuber yield

INTRODUCTION

Soil fertility is one of the major factors that affect the yield and quality of the potato. Several studies describe relationships between fertilizer applications, leaf nutrient concentrations, potato (*Solanum tuberosum* L.) tuber yield and tuber quality (Jackson and Carter 1976, Singh 1987, Krishnappa and Gowda 1988, Rykbost et al 1993). Potato cv. Desiree and Kufri Sinduri were the focus cultivars for this study due to its dominance in the farmers' field particularly in lower hills and terai. The primary objective of this experiment was to ascertain the nutrient status of the standing crop, by leaf analysis. This method has been found useful in potato to recommend fertilizers for optimum tuber yield and quality. Indiscriminate fertilizers use adds

costs to growers and enhances environmental pollution.

The present tuber yields of these cultivars in Chitwan are very low. The main reasons are unbalanced and inadequate use of nutrients. It is important to standardize the optimum dose of major nutrients. As potato cultivation practices change and yield increase, fertilizer application may require adjustment. Desiree with NPK in Chitwan valley produced a maximum tuber yield of 16.89 t ha⁻¹ (Basnet et al 1998-1999). The objectives of this study were to quantify the N, P and K doses on tuber yield and quality of Desiree and Kufri Sinduri and compare leaf nutrient concentrations with critical nutrient concentrations.

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Farm, Institute of Agriculture and Animal Science, Rampur, Chitwan during 1999/2000 in split plot design with four

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replications. Two released cultivars, Desiree and Kufri Sinduri included were considered as the main plot treatment and fertilizer doses as the sub-plot treatment. Seven level of fertilizers, ie 0:0:0, 50:50:50, 100:50:50, 100:75:50, 100:75:100, 100:100:100 and 150:100:100 kg ha⁻¹ of N:P₂O₅, K₂O were included in the sub plot. The sources of fertilizers were di-ammonium phosphate (18:46:0), urea (46:0:0) and muriate of potash (0:0:60). One kg of surface soil sample (up to 20 cm depth) was collected before planting the potato crop. The soil was analyzed for total nitrogen, phosphorous and potassium available by modified Kjeldahl distillation, modified Olsen's method and Flame photometer, respectively. The experimental plot was characterized by having sandy loam soil with pH range from 4.8 to 5.2 and organic matter from 2.55 to 3.22%. The NPK contents in the soil were 2400-2800, 96.54-108.58 and 211.87-277.76 kg ha⁻¹, respectively.

The plot size was 4.2- × 2.5-m having seven rows; each row consisting of 10 plants. A half dose of N and full dose of P₂O₅ and K₂O were applied in furrows and mixed thoroughly at planting time. The remaining half of N was top dressed at the time of earthing up after 5 weeks of planting. Disease free tubers of Kufri Sinduri and Desiree weighing approximately 40-50 g were planted at a spacing of 60 cm between rows and 25 cm between the plants. Two rows were left for borders in between two plots. The crop was irrigated after 45 days of planting through furrow method. Two sprays of mancozeb (Dithane M-45) and one spray of metalaxyl (Krilaxyl) were alternatively used to control late blight disease of the crop during the first fortnight of January, when the environment was

conducive for late blight pathogens. Weeding, earthing up and other cultural practices were carried out as per recommendation. Potato tubers of both cultivars were planted on 2 November 1999. Desiree and Kufri Sinduri were harvested on 3 Feb and 28 Feb 2000 respectively. The central three rows were net harvested for tuber yields.

Three plants were randomly selected from each plot at 45 day after planting. The fourth leaves from the growing tip were collected, chopped separately, dried at 70°C for 72 hours and ground to pass through a 40 mesh (0.368 mm) screen. Modified Kjeldhal, modified Olsen's and Flame photometer methods determined total N, P and K in leaf samples, respectively. Percent N, P and K content in the leaves were recorded. The results were analyzed using MSTAT program as described by Gomez and Gomez (1984). Duncan Multiple Range Test (DMRT) was used for mean separation.

RESULTS AND DISCUSSION

Regression of NPK on tuber yield showed that the accumulation of N, P and K in leaf had a definite bearing on tuber yield (Table 1). In both cultivars, total Nitrogen explained the maximum variation in yield were 77% and 42.8% linear, and 78.0% and 40.6% quadratic in Kufri Sinduri and Desiree, respectively.

Critical concentrations

Effect of N application on leaf N and tuber yield was calculated by grouping all treatment combinations with same levels of N together (Table 2). Similarly, effects of P and K

Table 1. Regression of leaf N, P and K (% DM) contents on tuber yield of potato at Rampur, 1999/2000

Variety	Regression equations†	R ²
Kufri Sinduri	1. Y = -25.01 + 16.20N	0.77
	2. Y = -189.1 + 107.9N - 12.72N ²	0.78
	3. Y = 159.8 + 92.3N - 13.94N ² - 31.0P - 813.0P ² + 113NP	0.78
	4. Y = 311 + 139.8N - 9.04N ² + 41.9K + 2.09K ² + 27.0NK + 638.51K ² + 956.36NK	0.80
	5. Y = -62.0 + 0N - 12.73N ² - 571P + 137P ² + 560NP - 9.10K + 1.6K ² + 22.5NK - 120.8NPK	0.78
Desiree	1. Y = 0.42 + 5.75N	0.43
	2. Y = -4.0 + 8.7N - 0.49N ²	0.41
	3. Y = -3.20 + 12.8N + 1.50N ² - 55.0P + 658.0P ² - 77NP	0.36
	4. Y = 93.2 - 10.4N - 2.73N ² - 40.4K + 1.10K ² + 10.2NK	0.37
	5. Y = 18.0 + 298.0N + 6.1N ² - 212P + 2334P ² - 1050NP - 125K + 32.9K ² - 79NK + 44PK + 223NPK	0.32

†Y, Tuber yield t ha⁻¹. N, P and K are leaf nitrogen, phosphorous and potassium, respectively. DM, Dry matter.

application on leaf P and K respectively and tuber yield were calculated (Table 3 and 4). Kufri Sinduri had significantly higher tuber yield than Desiree (Table 2). Application of 100 kg N ha⁻¹ yielded significantly more than 50 kg N ha⁻¹. However, 100 and 150 kg N ha⁻¹ levels were at par. Increases in leaf N was significant up to 150 kg N ha⁻¹.

Table 2. Effect of level of nitrogenous fertilizers on N-composition of leaf and tuber yield of potato at Rampur, Chitwan, 1999/2000

Treatment	Leaf N, %	Tuber yield, t ha ⁻¹
Variety (V)		
Kufri Sinduri (KS)	4.82	31.85a†
Desiree (De)	4.96	17.42b
F test	ns	**
Nitrogen, kg ha ⁻¹		
0	4.47c	20.31c
50	4.86b	23.19b
100	4.96b	27.21a
150	5.21a	27.81a
F test	**	**
Interaction		
KS × 0	4.37	25.68
KS × 50	4.78	31.62
KS × 100	4.92	34.83
KS × 150	5.22	35.27
De × 0	4.57	14.95
De × 50	4.93	14.76
De × 100	4.99	19.60
De × 150	5.20	20.36
F test	ns	ns

** Significant at 0.01. ns, Non significant. †Figures within column bearing the same letter(s) are not significantly different at 5% level of significance.

Kufri Sinduri and Desiree were not significantly different on leaf N. Therefore, the mean leaf N of 4.48% at 50 kg N ha⁻¹ was considered as deficient while N of 5.21% at 150 kg N ha⁻¹ as sufficient. The midpoint (5.04%) of these two leaf N values can be classified as critical. The critical level of nutrient is that concentration in a specific plant part at a specific stages of growth at which a 5 or 10% reduction in yield occurs, or that concentration which is associated with the breaking point of the nutrient response curve or that concentration which is at the midpoint of the nutrient response curve or that concentration which is at the midpoint of the traditional zone

between deficiency and sufficiency level (Ulrich and Hills 1973). Singh (1987) reported a similar value of 5.37% as critical leaf N concentration for potato in Jalandhar, India.

Leaf P increased significantly with P application up to 100 kg P₂O₅ ha⁻¹ (Table 3). Kufri Sinduri had significantly higher leaf P than Desiree (Table 3). Application of 50 kg P₂O₅ ha⁻¹ significantly increased the tuber yield over

Table 3. Effect of level of phosphorous fertilizers on composition of leaf and tuber yield of potato at Rampur, Chitwan, 1999/2000

Treatments	Leaf P, %	Tuber yield, t ha ⁻¹
Variety (V)		
Kufri Sinduri (KS)	0.31a†	32.19a
Desiree (De)	0.29b	17.92b
F test	*	**
P ₂ O ₅ (kg ha ⁻¹)		
0	0.27c	20.31c
50	0.30b	25.36b
75	0.31a	26.69ab
100	0.31a	27.88a
F test	**	*
Interaction		
KS × 0	0.28	25.68b
KS × 50	0.31	33.41a
KS × 75	0.32	34.68a
KS × 100	0.32	35.01a
De × 0	0.27	14.95e
De × 50	0.29	17.32de
De × 75	0.29	18.69cd
De × 100	0.30	20.75c
F test	ns	Ns

* Significant at 0.05. ** Significant at 0.01. ns, Non significant. †Figures within column bearing the same letter(s) are not significantly different at 5% level of significance.

control. In Kufri Sinduri application of P₂O₅ above 50 kg ha⁻¹ did not show significant different in tuber yield. Similarly, the application of 50 kg P₂O₅ ha⁻¹ in Desiree produced statistically the same yield as with control. Leaf P of 0.27% obtained without P application could be taken as deficient, while leaf P of 0.31% at 100 kg P₂O₅ ha⁻¹ as sufficient and the mid point (0.29%) as critical. Singh (1988) described similar critical P value on leaf.

Leaf K was affected significantly by K application (Table 4). Kufri Sinduri and Desiree had similar leaf K. Application of 100 kg K₂O ha⁻¹ significantly increased the tuber yield over control (Table 4). Significant interaction between variety and K application was obtained in tuber yield. Potassium more than 50 kg ha⁻¹ did not show significant difference in tuber yield in both cultivars. Leaf K of 3.57% was obtained without K application, while leaf K of 4.37% at 100 kg ha⁻¹ as sufficient and midpoint (3.97) as critical. Singh (1987) reported a similar value of 3.62% as critical leaf K concentration for potato in Jalandhar, India.

Table 4. Effect of level of potassium on leaf composition and tuber yield of potato at Rampur, Chitwan, 1999/2000

Treatment	Leaf K, %	Tuber yield, t ha ⁻¹
Variety (V)		
Kufri Sinduri (KS)	4.00	31.47a†
Desiree (De)	3.85	17.59b
F-test	NS	**
K ₂ O (kg ha ⁻¹)		
0	3.57b	20.31b
50	3.84b	25.82a
100	4.37a	27.47a
F-test	**	**
Interaction		
KS × 0	3.57	25.68b
KS × 50	3.84	33.82a
KS × 100	4.60	34.91a
De × 0	3.57	14.95d
De × 50	3.84	17.81c
De × 100	4.15	20.03c
F test	ns	*

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

†Figures within column bearing the same letter(s) are not significantly different at 5% level of significance.

Tuber yield

Kufri Sinduri had significantly higher tuber yield than Desiree (Table 5). Mean tuber yield increased significantly up to the application of 100:50:50 kg N:P₂O₅:K₂O ha⁻¹, beyond which there was no proportionate increase in tuber yield. Tuber yield ranged from 25.7 to 35.7 and 14.9 to 21.1 t ha⁻¹ in Kufri Sinduri and Desiree, respectively. The highest tuber yield (35.3 and 21.1 t ha⁻¹) was obtained at 150:100:100 and 100:100:100 N:P₂O₅:K₂O kg ha⁻¹, respectively. Among the three nutrients, response of N was consistent and significant up to 150 kg N ha⁻¹ irrespective of P₂O₅ and K₂O levels. Responses of

P and K were significant only at lower level fertilization. The increase in tuber yield of potato with increase N and P has been reported by Gurung et al (1977) and that with N, P and K application by Sharma and Singh (1988) and Rykbost et al (1993).

Soil samples before planting and after harvesting contained a high amount of organic matter, Nitrogen and Phosphorus and medium amount of Potassium. The value above 1.29% organic matter more than 543:22:333 kg ha⁻¹ the available N:P₂O₅:K₂O respectively was considered as rich soils (Arora et al 1979). In the experimental plot, Nitrogen and Phosphorus were higher than these values. High nutrient status of the experimental plot played a significant role in increasing the fertility status of the soils.

Table 5. Effect of NPK levels on potato tuber yield and specific gravity at Rampur, Chitwan, 1999/2000

Treatment	Tuber yield, t ha ⁻¹	Specific gravity
Variety (V)		
Kufri Sinduri (KS)	33.1a†	1.081a
Desiree (De)	18.7b	1.078b
F test	**	**
Nutrient (N)		
N:P ₂ O ₅ :K ₂ O (kg ha ⁻¹)		
0:0:0	20.3c	1.086a
50:50:50	23.7b	1.082b
100:50:50	28.1a	1.079c
100:75:50	26.7a	1.078cd
100:75:100	26.6a	1.077ef
100:100:100	27.9a	1.078de
150:100:100	27.8a	1.076f
F test	**	**
Interaction		
KS × 0:0:0	25.7	1.09a
KS × 50:50:50	31.6	1.085b
KS × 100:50:50	35.2	1.080d
KS × 100:75:50	34.7	1.079de
KS × 100:75:100	34.7	1.079de
KS × 100:100:100	34.8	1.079de
KS × 150:100:100	35.3	1.077fg
De × 0:0:0	14.9	1.086a
De × 50:50:50	15.9	1.082b
De × 100:50:50	21.0	1.079c
De × 100:75:50	18.8	1.078cd
De × 100:75:100	18.6	1.077gh
De × 100:100:100	21.1	1.076gh
De × 150:100:100	20.4	1.075h
F test	Ns	ns

** Significant at 0.01 level. ns, Non significant. †Figures within column bearing the same letter(s) are not significantly different at 5% level of significance.

Specific gravity

Specific gravity is considered an important quality character particularly for chips and flour making industries. Kufri Sinduri had higher specific gravity than Desiree (Table 5). It generally tended to decrease with increasing rate of N fertilizer across the entire range. The highest specific gravity (1.086) was associated with control treatment followed by 50:50:50 N:P₂O₅:K₂O kg ha⁻¹ (1.082) in both cultivars. The treatment 150:100:100 N:P₂O₅:K₂O kg ha⁻¹ had the lowest specific gravity (1.076) in both cultivars. Interaction effect between fertilizer levels and cultivars on specific gravity was highly significant. The fertilizer levels 100:50:50; 100:75:50; 100:75:100 and 100:100:100 N:P₂O₅:K₂O kg ha⁻¹ did not show significant difference on specific gravity in both cultivars. Increasing levels of Nitrogen and Potassium decreased specific gravity in both cultivars. Tubers from plants receiving highest Nitrogen and Potassium doses had lower specific gravity (Maier et al 1994, Westermann et al 1994, Smith 1968, Lauer 1986, Beukema and Vander Zaag 1990). High levels of P relatively did not influence specific gravity. This finding corroborates those of Dubetz and Bole (1975).

It is concluded that NPK application increases the potato yield significantly. However, the significant higher yield was obtained with the use of NPK in the ratio of 100:50:50 kg ha⁻¹ under the soil conditions prevailing in sandy loam soil of Chitwan valley.

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Content Analysis of Post Graduate Theses in Development Communication¹

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ABSTRACT

The study was conducted to find out the pattern of post-graduate research studies, the research design, the tools and the techniques used, the geographical distribution and the contents of 26 post-graduate theses. All the theses of Development Communication were taken for the study. The theses were categorized into fourteen areas of research. Majority of them were on educational technology followed by development journalism. Most of the theses had four objectives and had institutions as a locale of the study. Purposive sampling pattern was largely adopted. Majority of them had 101 to 150 respondents, dominated by students and rural women. Descriptive research design was used by the maximum respondents. Many of them used primary data. Maximum researchers used combination of schedules and questionnaires. Majority of them used original scale. Estimation (percentage) was used by majority of the researchers for analysis of data. Almost all theses had informative titles and majority of them had informative abstracts. Many of the theses contained 101-150 pages. Effective table of contents and standard format were used by the thesis writers. Majority of theses had 21-40 illustrations. All the theses had review presentations in chronological order and bibliography in alphabetical order. Many of them had 1-3 appendices and attached instruments used.

Key words: Content analysis, development communication, post graduate thesis

INTRODUCTION

The Development Communication is a recent academic field in Nepal, though the use of communication system has tremendously been increased during the past decade to bring about changes in rural livelihood. Most of the communication systems have been targeted to uplift the rural livelihood by covering the developmental messages in their media, although the content is not very much compatible to cope up with their need (Narula 1987). It is important to know the need of the development messages of our clients. Most of the researchers did not focus on the development of theoretical concepts, models, research methodologies that were appropriate to South Asian way of life and social

systems. Rather, they blindly followed western models, methodologies and concepts (Sharma and Chand 1998). Bhagat and Ramachandran (1993) reported that communication problems were not understood in the right perspective, if researched through the western tools. Though this research was conducted at Pantnagar, India, its implication would be equally important in Nepal. We have very much similar development communication issues and very similar social system and structure. Such kinds of research have not been carried out as of now in Nepal. Hence, Trikha (1986) reported that maximum studies were on the content analysis of newspaper and the magazine (56%) followed by readability (35%), evaluatory (5%) and production of publications (4%) during 1961-1985 on agriculture journalism. A periodical review of the researches done in any field of the study is useful in gaining insights into the general direction of research and ascertaining the future needs in the

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context of changing perspectives of a particular discipline.

We are in need of an indigenous approach to research practices particularly in the development communication research (Singh 1999). With a view to know the development communication research status, this study was carried out with the objectives: to analyze the major areas of research of the post-graduate theses of the Development Communication, to study the research methodology used in the theses and to study the format of presentation of the theses.

MATERIALS AND METHODS

The research was conducted during 2001/02 at the GB Pant University of Agriculture and Technology, Pantnagar, India. All the Post-Graduate (MSc and PhD) theses of the Development Communication submitted during the period of 1996 – 2001 were chosen for the study and analysed in three broad categories viz., area of research covered, research methodology adopted and format undertaken. The areas of research undertaken by the researchers were broadly categorized into the consultation of a panel of judges of the Department of Agricultural Communication, Pantnagar. The fourteen areas viz. communication pattern, development journalism, development studies, educational technology, evaluation, information source, instructional technology, management, mass media, motivation, speech communication, technology transfer, training and video for development were categorized,

The research methodology covered locale of the study, sampling methods, research design, types of data, tools, techniques of data collection and analysis of data. The format of the theses was analysed based on the number of pages, manuscript typing, table of contents, chapter distribution, number of illustrations, presentation of review, bibliography, number of appendices and attachment of tools and their uses. The content analysis technique was used to analyse the area of research covered, research methodology adopted and format of the theses

adopted. The salient research findings of the theses in development communication were also analysed qualitatively.

RESULTS AND DISCUSSION

Area of research covered

The distribution of theses according to the area of research is presented in Table 1. Fourteen areas of research were covered in which the maximum number (15.38 %) of theses was on Educational Technology followed by Communication Pattern (11.54 %), Development Journalism (11.54%) and Evaluation Studies (11.54%). The least (3.84%) focused areas were on Development Studies, Information Sources, Instructional Technology, Mass Media, Motivation, Technology Transfer and Video for Development. Singh (1985) reported that the most of communication researches during 1960s and 1970s were in the field of interpersonal communication. Similarly, Jain and Babu (1987) reported that during the period of 1965-84 the major areas of communication research were on multimedia, mass communication, radio, farm journalism, sources of information, television, audio-visual aids, interpersonal communication, group contacts, source credibility, communication skills, communication behavior of extension personnel and communication behavior of farmers. Now with the changing pattern of communication research, new areas have been added.

Table 1. Distribution of theses according to areas of research

SN	Area	Frequency	Percentage
1.	Communication Pattern	3	11.54
2.	Development Journalism	3	11.54
3.	Development Studies	1	3.84
4.	Educational Technology	4	15.38
5.	Evaluation	3	11.54
6.	Information Source	1	3.84
7.	Instructional Technology	1	3.84
8.	Management	2	7.69
9.	Mass Media	1	3.84
10.	Motivation	1	3.84
11.	Speech Communication	2	7.69
12.	Technology Transfer	1	3.84
13.	Training	2	7.69
14.	Video for Development	1	3.84

Research methodology adopted

The data in Table 2 shows that the maximum number of theses (42.31%) have taken institution / organization, which comprised of Universities, Krishi Vigyan Kendra, Aaganwadi Centers, Professional Assistance for Development Action (PRADAN), District Rural Development Agency (DRDA), Regional Institute of Rural Development, and Women Dairy Development Project as locale of the study followed by villages (23.07%) and block (19.23%), respectively. A total of five states and fifty-seven villages were covered in all the research studies.

Table 2. Distribution of theses according to locale of study

SN	Locale of the study	Frequency	Percentage
1.	State	1	3.85
2.	Region	2	7.69
3.	District	1	3.85
4.	Block	5	19.23
5.	Village	6	23.07
6.	Institution/Organization	11	42.31

Majority of theses used purposive sampling method for the selection of locale, while random sampling was used by majority of the researchers

for the selection of respondents (Table 3). In most of the theses 101-150 respondents were involved. The maximum and the minimum number of respondents were 256 and 32, respectively. Yadava (1987) reported that out of 889 methods of researches in research methodology-wise studies based upon the Indian Institute of Mass Communication (IIMC) bibliography on mass communication in India during 1975-84, the sample survey was by far the most common research methods followed.

Table 3. Distribution of theses according to sampling methods for the selection of respondents

SN	Sampling method	Frequency	Percentage
1.	Random sampling	10	38.46
2.	Census	7	26.92
3.	Purposive sampling	6	23.08
4.	Probability sampling	1	3.85
5.	Not mentioned	2	7.69

Majority of the respondents were rural women and students followed by combination of two or more respondents (Figure 1). The least focused respondents were head of farm family, rural poor, subscribers, trainers and tribes.

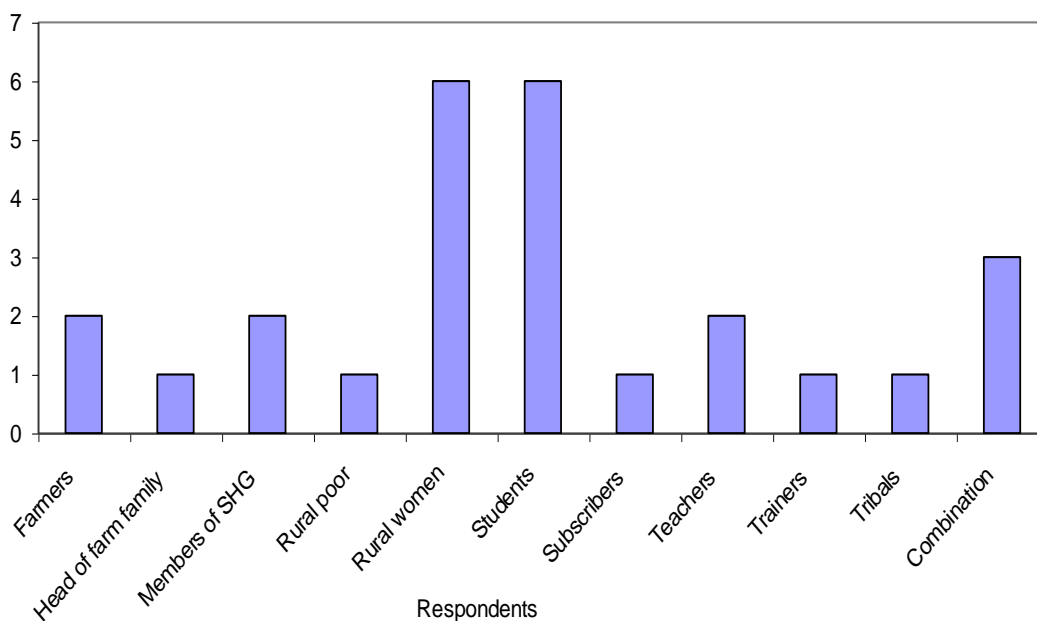


Figure 1. Distribution of theses according to the types of respondents

The descriptive research design (50.00%) was followed by majority of the respondents. Overwhelming majority (96.15%) used a single research design. Primary data was used by majority (57.69%) of the researchers followed by combination of primary and secondary data (42.31%). One researcher used explanatory research design and 12 used experimental research design.

The maximum number of theses (65.38%) used combination of schedule and questionnaire for data collection (Figure 2). Variables ranging from 16-20 were used by majority (30.77%) of the researchers. The maximum number of variables used by the researchers was 36 and the minimum was eight. Most of the researchers (65.38%) used original scale.

For the analysis of data, all the respondents (100%) used percentage method of statistical analysis (Table 4). Similarly, majority (61.54%) of the researchers used estimation. Many abstracts and titles were of informative type. Fifty per cent of the theses had four objectives.

Format adopted

Most of the theses (50.00%) had pages ranging from 101 to 150. Seven types of page sizes were used in all the theses. In majority of the theses

flush left typing was done, keeping more than 3.5 cm margin in the left side. In 88.46% theses a standard of not more than 25 lines per page was maintained. Effective type of table of contents was used in 65.38% of the theses. Majority of the theses (84.62%) followed standard chapter distribution. The findings and the discussion chapter had the maximum number of pages followed by research methodology chapter. The number of illustrations varied from 9 to 103. Regarding the number of tables used, 23.08 % of the theses used 31-40 tables. Similarly, 34.62% of the theses used one to 10 figures. Only 26.92% of theses attached photographs in which 82.27% of the photographs were with captions.

Table 4. Distribution of theses according to techniques used for analysis of data (Multiple analysis)

SN	Technique	Frequency	Percentage
1.	Percentage	26	100
2.	Frequency	22	84.62
3.	Mean	15	57.69
4.	Standard deviation	14	53.84
5.	Coefficient of correlation	14	53.84
6.	Weighted mean score	10	38.46
7.	T-test	8	30.77
8.	Analysis of variance	2	7.69
9.	Ranking	1	3.85
10.	Cumulative frequency distribution	1	3.85
11.	Multiple regression	1	3.85
12.	Factor analysis varimax rotation	1	3.85
13.	Z-test	1	3.85
14.	Chi-square test	1	3.85

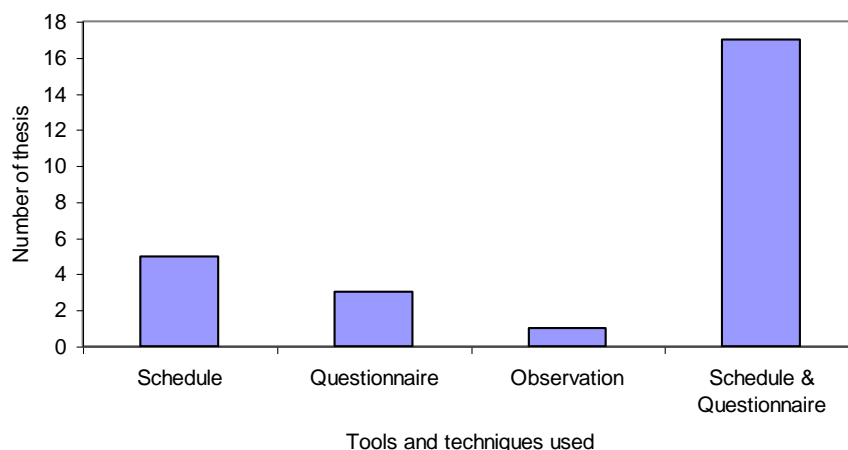


Figure 2. Distribution of theses according to tools and techniques

The presentation of review was in a chronological order. The maximum number of reviews incorporated in the theses was 137 and the minimum of 35, with an average of 75. Regarding the presentation of review, 46.15% of the theses had review according to the objective. The maximum number of references was 156 while the minimum number was 50. All the theses had the appendices with varying number, which ranged from one to seven. Research tools used in all the theses were attached.

To sum up, fourteen areas of research were covered. The more emphasized area of research was on the educational technology followed by the development journalism, communication pattern and evaluation studies. The institutions/organizations like University, Krishi Vigyan Kendra, Aaganwadi Centres, District Rural Development Agency and other governmental and non-governmental organizations were the locale for most of the studies. The purposive sampling method was the dominant pattern. Students and rural women were the target audience in majority of the research studies. A descriptive research design was used in most of the research studies. Majority of researchers used primary data. All the researchers used percentage for the analysis of data. Schedules and questionnaires were used for data collection by majority of the respondents. Most of the researchers used original scale. Majority had informative type of abstract and title. Many of the theses had pages ranging from 101 to 150. Graphic aids were discriminately used in all the theses. The standard

format for chapter distribution was followed by most of the theses.

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Evaluation of Common Nepalese Rice Cultivars Against Rice Root Knot Nematode

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ABSTRACT

Twelve commonly cultivated rice cultivars viz. Radha-7, Ghaiya-2, Rampur Masuli, Bindeshwari, Makawanpur-1, Sabitri, Janaki, Chaite-2, Radha-9, Radha-4, Chaite-6 and Masuli were tested against rice root knot nematode (*Meloidogyne graminicola*) in sick soil under greenhouse condition. Resistance screening of the cultivars was done based on the reproducibility of *M. graminicola* to IR-29 susceptible check and disease intensity grade was classified on the basis of root knot index. All the cultivars were susceptible to *M. graminicola* except Masuli and Chaite-6, which were moderately resistant. Ghaiya-2 and Janaki were even more susceptible than IR-29 and these cultivars can be used as susceptible check instead of IR-29. Since the common cultivars were susceptible to *M. graminicola*, it is necessary to screen more rice cultivars to explore resistant sources against root knot nematode of rice.

Key words: *Meloidogyne graminicola*, *Oryza sativa*, resistant sources

INTRODUCTION

Rice root knot nematode (*Meloidogyne graminicola* Golden and Birchfield) is an important pathogen of rice *Oryza sativa* L. (Plowright and Bridge 1990). It could cause economic loss in upland, lowland, deepwater rice (Prasad et al 1987, Bridge et al 1990) and nurseries (Bridge et al 1990). Yield loss up to 50% might be incurred due to severe infestation of *M. graminicola* in upland, rainfed and direct-seeded rice (Lorenzana et al 1998) under field condition. In pot experiment, reduction in grain yield was reported up to 98% (Plowright and Bridge 1990). This nematode was also reported in rice based cropping systems of Nepal and yield reduction up to 40% in farmers' field (Sharma-Poudyal et al 2002, Sharma et al 2001). All the varieties observed by Sharma-Poudyal et al (2002) were infected by *M. graminicola*. These indicate the presence of potential nematode pest attacking on rice varieties in Nepal. Detailed information about the common cultivars response to *M. graminicola* is still inadequate in Nepal.

Research conducted in many countries revealed that the most of rice cultivars were susceptible to

M. graminicola (Bridge et al 1990) however, limited number of rice cultivars and breeding lines has been recorded as resistant to *M. graminicola* (Jena and Rao 1976, Kalita and Phukan 1990, Tandingan et al 1996, Soriano et al 1998). Nematicides like Fensulfthion, Oxamyl, Phorate (Prasad and Rao 1976a, 1976b, 1977a, 1977b) and Carbofuran (Prasad and Rao 1976a) were effective to control *M. graminicola*. However, most of the farmers are not using the nematicide due to lack of information about the disease, lack of technical know-how, unavailability and high cost of the chemicals. Besides, nematicides are more hazardous to the environment. Therefore, rice root knot management through deployment of resistance varieties is paramount and therefore screening of common rice cultivars cultivated in Nepal was tested against *M. graminicola*.

MATERIALS AND METHODS

Twelve commonly grown rice cultivars in Nepal viz. Radha-7, Ghaiya-2, Rampur Masuli, Bindeshwari, Makawanpur-1, Sabitri, Janaki, Chaite-2, Radha-9, Radha-4, Chaite-6, and

Masuli and two check cultivars IR-29 (susceptible) and IR-72 (resistant) (Tandingan et al 1996) were grown in plastic pots (19 cm diameter) in greenhouse, Department of Plant Pathology, Institute of Agriculture and Animal Sciences at Rampur, Chitwan. Three kg of soil (sandy loam) infested with *M. graminicola* was used as source of inoculum per pot. Pre sprouted 5 seeds of each cultivars were seeded in each pot. Cultivars were replicated six times in complete randomized block design. FYM @ 10 t ha⁻¹ and N:P₂O₅:K₂O @ 50:30:30 kg ha⁻¹ was incorporated in soil as basal application. Rice seedlings were grown in stimulated upland soil condition. Nematode population and diseases parameters were observed on 50 day old seedlings (Weerapat and Chongkid 1990). Soil temperature was recorded at 5 cm depth from the time of seeding to disease observation.

M. graminicola second stage juvenile (J2) from root and soil was extracted by blender cum modified Baermann tray method and sieving cum modified Baermann funnel method, respectively (Hopper 1970). J2 were extracted from 100 g soil and 2 g root sample from each pot. Eggs were extracted from 1 g of root sample as suggested by Hussey and Barker (1973). Final J2 and eggs population were counted as described by Bridge et al (2000). Root galling was indexed from 0 to 10 scale (Zeck 1971), (0 = complete and healthy root system, no infestation, 1 = very few small galls can only be detected upon close examination, 2 = small galls as in '1' but more numerous and easy to detect, 3 = numerous small galls, some grown together, function of roots non seriously affected, 4 = numerous small galls some big galls, majority of roots still functioning, 5 = 25% of root systems severely galled and root functioning, 6 = 50% of root system severely galled and root not functioning, 7 = 75% of root system severely galled and lost for production, 8 = no healthy roots, nourishment of plant interrupted, plant still green, 9 = the completely galled root system is rooting, plant is dying and 10 = plant is dead).

Classification of resistance and susceptibility of rice cultivars was done based on reproducibility percentage nematode population in susceptible

check cultivar ie IR-29 (Taylor 1967). Normal reproduction of *M. graminicola* ie 100% was considered in susceptible check (IR-29). Reproducibility percentage of J2, egg and final (J2 + egg) on test cultivar was calculated as Nematode Population in Test Cultivar × 100/ Nematode Population in Susceptible Cultivar. Susceptibility and resistance was classified as follows (Taylor 1967):

- Susceptible: Plants, in which nematode reproduction is normal (susceptible check),
- Slightly resistant: Plants, in which reproduction is about 26 - 50% that of susceptible plants,
- Moderately resistant: Plants in which reproduction is about 11 - 25% that of susceptible plants,
- Very resistant: Plants in which reproduction is about 1 - 10% that of susceptible plant,
- Highly resistant: Plants in which reproduction is less than 1% that of the susceptible plants, and
- Immune: Plant in which no reproduction of the nematode occurs.

Root knot disease was graded as given below to find out the more consistent result (Taylor and Sasser 1978).

Disease scale	Disease intensity
0	Disease free
1-2	Very mild
3	Mild
4-5	Moderate
6-8	Severe
9-10	Very severe

RESULTS AND DISCUSSION

Initial population of the *M. graminicola* second stage juvenile (J2) ranged from 0.4 - 4.4 g⁻¹ soil in the experimental pots. Covariance analysis revealed that there was no effect of initial J2 population on observed *M. graminicola* population and disease parameter. Soil temperature at seeding to disease observation was ranged from 23 to 27 °C.

Among the tested cultivars based on the J2 reproducibility in root, moderately resistance cultivar was only Masuli (24%) and Masuli was found similar to resistant check ie IR-72 in resistant reaction. Slightly resistant cultivars were Rampur Masuli (49%), Chaite-2 (32%), Radha-9 (48%), Radha-4 (39%) and Chaite-6 (32%) and other cultivars were found to be susceptible. However based on the egg reproducibility (%) in root besides Chaite-6 (22%) and Masuli (25%) were found as the moderately resistant. Both cultivars Radha-7 (46%) and resistant check i.e. IR-72 were found as slightly resistant and other cultivars were found susceptible (Table 1). Final nematode population was considered as the sum of J2 and egg of root. Based on final population, Masuli (24%) and Chaite-6 (24%) were found moderately resistant. Other cultivars were found susceptible. Final reproducibility of nematode

was found higher in Ghaiya-2 and Janaki than susceptible check ie IR-29. Similarly, Masuli and Chaite-6 had less reproducibility than resistant check ie IR-72. The lowest root knot intensity grade was mild in Chaite-6 (3). Janaki (6) and Radha-4 (6) had the highest disease intensity grade ie severe (Table 1).

Resistance and susceptibility level of rice cultivar was differed with the basis of classification ie reproducibility of J2, egg, final population and root knot disease intensity. Jena and Rao (1976) also observed the similar inconsistent result. However, Sahu et al (1994) screened on the basis of root knot index. Jena and Rao (1976) suggested the best criteria for evaluation of rice cultivars against *M. graminicola* is based on the reproduction of egg. Present study indicates the inconsistent result on resistant class between the

Table 1. Rice root knot nematode resistance and disease intensity grade of Nepalese rice cultivars based on the nematode reproduction and root galling in pot experiment†

Cultivar	J2 Reproducibility, %	Resistance class	Egg reproducibility, %	Resistance class	Final reproducibility, %	Resistance class	RKI (0-10)	Disease intensity
Radha-7	73 (1761)	Susceptible	46 (4947)	Slightly Resistant	51 (6708)	Susceptible	4	Moderate
Ghaiya-2	51 (1241)	Susceptible	518 (56167)	Susceptible	433 (57408)	Susceptible	5	Moderate
Rampur Masuli	49 (1171)	Slightly Resistant	56 (6047)	Susceptible	54 (7218)	Susceptible	5	Moderate
IR-72 (RC)	21 (518)	Moderately Resistant	26 (2844)	Slightly Resistant	25 (3362)	Moderately resistant	3	Mild
Makwanpur-1	67 (1613)	Susceptible	70 (7533)	Susceptible	69 (9146)	Susceptible	5	Moderate
Bindeswary	91 (2201)	Susceptible	51 (5478)	Susceptible	58 (7679)	Susceptible	5	Moderate
IR-29 (SC)	100 (2413)	Susceptible	100 (10833)	Susceptible	100 (13246)	Susceptible	5	Moderate
Sabitri	67 (1610)	Susceptible	65 (7040)	Susceptible	65 (8650)	Susceptible	5	Moderate
Janaki	101 (2448)	Susceptible	107 (11613)	Susceptible	106 (14061)	Susceptible	6	Severe
Chaite-2	32 (777)	Slightly Resistant	77 (8335)	Susceptible	69 (9112)	Susceptible	5	Moderate
Radha-9	48 (1153)	Slightly Resistant	88 (9535)	Susceptible	81 (10688)	Susceptible	6	Severe
Radha-4	39 (944)	Slightly Resistant	58 (6285)	Susceptible	55 (7229)	Susceptible	5	Moderate
Chaite-6	32 (774)	Slightly Resistant	22 (2388)	Moderately Resistant	24 (3162)	Moderately resistant	3	Mild
Masuli	24 (571)	Moderately Resistant	25 (2669)	Moderately Resistant	24 (3240)	Moderately resistant	4	Moderate

† Number in the parenthesis represents the respective nematode population per gram of root. J2, *M. graminicola* second stage juvenile. Final, Sum of J2 and egg. SC, Susceptible check. RC, Resistance check. Reproducibility (%), Nematode population in test cultivar × 100/ Nematode population in susceptible cultivar (IR-29), Susceptible, Plants in which nematode reproduction is normal. Slightly resistant, Plants in which reproduction is about 25 to 50% of that of susceptible plants, Moderately resistant, Plants in which 10 to 25% of that in susceptible plants. Very resistant, Reproduction one to 10% that in susceptible plants, Highly resistant, Plants in which reproduction is less than 1% of that in the susceptible plants. Immune, Plant in which no reproduction of the nematode occurs (I). Disease intensity grade: 0 root knot, Disease free. 1-2 root knot indexing, Very mild. 3 root knot indexing, Mild. 4-5 Root knot indexing, Moderate. 6-7 root knot indexing, Severe. 9-10 root knot indexing, Very severe. Root knot Index (0-10): 0, Complete and healthy root system, no infestation. 1, Very few small galls can only be detected upon close examination. 2, Small galls as in '1' but more numerous and easy to detect. 3, Numerous small galls, some grown together, function of roots non seriously affected. 4, Numerous small galls some big galls, majority of roots still functioning. 5, 25% of root systems severely galled and root functioning. 6, 50% of root system severely galled and root not functioning. 7, 75% of root system severely galled and lost for production. 8, No healthy roots, nourishment of plant interrupted, plant still green. 9, The completely galled root system is rooting, plant is dying. 10, Plant is dead.

egg reproducibility and final nematode reproducibility. Since, *M. graminicola* is endoparasite of root and its progeny has different form in root, it would be better to include sum of progenies while considering the population and reproduction. Therefore, final population ie sum of its progenies would represent the total number of J2 and egg in root than single population parameter J2 or egg. Masuli and Chaite-6 was moderately resistant based on the final nematode reproducibility (%) while others were susceptible. However, yield reduction due to *M. graminicola* in Masuli was reported about 40% in farmers' field (Sharma-Poudyal et al 2002). Therefore there might be serious yield loss, where the susceptible cultivars are being cultivated in infested field. Higher nematode multiplication was observed in Ghaiya-2 and Janaki than susceptible check ie IR-29 indicates the higher susceptibility of these cultivars to *M. graminicola*. These cultivars can be used as a susceptible check in screening of Nepalese rice cultivars. Difference in resistance reaction of IR-72 observed in this study and as reported by Tandingan et al (1996) might be due to difference in the water management. Tandingan et al (1996) reported IR-72 as resistant cultivars in permanent flooded condition and present study was carried out in simulated upland water condition. Environmental factors affect the resistance to *M. graminicola* (Plowright and Bridge 1990, Wallace 1987).

Generally most of the cultivars of *O. sativa* were susceptible and only a limited number of rice cultivars were resistant (Bridge et al 1990). Since, most of the commonly grown Nepalese rice cultivars were also found susceptible to *M. graminicola*, more cultivars including local landraces should be screened against the nematode to identify resistance sources. This study indicate that the chances of getting sources of genetic resistance against *M. graminicola* seems to be poor in Nepalese rice cultivars. Thus we need to develop an alternative integrated management practices to keep the damage below the economic threshold level.

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Soil Fertility Status of Bari and Khet Land in a Small Watershed of Middle Hill Region of Nepal¹

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ABSTRACT

Soil fertility is a critical issue to the farmers, particularly where population pressure is high and agriculture is the main source of income. A study to identify soil-fertility status of land use systems ie Bari (upland) and Khet (irrigated lowland), which are the two district and dominant agricultural land use systems in the Hills of Nepal was carried out in Lohorne Watershed, Dailekh District of Nepal. Soil fertility status of nitrogen (N), phosphorous (P), potassium (K) and organic matter (OM) is better in Bari than in Khet land. The pH was found to be slightly low, more acidic in Khet than in Bari land. Root depth and bulk density of Khet land were higher than that of Bari land. Higher application rate of farmyard manure (FYM) in Bari land and less crop intensity resulted Bari land more fertile than Khet land.

Key words: Nutrient land use, nutrient management, plant nutrients, soil fertility

INTRODUCTION

A vast majority of the agricultural population has been residing in the hills where the average land holding is less than 0.5 hectares, compared to 1.7 hectares in the Terai (CBS 2000). The hills of Nepal are generally characterized by two distinct and dominant land-use systems, ie (i) Bari (rainfed uplands, with maize-based cropping systems) and (ii) Khet (irrigated lowlands, with rice-based cropping systems). Agriculture is largely subsistence type and people have to rely on limited land parcel. Soil fertility status of farmland depends directly on farming practices. Soil fertility management issues are becoming critical for the productivity of the land, particularly in the hills of Nepal, where population pressure is high.

The increasing population pressure in the hills of Nepal stresses the environment and threatens the agricultural productivity and consequently the food security. The sustainability of hill agriculture depends how farmers manage, protect and utilize their farm and forest resources (Basnyat 1995). Shifting cultivation, overgrazing, overuse of marginal land are contributing to the loss of soil-fertility (Regmi 1999). The topsoil being washed down the river systems into India and Bangladesh is now Nepal's most precious export, for which it receives no compensation (Eckholm 1976). The annual silt load from the Karnali catchment in the mid-western region of Nepal has been estimated at 75 million m³, equivalent to a denudation rate of 1.7 mm/year (Ives and Messerli 1989). Soil loss and nutrient depletion due to rainfall erosion are very high, particularly in the rainfed marginal land and the degraded grazing lands in hills. The losses of soil organic matter and nutrients are threatening the sustainability of agriculture (Thapa 1996).

Farmers' indigenous knowledge on soil fertility management strategy is crucial in managing their agricultural soils. How and what resources are being used by the local people to sustain soil

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fertility in different land use systems is the key question. Therefore, there is need to investigate on soil fertility status between Khet and Bari land. For a typical small watershed, this paper examines the fertility status and management practices in these two land-use systems. The main objective of this study was to find out soil fertility status between two distinct land use systems (ie Khet and Bari). Other specific objectives were to find out the levels of input use, to find out crop production and productivity and to prepare nutrient budget for two distinct land use systems.

METHODOLOGY

Lohorne Khola, a small watershed in western Nepal (Dailekh District, Narayan Municipality, Kharigaira VDC), which is typical for the Middle-Hill region of Nepal, was selected for the study (Figure 1). Household survey to characterize socioeconomic conditions of the local people and a soil survey were carried out covering both land-use systems (Bari and Khet). Thirty-two soil samples, 16 from each land use system were analyzed for plant nutrients. Topsoil samples (0 – 20 cm) were collected and analyzed. Soil samples were measured in the lab of Nepal Agricultural Research Council (NARC), Katmandu using standard methods (Table 1). Composite soil samples were taken out from the depth of 6-9 cm. Random sampling was done for selecting the households to be surveyed and participatory discussion was carried out in order to identify the sites for soil samples collection from two land use systems.

The cropping pattern and practices may vary from place to place depending on the location and variation in soil, climate, farm-size, family labour supply, transportation, market demand and availability of inputs. However, it may not vary within a homogenous agro-ecological zone. The

farmers' practices for the soil fertility management are assumed to be homogenous. Farmers having upland fields have also the lowland fields in the same watershed. Another facet of the land holding is that it is not concentrated in a single place but rather scattered in different parcels of small sizes. Therefore, soil management in individual parcels as well as upland and low land may vary. But under the umbrella of broader farming system perspectives, the households' practices are found to be more or less homogenous within the watershed. Considering this fact 55 households (equal to 20% of the total households in the watershed) were selected for the study purpose.

The primary data were collected through reconnaissance survey, group discussion, key informant interviews and households' surveys. Secondary data were collected from different government offices, ie, Kharigaira Village Development Committee (VDC), District Agricultural Development Office (DADO), District Soil and Water Conservation Office (DSWCO), District Forestry Office (DFO) and District Development Committee (DDC) and Narayan Municipality. Land use and land capability maps were collected from His Majesty's Government (HMG) of Nepal, Department of Survey (DoS).

Table 1. Soil characteristics and method of measurement

Characteristics	Methods of measurement/analysis
Slope and altitude of the sample sites	Topographic map
Soil color	Munsell color chart
Bulk density	Replacement method
Nitrogen	Kjeldahal titration method
Phosphorous	Bray I and Bray II method
Potassium	Ammonium acetate extraction method
Organic matter	Wakley-Black method
pH	Electronic pH meter
Texture	Hydrometer
Rooting depth	Measuring tape

RESULTS AND DISCUSSION

Farmers in the hills of Nepal have been facing a serious problem in managing the soil fertility because of the steep slopes, the dependency on rainfall and unavailability of required inputs such as fertilizers. The gradual decline in soil fertility, the increase in soil erosion, a reduction of the productive forest area and misuse of agro-chemicals are the major agricultural and environmental problems in Nepal. The agricultural environment, particularly in the hills of Nepal, is degrading at a high rate (Regmi, 1999). Apart from these problems, the most severe constraint recognized by the farmers as well as agricultural scientists is the declining crop productivity.

Main crop yields

Major crops grown in the area were maize, wheat and rice. However, millet and buckwheat were also grown in some areas as minor crops. Vegetables were grown only for home consumption but a few farmers started growing vegetable for selling. Table 2 reflects the situation of crop productivity in the area as compared to the national figure.

Table 2. Yield levels of main staple crops

Crop	Average yield of grain, t ha ⁻¹	
	Study area	National
Maize	1.11	1.68
Wheat	1.59	1.59
Rice	0.89	2.40
Potato	7.92	9.87

Source: Field survey 2001, CBS 2000.

Manure and fertilizer uses

Poor soil fertility status of the farmland in the Middle Hills of Nepal is a major constraint faced by the farmers (Pandey 1995). Soil productivity

is being reported as declining because of increasing agricultural activities such as crop intensification and the expansion of agriculture into marginal lands with insufficient plant nutrient replenishment.

The number of livestock per household determines the extent of farmyard manure (FYM) use in the farmlands. A positive relation was found between livestock number and farmyard manure application. A negative relation was found between livestock number and the use of chemical fertilizers (Regmi 2001). The farmers used less chemical fertilizers when they had more livestock that produced manure. The major share of manure was produced by cattle and buffaloes (Table 3). However, sheep and goats were also important sources of manure. Pigs and poultry contributed insignificant quantities.

The study also revealed that the dose of FYM was different for Khet and Bari lands (Table 4). Farmers believed that maize – grown on Bari land – removes more plant nutrients from the soil than other crops. Therefore, they needed to apply more nutrients. Also Bari land is located nearby household. Therefore, Bari land received more FYM than that of Khet land.

Chemical and physical soil fertility parameters

Some selected chemical and physical soil properties have been used as indicators for the soil-fertility status of Bari and Khet lands in the study area.

Nitrogen

Nitrogen (N) is the key macro-nutrient for the crops. The soil analyses have shown that N level in the soil was low. The range of total nitrogen in

Table 3. Average farmyard manure (FYM) and fertilizers application, kg ha⁻¹ yr⁻¹

Village	Chemical fertilizers†	Total farmyard manure	Cattle and buffalo manure	Goat and sheep manure	Pigs and poultry manure
Bhirmoura	30.16	15791	9967	5698	129
Wallo Kalimati	39.00	12164	9847	2282	35
Pallo Kalimati	43.29	12097	6175	5200	723
Golsin	23.98	14092	10113	3987	0
Luchhekanda	42.70	12414	6946	5425	43
Dewalkanda	28.08	9913	4996	3218	1699
Overall	34.32	12842	8190	4253	399

† Refers to urea, muriate of potash (MOP), diammonium phosphate (DAP) and potassium sulfate.

the sampled soils was between 0.083% to 0.223%. Bari land had a slightly higher nitrogen content than Khet land (Table 5). The reason for this is the higher FYM and compost use, which contributed to the increase in N. Khet lands are irrigated, with high N losses through leaching and runoff. In the rainfed Bari land the level of leaching is much lower.

Table 4. Average application of farmyard manure (FYM) and chemical fertilizers on Khet and Bari land, kg ha⁻¹ yr⁻¹

Village	Bari Land		Khet Land	
	FYM	Chemical fertilizers	FYM	Chemical fertilizers
Bhirmoura	12456	5.32	3345	24.84
Wallo Kalimati	8678	4.75	3487	34.25
Pallo Kalimati	9184	7.89	2914	35.40
Golsin	10238	4.25	4035	19.73
Luchhekanda	9136	7.87	3274	34.83
Dewalkanda	7069	2.36	2832	25.72
Overall	9523	5.41	3370	28.91

Table 5. Some physical and chemical parameters of soil of Khet and Bari land

Soil parameter	Khet	Bari
Nitrogen, %	0.13	0.14
Phosphorous, kg ha ⁻¹	14.38	54.53
Potash, kg ha ⁻¹	305.86	648.90
Organic Matter, %	2.09	2.70
pH	5.20	5.57
Bulk Density, g cm ⁻³	1.36	1.28
Rooting depth, cm	59.69	55.19

Phosphorous

Phosphorous (P) has great importance for crop production. Phosphorus is essential for the maturity of crops and for root growth. Especially small seedlings benefit from a good phosphorus supply. The available phosphorous in the soil was very limited, although the total phosphorous levels were high. The soil conditions that made phosphorus available to plants varied greatly in the area. Soil pH plays very crucial role in P availability. The soil tests showed that available phosphorous in Bari land was higher than on Khet land. However, most of the soil samples were in the lower range. Only a few soil samples had a high P levels. The reason for the higher P content on Bari land could be due to the higher levels of pH (Table 5) and the high soil organic matter content that improved the general soil condition and provided some P to the soils.

Potassium

Most potassium (K) in plants is found in the above-ground portion, mainly in the straw. Therefore, if crop residues are returned to the soil, a good proportion of the potassium is conserved. In soils, potassium is found as part of the mineral structure of many clay minerals particularly micas. In this form, however, K is locked up from plant roots. The soil tests have shown that the K-content of the soil was generally high. This is typical for the soils of Nepal. The soil tests have also revealed that K-levels were significantly higher in Bari land than in Khet land. This is due to the returning of crop residues into the soil and the higher rate of organic fertilizer use (eg farmyard manure) on Bari land.

Soil pH

The range of soil pH was between 4.7 to 7.7 in the sampled soil. The lowest pH was found on Khet land and the highest on Bari land. On an average, pH-levels in Bari land were higher than in Khet land (Table 5). The reasons for the lower pH-levels in Khet land are most likely to be the higher chemical fertilizer use and the effect of leaching induced by the irrigation of Khet land, contributing to the more acid conditions. This was not the case with the rainfed Bari land (Table 4).

Organic matter

The organic matter content of the topsoil on Bari land was significantly higher than on Khet land (Table 5). Generally, however, most of the soil samples were in the lower range of acceptable organic matter level, only a few samples could be classified as medium. The field survey showed that the use of farmyard manure, compost and the level of in situ manuring were higher on Bari land than on Khet land. This explains the more favorable organic matter conditions on Bari land.

Bulk density

Bulk density is a measure of the compactness of the soil. It relates to the pore size distribution, thus indicating the range of water-holding capacity and soil aeration. Bulk density can be modified by soil-organic matter management and tillage practices. Bulk density on Khet land was

generally higher than on Bari land (Table 5). This is because of higher soil organic matter content on Bari land, which is favorable for a good soil structure and the tillage practices on the Khet land, with common soil puddling that compacts the soil, resulting in a high bulk density. However, for rice, which is the dominant crop on Khet land, puddling is required to prevent percolation of water losses.

Soil depth

The field survey revealed that the average soil depth (ie rootable soil depth) on Khet land was

nutrient application and nutrient uptake by the crops. Fertilizer and organic matter applications varied significantly between farms, depending on factors such as the economic condition of the farmers, the number of farm animals, access to forest resources and access to the market.

The nutrient (ie N, P and K) contents and the average application rates of different types of fertilizers (ie farmyard manure, compost, green manure and chemical fertilizers) that are applied by the farmers were determined to establish an estimate of the total quantity of nutrients applied

Table 6. Plant nutrient input and output levels for different system components

Input and uptake	System component	N	P	K
Input (gains)				
Organic materials	Farmyard manure % of fresh weight ¹	0.6	0.13	0.6
	Compost % of fresh weight ²	0.6	0.06	0.6
Nutrients contents in green plants	Oilseed cake % of fresh weight basis ²	6.9	3.1	1.6
	Adhotoda vesicica % of fresh weight ²	4.3	0.9	4.5
	Artimesia vulgaris % of fresh weight ²	2.06	.22	4.1
	Writiya antidysentica % of fresh weight ²	2.99	0.37	2.31
Mineral fertilizers	Albizza lebbeck % of fresh weight ²	2.9	0.65	2.59
	Urea % of fresh weight ³	46	0	0
	Diammonium phosphate ³	18	23.5	0
	Muriate of Potash ³	0	0	60
Uptake by crops (losses, kg ha⁻¹)				
	Paddy per t of yield ⁴	23.7	3.4	26.3
	Maize per t of yield ⁴	27.4	4.9	18.1
	Wheat per t of yield ⁴	19	3.4	20
	Millet per t of yield ⁴	48.3	5	13.3
	Barley per t of yield ⁴	44.1	6.2	45.6

¹ Tandom and Kimmo 1993. ² Subedi and Gurung 1991. ³ Joshi and Khatiwada 1986. ⁴ White 1979.

generally higher than on Bari land, although the ranges in both Khet land (38-77 cm) and Bari land (35-71 cm) were similar (Table 5). The differences might be due to the higher soil erosion rates on the sloping Bari land. Because the Khet land is flat and usually located further downstream, it acted as sedimentation area for the eroded soils of the Bari land. However, most of the eroded soil entered directly into the streams and the absolute quantity of sedimentation on Khet land was not significant.

Nutrient balance in the farmers' fields

Assessment of the nutrient balance in farmland is dependent on the methods used and the information available. For the study area, the assessment focused on the balance between

to the soil (Table 4). Based on reported yields, the quantities of nutrients extracted by the different crops were estimated (Table 6). The nutrient status was then determined by subtracting plant uptake from input.

Table 7. Cropped area under different crops (ha)

Crop	Cropped area	Percentage of total area
Rice	19.21	28.4
Wheat	18.51	22.4
Maize	20.63	32.2
Millet	6.23	8.7
Barley	1.21	3.8
Vegetables	0.51	0.01
Mustard	2.11	3.5
Total	59.93	100

Table 8 shows the nutrient balance on the farmlands of studied area. The table shows that there was a significant difference between the two land use systems. Though fertilizer applications on Khet land were much higher than on Bari land (Table 4). There was a general negative nutrient balance in Khet land. This might be explained by the higher crop yields on Khet land, which extracted significantly more nutrients. However, there are also other factors that need to be considered in the nutrient balance. Bari was a more complex system than Khet, with an important agroforestry component that contributed large quantities of organic matter and nutrients to the soil.

Table 8. Nutrient balance in Bari and Khet lands†

Land use type	Input and uptake	Nutrient balance, kg ha ⁻¹		
		N	P	K
Bari	Input	59.62	12.38	57.14
	Uptake	56.35	9.00	37.34
	Balance	3.27	3.38	19.8
Khet	Input	33.52	4.38	20.22
	Output	34.02	5.2	34.07
	Balance	-0.5	-0.82	-13.85

† This analysis was based on Tables 2, 4, 6 and 7.

A similar study by Poudel (2001) in the Middle Hills of Nepal found that there were significant differences in nitrogen, phosphorous and potassium contents between Khet and Bari land, with Khet land also showing a negative nutrient balance.

Generally, the current soil fertility status in the study area was low, but not alarming. Although all indications pointed to a negative nutrient balance in the Khet lands, the general nutrient level and other soil conditions were not in an acutely marginal state. The farmers understood very clearly the importance of nutrient and organic matter management and they were keen to recycle as much organic matter as possible. The need to produce higher yields from the limited farmland would jeopardize the fragile agricultural production system.

However, there are scopes to improve overall soil fertility management in view of both ecological suitability and the growing needs of the farm families. There is a need to develop land-

management guidelines that focus on the farmer specific needs rather than on the conventional general blueprint recommendations. This is a challenge to the extension service, which is traditionally accountable to its employer (usually government) rather than to its clients, the small farmers who need to survive under increasingly adverse conditions. It obviously showed that the fertility status in the farmland was low. Nutrient balances further depicted that the sustainability of the soil fertility status were under threat. However, it is not a comprehensive calculation for exact amount of plants nutrients in and out, it is based on plant removal and prevailing soil fertility management practices, where balances seemed negative and marginal. There is a need to manage plant nutrients in an integrated way so as to achieve sustainable crop production through management of soil fertility.

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Intensity of Common Root Rot on Wheat Genotypes¹

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ABSTRACT

Common root rot of wheat caused by *Bipolaris sorokiniana* (Sacc. in Sorok.) has been an emerging problem in Nepal. This study was conducted to determine the level of resistance in promising wheat genotypes. Thirty wheat genotypes were tested under natural epiphytotic condition for the intensity of infection on subcrown internode and crown root. None of the wheat varieties were found immune common root rot. However, genotype BL 2246, BL 2203, CHAM-4 and BL 2262 had low level of infection denoting resistant character. Most of the genotypes had moderate level of root rot index that ranged from 20-35 percent. Genotypes BL 2302, BL 1724 had more than 50 percent root rot index. The resistant genotypes have to be further tested under artificial and sick plot condition for confirmation of the above result.

Key words: *Bipolaris sorokiniana*, common root rot, dry land root rot, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the third staple food crop of Nepal. It is suffering from many diseases including common root rot caused by *Bipolaris sorokiniana* (Sacc. in sorok.). *B. sorokiniana* causes spot blotch, common root rot, black point and seedling blight on wheat (Duveiller and Gilchrist 1993). *B. sorokiniana* is the dominant pathogen among many other root rot causing fungi of wheat (Dubin and Bimb 1991). Root rot is a inconspicuous disease that reduces seedling vigour and impair the functioning of roots and crowns resulting in stand loss, reduce yield and quality reductions (Duczek et al 1985). Root rot and seedling blight are more common in the tropical environments (Perscott 1984, Nsarellah and Mergoum 1997). For every one percent increase in root rot intensity, there is a yield loss of 46 kg per hectare (Statler and Darlington 1972). The average yield loss due to root rot problem in South Asia is about 14 percent (Saari 1997). Chemical method of

controlling the disease is not practical and economical in our condition. In European countries, various cultivars have been identified as having mature plant resistance but no commercial cultivars had high level of resistance to common root rot (Mathre 1982). In tropical areas, the inoculum level of the pathogen is very high as compared to temperate areas. So, functional level of resistance in temperate areas might not be useful in the tropical areas. In Nepal, various wheat genotypes have been developed with a good level of spot blotch resistance and high yielding capacity. However, the assessment of level of resistance on those varieties against root rot has been still lacking. Therefore, this study was carried out to identify the level of resistance in different wheat genotypes against common root rot.

MATERIALS AND METHODS

Thirty wheat genotypes were planted under natural epiphytotic condition at IAAS, Rampur, Nepal during 2000-01 wheat seasons. Plot size for each experimental plot was 2- × 1.5-m. Seed was planted in six rows at 0.25 m apart. The experiment was conducted in the Randomized

¹ Part of the thesis submitted by the first author in partial fulfillment of MSc, Plant Pathology to Tribhuvan University, IAAS, Rampur, Nepal.

complete block design with three replications. Fertilizers dose was 120:60:40 kg N:P₂O₅:K₂O ha⁻¹. Five plants were randomly selected in each plot and uprooted at soft dough stage. The root of each genotype was washed in running tap water. The root rot was scored on 0-3 scale,

Where,

- 0 = healthy, creamy white, no discoloration of sub crown internode and crown roots,
 1 = light brown discoloration of sub crown internode and crown roots,
 2 = brown discoloration of sub crown internode and crown roots,
 3 = dark brown to black discoloration of sub crown internode and crown roots and /or roots mostly decayed.

The original data were subjected to logarithmic transformation. The score was transformed to root rot index by using the formula (Tinline et al 1975).

Root rot index

$$= \frac{\sum (\text{Category value} \times \text{Number of roots in category})}{\text{Number of roots rated} \times \text{Maximum rating}} \times 100$$

RESULTS AND DISCUSSION

Root rot index was low for all tested wheat genotypes. However, there were significant differences among genotypes for root rot index (Table 1). The damage caused by root rot pathogen depends on the amount of inoculum present in the soil and seed, cultural practices and climatic factors (Statler and Darlington 1972). Wheat genotypes were grown under natural epiphytotic condition in Wheat-Dhaincha-Fallow rotation system. So, the survival of the pathogen in the soil was minimum. Wheat genotypes BL 2302 (51.1%), BL 1724 (51.1%), BL 2295 (46.66%) and Annapurna-4 (46.66%) had comparatively high level of root rot index. Genotypes showing more than 50 percent root rot index were considered susceptible. Genotypes BL 2246 (15.55%), BL 2203 (17.77), CHAM -4 (19.99) and BL 2262 (20%) had low root rot index and were grouped as resistant. CHAM-4

belongs to synthetic wheat and the other have Ning and Suzhoe in their pedigree. Genotype Crock, which has *Aegilops squarrosa* in its pedigree showed intermediate level of root rot resistance. However, genotypes with *Aegilops squarrosa* were reported to possess high level of resistance (Conner 1989). Most of the tested genotypes had intermediate level of root rot index, which ranged from 20 to 35 percent.

Result indicated that none of the genotypes was immune to common root rot infection in the study. All wheat genotypes tested have various levels of root rot severity. Genotypes with low level of root rot index may be grown in disease prone area and/or crossing program, however, further confirmation in a sick plot with optimum level of inoculum before recommendation.

Table 1. Root rot severity of 30 wheat genotypes caused by *B. sorokiniana* in the field condition during 2001 at Rampur, Nepal

SN	Genotype	Root rot severity, %
1	RR 21	39.997 a-f†
2	UP 262	42.220 a-d
3	Nepal 297	28.883 c-h
4	Bhrikuti	35.553 b-g
5	Rohini	24.443 d-h
6	Annapurna-4	46.660 a-c
7	BL 1473	39.997 a-e
8	BL 1724	51.107 ab
9	NL 781	28.887 c-i
10	BL 1868	37.773 a-f
11	BL 1905	31.110 c-h
12	BL 1923	35.550 b-g
13	BL 2246	15.553 h
14	BL 2254	35.553 b-g
15	BL 2262	20.000 f-h
16	BL 2279	46.663 a-c
17	BL 2201	24.440 e-h
18	BL 2295	46.663 a-c
19	BL 2299	28.887 c-h
20	BL 2302	51.107 a
21	BL 2304	38.443 a-f
22	BL 2203	17.777 gh
23	CHIL/WUH.3	24.443 e-h
24	RL 6043/4*NAC	24.440 e-h
25	CHAM -4/VENAC "S"	19.997 f-h
26	NL 724	28.883 c-h
27	PAVON 76	31.107 c-h
28	CHIRYA -3	24.440 e-h
29	G 162	24.330 e-h
30	CROC1/Ae.Squa 9205//	24.440 e-h
CV, %		35.62

† Means in a column followed by the same letter do not differ significantly at P = 0.05 according to Duncan's multiple range test.

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Socio-economic Study on Current Farmer's Practices on Wheat and Mustard Production Systems in Surkhet, Salyan and Doti Districts

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ABSTRACT

Wheat is one of the major cereal crops grown as a mono crop or mixed with mustard/lentil or pea in the Mid and Far Western Development Regions. The main objective of the study was to explore the existing cropping practices of wheat and mustard production systems and to establish a benchmark for further impact evaluation. Three representative districts Surkhet, Salyan and Doti were selected for the socio-economic study in wheat and mustard production system. A total of 92 households were surveyed (using two stage purposive random sampling method) in the districts and information was also collected through RRA techniques. The total population of the surveyed households was 744 with an average family size of 7.8, 8.3 and 8.3 persons in Surkhet, Salyan and Doti, respectively. Brahmin/Chhetri (66%) and Gurung/Newar (1%) were the major and minor groups, respectively. The total area of the surveyed households was 79.96 hectares with an average farm size of 0.91, 1.02 and 0.60 hectare for Surkhet, Salyan and Doti respectively. Recommendation was made to identify the technology on mixed cropping of wheat and mustard for appropriate time of planting to maximize productivity of wheat and mustard crops without disturbing the existing farmer's practices.

Key words: Farmer's practice, impact evaluation, mixed crops, socio-economic study

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major cereal crops mostly grown as a mono crop in Nepal. Being a component of various cropping patterns, wheat crop is also mixed with mustard (*Brassica juncea*), lentil (*Lens culinaris* M) and pea (*Pisum sativum*) in the lower hills of Mid and Far Western Development Regions with altitudes ranging from 300-800 masl. Productivity was higher in mix cropping of wheat, lentil and mustard than sole crop so the gross benefit from seed and grain was higher in wheat, lentil or mustard intercrop than sole (Neupane et al 1997). Intercropping of wheat and pea was profitable in terms of overall grain yield, land advantage, economic return and dietary requirements of the subsistent farmers, though the sole crop of pea gave the highest net benefit (Subedi 1996). There are several reports which suggest intercropping is advantageous in many ways such as yield stability, soil fertility improvement, human and animal nutrition (Willey 1979, cited by Subedi 1996). Similarly on the fertility trial of Wheat +

Mustard mixed crop in maize based systems at Kotjhari, with 60:30:0 NPK kg ha⁻¹ gave the highest gross return of Rs 13111 ha⁻¹ as against the other treatments (Yadav and Thapa 1990). The improved cropping pattern of Rice + Maize-Wheat + Mustard produced higher yield (9.39 t ha⁻¹) than the farmer's practice (7.96 t ha⁻¹) in the same upland situation (Joshi and Adhikari 1986). Food security and high intensity production systems have been perceived as priority areas by the Agricultural Perspective Plan (APROSC and JMA 1995) and also the ongoing 10th Five Year Plan. Wheat is one of the priority crops for food security, whereas mustard is a cash crop and both have direct impact on poverty reduction.

The objective of the present study was to identify the existing socio-economic status of the farmers, explore the existing cropping practices, identify and prioritize bio-physical and socio-economic constraints and establish benchmark of present socio-economic status of the farmers for future impact evaluation.

MATERIALS AND METHODS

The survey covered the socio-economic status of the farmers and their mixed cropping practices of wheat + mustard/lentil/pea. A total of 92 households of Surkhet, Salyan and Doti districts were purposively selected at random from different Village Development Committees (VDCs). The survey was carried out in October 2000. Primary data were collected through household survey and rapid rural appraisal (RRA) techniques. Checklists and structured questionnaires were developed and filled up by interacting with persons and households, the owners of socio-economic conditions and farming practices. A multidisciplinary team of experts of Nepal Agricultural Research Council (NARC) and concerned District Agricultural Development Offices (Surkhet, Salyan and Doti) were involved in the study. Data sets obtained through the household survey were analyzed using SPSS software. The information obtained was based on memory recall. Secondary information was collected from the respective Agricultural Offices at Surkhet, Salyan, and Doti districts as well as NARC library.

Surkhet

Melkuna, Maintada, Chhinchhu and Uttarganga VDCs of Surkhet were the sites surveyed. Settlement in these areas started after deforestation in the year 1965. The major farming ethnic groups at present are Magar (Bhudha), Brahmin, Chhetri/Thakuri, and Gurung. These groups had migrated from Salyan, Musikot, Rukum, Rolpa and Jajarkot districts. Melkuna, Chhinchhu and Utterganga VDCs are about 26, 20 and 0.5 miles away from the district headquarters respectively. The sites of Melkuna, Chhinchhu and Uttarganga VDCs have an area of about 2543, 5434 and 4986 hectares respectively. The elevations range from 198 to 2367 masl. There are about 1404, 1436 and 1260 households in the VDCs mentioned above with a population of 7649, 8319 and 6704 respectively. The total cultivable land in Melkuna, Chhinchhu and Utterganga VDCs are about 636, 498 and 1057 hectares respectively (DADO 1999).

Salyan

The study areas are located at Chhayachhetra, and Khalanga VDCs in ward numbers 8, 9 and 4, 5 respectively. These VDCs have 678 and 999 households with the population of 3850 and 5313 respectively. The total cultivable areas in these VDCs are 2613 and 2199 hectares of which 807 ha and 715 ha is cultivated respectively. The elevations range from 326 to 1500 masl. The average annual rainfall is about 2039 mm of which 80 % is received between June to September. The average maximum and minimum temperatures are recorded 25°C and 15°C respectively (DADO 1999). The major ethnic groups are Brahmin, Chhetri/Thakuri, Magar, Gurung and Schedule Castes (blacksmith, shoemaker and tailor).

Doti

The study areas are ward numbers 9 and 10 of Dipayal Municipality and 8 and 9 of Latamandu VDC. These survey sites are located physiographically in low hills of Dipayal Municipality and Latamandu VDC at a distance of 0 and 10 km respectively from Dipayal, the regional headquarter of Far Western Development Region. Dipayal and Latamandu VDCs have cultivable areas of 908 and 100 hectares respectively with 1962 and 868 households and a population of about 12360 and 4858. The elevations range from 305 to 1300 masl. The temperatures are rather extreme and fall down to 5°C in the coldest month and rise up to 42°C during the hottest month (DADO 2000). The major ethnic groups are Brahmin, Chhetri/Thakuri, Newar, Gurung, Magar and Schedule Casts (blacksmith, shoemaker and tailor).

RESULTS AND DISCUSSION

Socio-economic attributes

The total population of the 92 households was 744 with an average family size of 8.1 persons. The average family sizes were 7.8, 8.3 and 8.3 respectively in Surkhet, Salyan and Doti districts. The average family size of Surkhet was observed comparatively smaller than that of Salyan and Doti. Among the surveyed VDCs, the highest

average family size was observed for Maintada VDC (9.6) and the lowest for Utterganga VDC (6.1) of Surkhet district (Table 1). The male (49.6%) and female (50.4%) population virtually were in equal proportion. Population of age group between 15 to 60 years was engaged in different type of production activities including field crops, livestock raising and other income generating activities. The percentage of major ethnic composition of the Surkhet, Salyan and Doti sites comprises of 47, 74 and 82 percent of Brahmin/Chhetri and 34, 6 and 9 percent of schedule caste respectively (Figure 1).

Table 1. Distribution of households (HH), population and family size in different Village Development Committees of Surkhet, Salyan and Doti districts

District/VDC	HH†	HH, %	Population			Family size
			Male	Female	Total	
Surkhet	38	41	146	152	298	7.8
Utterganga	10	11	33	28	61	6.1
Maintada	10	11	45	51	96	9.6
Chhinchhu	9	10	29	30	59	6.5
Melkuna	9	10	39	43	82	9.1
Salyan	31	34	128	128	256	8.3
Chhayachhetra	16	17	70	68	138	8.6
Khalanga	15	16	58	60	118	7.9
Doti	23	25	95	95	190	8.3
Dipayal	15	16	35	27	62	7.7
Latamandu	8	9	60	68	128	8.5
Total	92	100	369	375	744	8.1

† HH, Household.

Agricultural land

The total cultivated area of the surveyed households was 79.96 ha with an average farm size of 0.87 ha. A detail of land holding is given in Table 2. The average farm size of Salyan was

comparatively bigger (1.02 ha). Doti had the smaller farm size (0.6 ha) than the overall average (0.87 ha). The highest average farm size (1.61 ha) was observed in Utterganga VDC, Surkhet and the lowest (0.42 ha) in Dipayal, Doti because the land is located in the river basin area, which is comparatively fertile. In the same way, Chhinchhu of Surkhet is close to the market and limited area located nearby.

About 48% of the total households categorized as small farm size (0.5 - 1.0 ha) occupied 39% of the total farm area. The percentage of big holders was very much limited (5%). Only large farmers had enough food production for their home consumption. A few of them had some surplus to sale in the local market. About 39% of the total households categorized as marginal farm size (< 0.5 ha) and the food availability is for less than eight months (Figure 2).

Land utilization

Out of the total cultivated area of 126.5 ha about 87% of the land was used for production of cereal crops and 10% for cash crops and 1% for fruits and 2% for own forest (Figure 3). In lowland area, paddy crop was grown in summer followed by wheat + mustard or wheat/potato as mono crop in winter. The other crops grown in upland were maize, finger millet and legumes in summer and mustard in winter. Despite these crops, maize has also been started to grow as a spring crop especially in the lowland area.

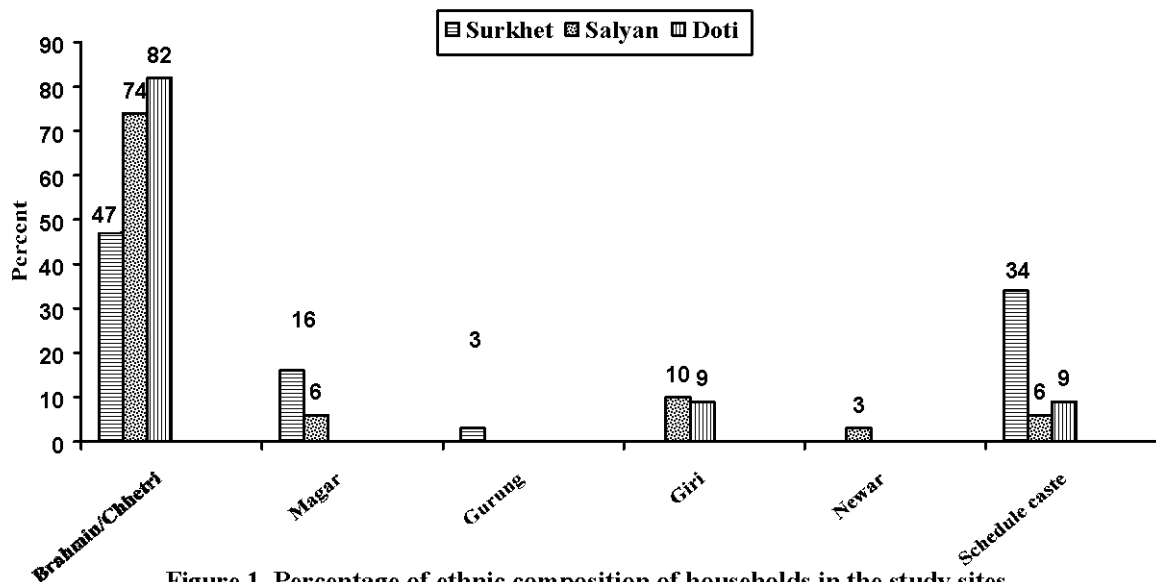


Figure 1. Percentage of ethnic composition of households in the study sites

Table 2. Land type distribution in different Village Development Committees of Surkhet, Salyan and Doti districts[†]

District/VDC	Marginal		Small		Medium		Large		Total		Av land ha
	HH, n	Total area, ha	HH, n	Total area, ha	HH, n	Total area, ha	HH, n	Total area, ha	HH, n	Total area, ha	
Surkhet											
Utterganga	3	0.79	4	2.87	-	-	3	12.47	10	16.1	1.61
Maintada	3	0.92	7	5.78	-	-	-	-	10	6.69	0.67
Chhinchhu	5	1.40	3	1.78	1	1.53	-	-	9	4.71	0.52
Melkuna	4	1.32	3	2.32	1	1.02	1	2.39	9	7.05	0.78
Salyan									31	31.7	1.02
Chhayachhetra	1	0.36	9	6.72	5	7.15	1	4.07	16	18.3	1.14
Khalanga	2	0.56	7	5.06	6	7.79	-	-	15	13.4	0.89
Doti									23	13.7	0.60
Dipayal	5	1.48	7	4.68	3	4.17	-	-	15	10.3	0.42
Latamandu	4	1.12	4	2.21	-	-	-	-	8	3.33	0.69
Overall	27	7.95	44	31.4	16	21.7	5	18.93	92	79.96	0.87
Percentages	29	10.00	48	39.00	17	27.00	5	24.00	100	100	100

[†] Marginal = <0.5 ha. Small = 0.5-1 ha. Medium = 1-2 ha. Large = > 2 ha. HH, Household. Av, Average.

Area and production of major crops

The major cereal and cash crops grown in the surveyed area were paddy, wheat, maize, finger millet and mustard. Farmers gave top priority to paddy, wheat and maize. Farmers' opinion showed that bio-physical condition was most suitable for these crops. The main products of these crops were utilized for human and the crop residues for livestock.

Wheat

Wheat was the major cereal crop grown in both upland and lowland area in the winter season. About 96% of the total households grew wheat. The total area under wheat was 41.0 ha with an average land of 0.44 ha per household. The average area under wheat in Surkhet, Salyan and

Doti districts were 0.38, 0.51 and 0.46 ha per household respectively. The average yield of wheat + mustard mixed crops was estimated to be 846 kg ha⁻¹ that is about half of the national average of sole wheat. The highest average yield (1242 kg ha⁻¹) of wheat was observed at Melkuna VDC whereas the lowest yield (520 kg ha⁻¹) was at Maintada VDC in rainfed eco-system (Table 3). It was nearly half of the national average (1806 t ha⁻¹) because the farmers grew degenerated cultivars like Vaskar in poor management condition.

Mustard

Mustard was the main cash crop grown in the low land as well as upland in the winter season. About 42% of the total households grew mustard.

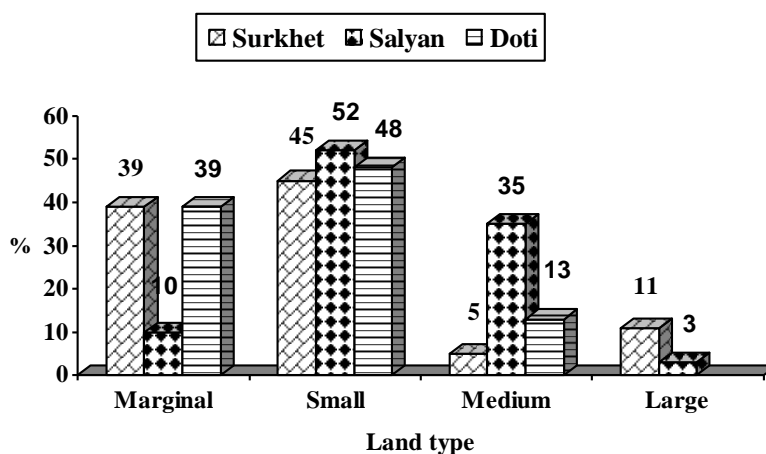
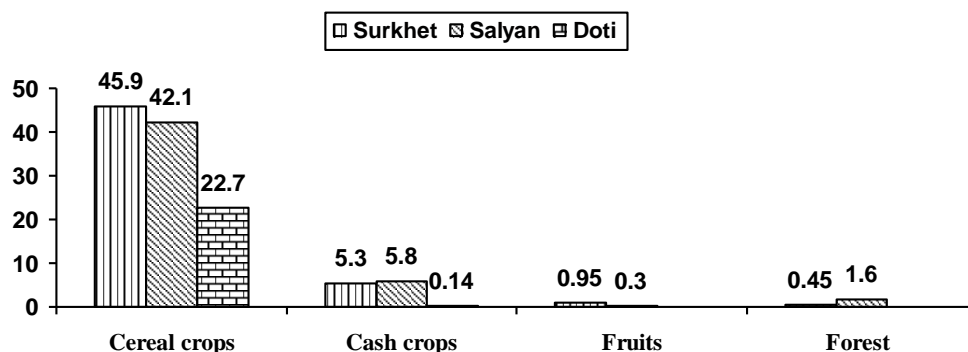


Figure 2. Percentage distribution of households by type of farms of surveyed districts

Table 3. Area and productivity of wheat and mustard crops by Village Development Committees

District/VDC	Wheat		Mustard	
	Area, ha	Productivity, kg ha ⁻¹	Area, ha	Productivity, kg ha ⁻¹
Surkhet	0.41	899 (1789)	0.27	267 (750)
Utterganga	2.2	1174	1.4	414
Maintada	4.6	520	0.5	144
Chhinchhu	3.2	627	0.2	180
Melkuna	4.5	1242	1.3	174
Salyan	0.51	840 (1599)	0.13	221 (585)
Chhayachhet	10.4	1123	0.8	237
Khalanga	5.4	575	2.1	228
Doti	0.46	800 (1768)	0.20	213 (745)
Dipayal	7.9	800	0.2	216
Latamandu	2.8	-	-	-
Total/average (92)†	41.0	846	6.5	286

† Figures in the parentheses refer the district yield (MOAC 2001).

**Figure 3. Land use pattern**

The total area under mustard was 6.5 ha with an average land of 0.18 ha per household. The average area under mustard was 0.27, 0.13 and 0.20 ha per household in Surkhet, Salyan and Doti districts respectively. The average yield of mustard in wheat plus mustard pattern was estimated to be 286 kg ha⁻¹. The highest average yield (414 kg ha⁻¹) of mustard in wheat mustard mixed crops was observed at Utterganga VDC whereas the lowest (144 kg ha⁻¹) at Maintada VDC (Table 3). It is about half of the national sole mustard crop (702 t ha⁻¹).

Cropping patterns

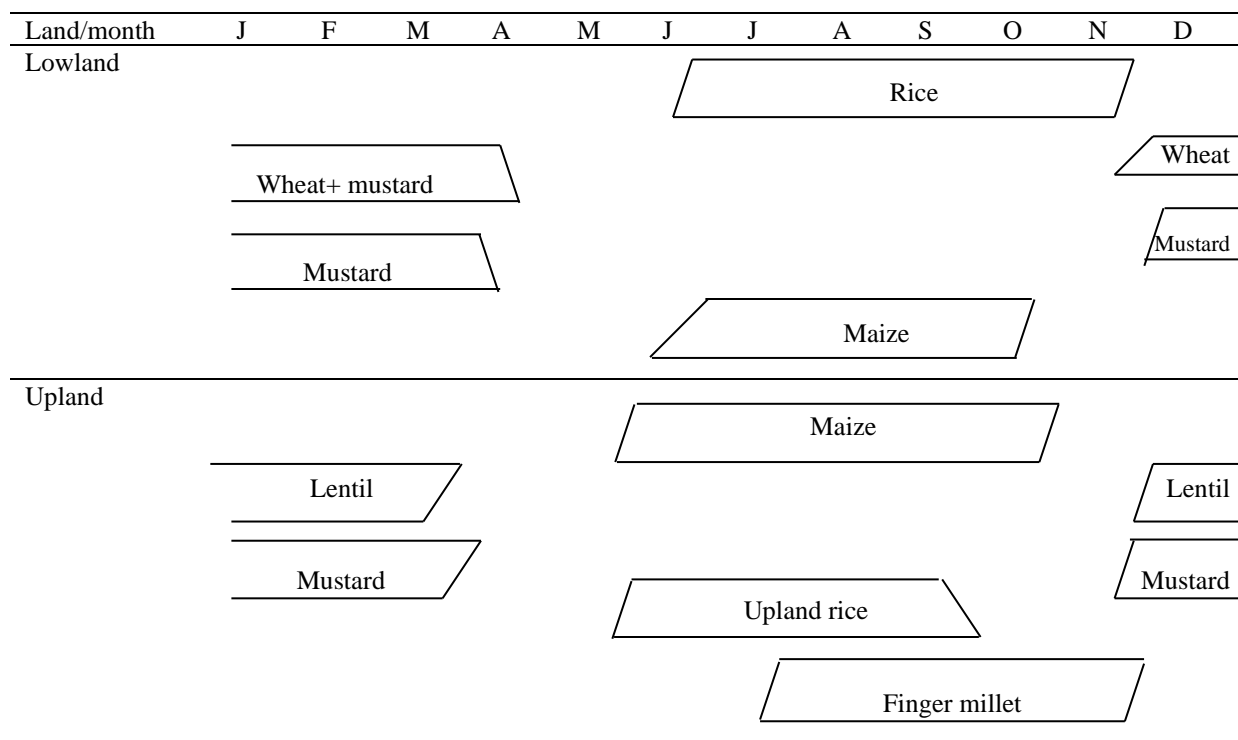
Rice - wheat + mustard - fallow and upland rice - wheat + mustard - fallow were the dominant cropping patterns of irrigated lowland as well as fertile upland of river basin areas of all three districts, among which, Doti occupied the maximum area (90%) (Table 4).

Apart from the above patterns, specially in the hills of Doti the farmer also adopted slightly different cropping patterns in the marginal upland condition and where they grew triple crops in two years rotation (upland rice - wheat + mustard - finger millet - fallow) against the double crops in other districts. In such case, farmers had been experiencing that the finger millet depletes substantially higher amount of plant nutrients from soil than any other cereal crops. Hence, they left their lands fallow in the succeeding season after finger millet (Figure 4). In recent years, a few number of small farmers have initiated triple cropping patterns ie rice - wheat + mustard - maize in limited irrigated area where transportation and market facilities for green cobs were available.

Table 4. Existing cropping patterns, cropping intensity (CI) and cropping coverage (CC)

Cropping patterns	Surkhet		Salyan		Doti	
	CI	Coverage, %	CI	Coverage, %	CI	Coverage, %
Low land						
Rice-wheat + mustard-fallow	200	45	200	15	200	85
Rice-wheat-maize	300	5	-	-	-	-
Rice-potato-maize	300	15	300	5	-	-
Rice-wheat-fallow	200	25	200	80	200	10
Rice-legumes-fallow	200	10	-	-	200	5
Upland†						
Maize-wheat+mustard-fallow	200	50	200	5	-	-
Maize-mustard+lentil-fallow	200	15	-	-	-	-
Maize-mustard-fallow	200	10	200	5	-	-
Maize+legumes-wheat-fallow	200	15	200	80	-	-
Maize-barley-fallow	200	5	-	-	-	-
Maize+legumes-mustard-fallow	200	5	200	10	-	-
U rice-wheat+mustard-FM-fallow	-	-	-	-	150	30
U rice-wheat+mustard-fallow	-	-	-	-	200	30
FM-wheat+mustard-fallow	-	-	-	-	200	40

† U, Upland. FM, Finger millet.

**Figure 4. Existing major crops calendar****Cropping practices**

Unavailability of irrigation is the primary limitation to improve the productivity of winter

crops like wheat and mustard. About 28% of the total cultivated land is covered by irrigation in the surveyed districts. About 1-3 times irrigation

is the usual practice in irrigated lowland condition whereas rests of others entirely depend upon natural precipitation.

For planting wheat, seed broadcasting followed by one or two plowings was the usual farmer's practice. 90% of the farmers applied compost (FYM) @ 5-15 t ha⁻¹ before planting. Although some farmers used chemical fertilizers along with compost as a basal application or top dress during late tillering stage (Table 5).

Table 5. Average seed rate, fertilizers and FYM used in wheat and mustard crops

VDC	Wheat, kg ha ⁻¹				Mustard,
	Seed	Urea	DAP	FYM	kg ha ⁻¹
Surkhet					
Utterganga	120	60	62	35000	7.20
Maintada	140	56	100	42500	5.60
Chhinchhu	90	40	68	33760	5.6
Melkuna	110	140	140	18760	5.4
Salyan					
Chhayachhetra	126	100	60	36340	5.3
Khalanga	130	80	40	15000	4.0
Doti					
Dipayal	106	80	100	22800	7.6
Latamandu	100	160	180	34820	5.8
Average	115	90	94	29872	6.00

While seeding was usually done by broadcasting (by 96%), some people (4%) also planted wheat behind the plow in moisture stress condition. Normal planting time was from November to mid-December. However, rarely the planting goes even beyond this period if moisture is not enough. Farmers reported that the seed rate of wheat and mustard for mixed cropping was 100 kg and 4 kg ha⁻¹ respectively while for sole crops 115 and 6 kg ha⁻¹ respectively. The seed rate used by the farmers found slightly higher than NARC recommended dose in wheat and mustard sole crop situation. Another factor of high seed rate used by the farmers was poor quality seed. Besides the mixed crop of wheat plus mustard, in some cases, people also grew wheat mixed with winter legumes like pea in low land and lentil in upland eco systems.

The average use of urea in wheat was 90 kg ha⁻¹. It was observed that the highest urea (160 kg ha⁻¹) was used in wheat crop at Latamandu VDC. The average amount of FYM used for wheat was too high 29872 kg ha⁻¹ (Table 5) because of small

land holding. The application of FYM depends upon the livestock herds holding by households. The improved varieties of seed were used for the last 20 years. Over the time farmers are using the same seed.

Rice, wheat, maize, legumes and mustard were the popular crops grown in the surveyed areas. Farmers usually grow rice, wheat, mustard, potato in lowland and maize, wheat, rapeseed and winter legumes in upland ecosystems. Among the cropping practices, wheat and mustard mixed cropping was popular pattern in the river basin areas of Surkhet, Salyan and Doti districts. The most popular varieties of mustard for mixed crops (wheat + mustard) were Barsali, local and Vikash improved. The varieties used for mixed crop were phenotypically different from that of the sole crop. It is taller and fruiting branches were always above the wheat crop. Wheat and mustard varieties grown in the survey sites are given in Table 6.

Table 6. Crops and varieties adopted in the districts

Crop	Districts		
	Surkhet	Salyan	Doti
Wheat	1. BL 1022	1. BL 1022	1. RR 21
	2. Nepal 297	2. Bhrikuti	2. Kalyansona
	3. Annapurna 1	3. Nepal 297	3. BL 1135
	4. Bhrikuti	4. RR 21	4. BL 1022
	5. Vaskar		5. Dabdekhami
Mustard	1. Surkhet local	1. Vikash	1. Kalo local
	2. Barsali	2. Local	2. PT 30
	3. Vikash		
	4. Pusa bold		
	5. Pragati		

Farmers were very much choosy in selecting wheat and mustard crops for mix cropping. Generally, they did mix mustard or rape seeds with wheat in lowland and fertile upland conditions to get extra yield over the sole crop of wheat. More than 80% growers of Surkhet and Doti plant tall type of mustard (Rai), which would not affect the wheat crop. During wheat heading, mustard started shedding their leaves. It allowed for better solar radiation that resulted into better yield of wheat. Besides this, it was also desirable from standpoint of utilizing plant nutrients from different soil depths because of their different root systems. Hence, it could be said that the crops were compatible for mix cropping.

In mixed crop of wheat plus mustard, maturity period of crops did not coincide, though the planting was done at the same time. Normally, mustard matures about a month earlier than wheat. Only harvesting of fruiting branches or uprooting whole plants were practiced for mustard harvest in all the districts. For wheat in Doti heads were picked whereas in Salyan and Surkhet, the whole plants were harvested. Threshing was done by stick beating in Doti while treading by bullock around the centrally fixed wooden pole was practiced for threshing in Salyan and Surkhet.

Utilization of wheat, mustard and by-products

Wheat is the staple food of hilly areas of Mid and Far Western Development Region. It is used for making different food items like bread, Puri, Paratha, Bhat, Haluwa and even liquor (alcohol and local beer). Among these, use of wheat flour as bread and grains as liquor are common in all survey districts. Besides, grain by-products like wheat bran is used as a part of animal feed. Wheat straw was widely used for animal feed particularly in lean period as well as for roofing.

Mustard oil is quite commonly used as edible or cooking oil. It is also used for other purposes like body massage, hair care, health care item for eye and ear etc. Oil cake as a by-product is used as animal feed, manure as well as preservative of household bamboo crafts such as Nanglo, Dalo, Kotha, etc.

Food sufficiency situation

About 45, 51 and 75 percent of the total households in Surkhet, Salyan and Doti respectively reported that their agricultural produce is enough for less than 8 months of their annual food requirements and 26, 24 and 8 percent respectively had surplus (Figure 5). Only 3% farmers in the Maintada VDC and 8% in Dipayal Municipality reported that their agricultural produce is enough only for 4 months. Farmers reported that off-farm income contributes towards fulfilling their food requirements during deficit period.

Bio-physical and socio-economic constraints

Different types of bio-physical and socio-economic problems were reported and recorded during the field survey. In the study area, frequent drought and decline in soil fertility were the major constraints for crop production. Furthermore, pests, hailstone and weeds were also identified as the major bio-physical problems during the cropping season (Table 7).

Similarly, small land holding, lack of labor, unavailability of credit and lack of technical information were the important prevailing socio-economic constraints. Besides these, low market price of products and unavailability of fertilizers were also reported as the frequent problems during cropping season (Table 7).

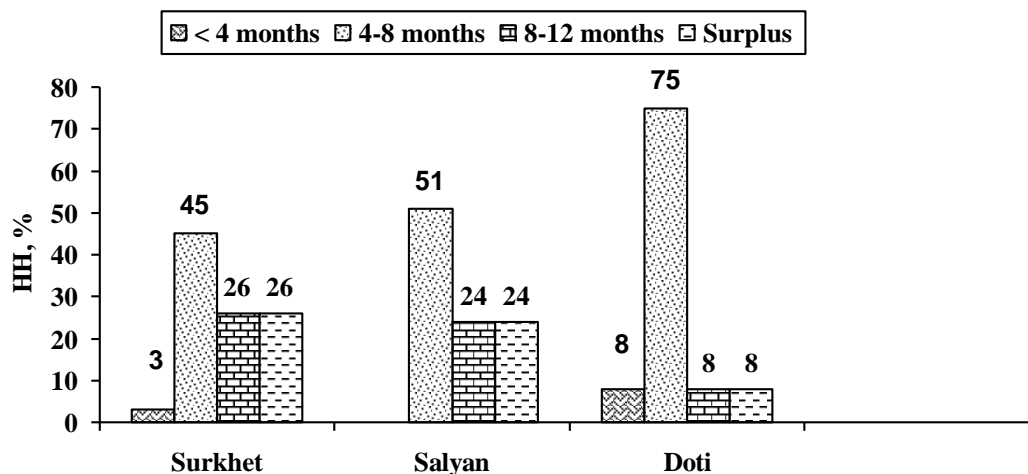


Figure 5. Food sufficiency situation in the sampled households (HH)

Table 7. Perceptions ranking of bio-physical and socio-economic constraints

Bio-physical constraint	Preference ranking					Socio-economic Constraint	Preference ranking				
	I† (85)	II (77)	III (61)	IV (17)	V (10)		I (87)	II (74)	III (74)	IV (33)	V (11)
Heavy rain	1	3	2	-	90	Landholding	42	5	5	3	-
Drought	43	12	13	6	-	Labor	2	4	1	6	18
Hailstone	6	8	2	6	-	Cash	14	38	21	6	9
Soil fertility	33	26	21	24	-	Credit	2	9	13	21	18
Pests	12	45	33	6	-	Information	2	7	13	3	18
Weeds	5	6	29	58	10	Fertilizers	6	11	24	15	18
						Improved seed	22	19	12	33	9
						Price	10	7	11	12	9
Total	100	100	100	100	100		100	100	100	100	100

† Figures in arenses refer the frequency.

Gender roles in farm activities

Both male and female members were actively involved in carrying out the farm activities. Land preparation, seeding, weeding, harvesting, threshing and marketing were major farm activities where gender involvement was reported in different crop activities. It was observed that male farmers were involved exclusively in plowing activity and females for cleaning and weeding activities. Both male and female farmers carried out harvesting and threshing activities.

Wheat is one of the major cereal crops grown as a mono crop or mixed with mustard/lentil/pea in the Mid and Far Western Development Regions. About 87% of the total land was used for cereal crops and 10% for cash crops in the surveyed sites. Rice - wheat + mustard - fallow and upland rice - wheat + mustard - fallow were the dominant cropping patterns in irrigated lowland as well as in fertile upland of river basin areas of all three districts among which Doti occupied the maximum area (90%) and Salyan the lowest (40%). The popular cultivars of wheat are BL 1022, NL 297, Bhrikuti and RR 21 and for mustard they are Barsali local and Vikash improved. Productivity of wheat and mustard is quite lower than that of district average. Subsequently about 52% of the total households reported that their agricultural produce is enough only for less than 9 months and during the deficit period, food requirement is met through off-farm income.

Hence, the present level of productivity of both the crops can be enhanced through varietal identification and crop management practices. A complete package of practices for mixed cropping of wheat and mustard needs to be developed for further dissemination of technology in river basin areas of Mid and Far Western Development Regions. These crops can contribute to improve food security and employment opportunity and have direct impact on poverty reduction through management of sustainable farming systems.

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Isozyme Variations in Fine and Aromatic Rice Genotypes

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ABSTRACT

Allozyme electrophoresis has been a reliable technique in estimating the genetic variation in crops. We surveyed isozyme variation of 24 aromatic and fine rice varieties collected from Nepal including Jetho budho landrace. Five enzyme systems were analyzed for allozyme variability that detected distinct 10 isozyme loci and 15 alleles including null alleles. The polymorphic enzyme systems, esterase revealed 8 phenotypes, 6-phosphoglutamate dehydrogenase and peroxidase each with 3 phenotypes and alcohol dehydrogenase and aspartate aminotransferase each with 2 phenotypes based on the combination of presence and absence of alleles. Dendrogram did not indicate any clear pattern of these populations into definite clusters. However 3 groups were detected at 84% of dissimilarity among 24 populations. Nepalese varieties Rato Basmati, Pahenle and Jetho Budho grouped in a separate cluster in the dendrogram.

Key words: Fine and aromatic rice, genetic diversity, isozyme

INTRODUCTION

Isozyme polymorphism in cultivated rice has received much attention in recent years. A major input was the demonstration by Second and Trouslot (1980) that considerable variation can be revealed by starch gel electrophoresis. Some extensive studies have involved up to 25 genes expressed at tillering and flowering (Second 1982) and 21 genes in coleoptiles a few days after germination (Glaszmann 1985). Knowledge of the extent of polymorphism and the chromosomal location of genes encoding isozymes makes them helpful as genetic markers in rice. These genes present various advantages (Tanksley and Rick 1980) such as stable expression in a wide range of environments, the absence of epistatic interrelationships, which permits surveying many genes simultaneously and usually codominance, which permits determining the exact genotype. The use of tissue of young plants simplifies the manipulation of the materials, permits early determination of their enzymatic characters and thus makes the possible associated screening procedures more efficient. Rice varieties and landraces in Nepal constitute a high degree of morphological variations and are

the important genetic resources for crop improvement. To optimize and accelerate the breeding process in rice, it is essential to screen, evaluate and classify the existed variability in genetic level. Thus, we focused on isozyme analysis in rice coleoptile. 24 fine and aromatic rice varieties for their significance in conservation and improvement.

MATERIALS AND METHODS

Extraction

Seed samples of fine aromatic rice were collected from different sources (Table 1). A total of 24 lines of rice varieties were considered for the isozyme analysis. Enzymes were extracted from fresh coleoptile of 7 day old seedlings grown in controlled condition of 30°C in darkness. Coleoptiles from 10 seedlings from each line or variety were cut into small pieces and crushed individually in pre-chilled cavity block with 20 drops of chilled extraction buffer (L. Ascorbic acid 8.3 g, Glycerol 30 ml and pH 7.4 with NaOH, total volume 100 ml in distilled water) (GEVES 1993). Rectangular small pieces of

Whatman filter papers (wicks) were dipped in the extracted solution and then after few minutes these filter papers were stored in deep freeze (-20°C) for further process.

Gel preparation

A starch gel was prepared using the appropriate gel buffer for the specific enzymes (Table 2). A solution of hydrolyzed starch (12%) and buffer was carefully homogenized in a litter conical flask and heated with continuous swirling on a Bunsen burner flame until a clear, vigorously boiling solution was obtained. The solution was then de-aerated with membrane vacuum pump and poured into an acrylic gel mold in which electrode strips were sealed with masking tape. Solid particles and air bubbles were quickly removed with help of forceps. The gel was allowed to cool and set for approximately 30

minutes at room temperature and then it was placed for 1 h in a refrigerator for final cooling before use.

The wicks with extraction solution stored earlier in deep freeze were placed on spot plates while the gel was cooling. A slit was prepared on to cooling gel approximately 5 cm far from its cathodal end. A wick with bromophenol blue solution was inserted to serve as a tracking dye. The wicks were inserted in the slit so that they form a continuous arrangement with some gaps to avoid distortion on the sides of the papers and to facilitate comparison of migration distances among the bands produced. Intermixing between adjacent papers was avoided by removing excess extract with absorbent paper prior to insertion into the gel.

Table 1. Populations of fine and aromatic rice genotypes for isozyme analysis

SN	Genotype	Source	Origin	Remarks
1	IR 66231-127-1-3	AVT 01.7	IRRI	High yield, medium maturity (135 days), dwarf (60 cm), fine grain
2	IR 43450	AVT 01.5	IRRI	High yield, medium maturity (140 days) medium plant (110 cm.)
3	IR 43850	AVT 01.5	IRRI	High yield, medium maturity (140 days) medium plant (110 cm.)
4	IR 67015-49-2-6-3	AVT 00.3	IRRI	Medium yield, medium maturity (135 days), dwarf (70 cm), coarse grain
5	IR 65610-105-2-5-2-2-2	FFT 01.3	IRRI	High yield (4 t ha ⁻¹), medium maturity (135 days), medium plant (100 cm)
6	IR 65610-38-2-4-2-6-3	CVT 01.2	IRRI	High yield, medium maturity (120 days), short plant (90 cm)
7	IR 67017-180-2-1-2	AVT 01.2	IRRI	High yield, long maturity (160 days), medium plant height (100 cm), fine grain
8	IR 43850-SKN-506	AVT 01.6	IRRI	High yield (4 t/ha), medium maturity (125 days), tall plant (130 cm.), excellent aroma, high protein content (10%)
9	IR 66231-106-1-2	AVT 00.12	IRRI	High yield medium maturity (140 days), dwarf (60 cm.), fine grain
10	IR 67017-13-3-3	AVT 00.5	IRRI	Medium yield, medium maturity (130 days), dwarf (85 cm), medium fine grain
11	IR 67417	AVT 01.4	IRRI	High yield (5 t ha ⁻¹), medium maturity (135 days), medium plant height (110 cm)
12	Basmati 370	AVT 01.15	India	Fine grain, medium maturity (130 days), short plant (90 cm)
13	Basmati 385	HB-00 (Parent)	India	Fine grain, medium maturity (130 days), short plant (90 cm)
14	Rato Basmati	CVT 01.14	Nepal	Local variety of Terai, late to mature (150 days), aromatic
15	ARC 10796	HB-00 (Parent)	India	Fine grain, medium maturity (130 days), short plant height (80 cm)
16	ARC10863	HB-00 (Parent)	India	Fine grain, medium maturity (140 days), tall plant height (140 cm)
17	ARC 10679	AVT 01.3	India	High yield, long maturity period (150 days), tall plant height (150 cm.)
18	Pahenle	AVT 01.11	Nepal	Local variety of Kaski district, long maturity period (150 days), medium plant height (140 cm), aromatic
19	Pusa 834	FFT 01.1	India	High yield (5t ha ⁻¹), medium maturity (135 days), medium plant height (100 cm), aromatic
20	Jetho Budho	AVT 01.12	Nepal	Local variety of Kaski district, long maturity period (150 days), tall plant height (160 cm), excellent aroma
21	FRX 92F38	AVT 01.1	India	High yield, medium maturity (140 days) short plant (90 cm)
22	Zhong Fan 11	CVT 01.4	IRRI	High yield, long duration (140 days), coarse grain, aromatic
23	PK 1501-9-2-B-1	AVT 01.8	India	High yield (5 ha ⁻¹), medium maturity (135 days), dwarf plant height (90 cm), aromatic
24	CNTRL 85033-9-3-1-1	AVT 01.1	India	High yield, good aroma, medium maturity (140 days), medium plant height (120 cm)

Electrophoresis

Enzyme was separated into discrete bands by horizontal starch gel electrophoresis. The plastic film was trimmed at the edges of mold and the masking tape was peeled off to expose the gel in the electrode strips. The gel was then mounted onto the electrode trays containing appropriate tray or tank buffer in a refrigerator at about 2°C (Table 2). The side where the samples were loaded was connected to the cathodal tray. A plastic bag of the ice water was placed at the gel to provide additional cooling. The appropriate wire in anodal and cathodal tray served as electrodes and was connected to the continuous current power supply. The constant parameter was the intensity, which was chosen so that the initial voltage will be about 4 volts/cm of length of the gel. The electrophoresis was stopped after 15 h.

Table 2. Gel and tank buffer system for 5-enzyme systems

Tank buffer	Gel buffer
0.400M Tris, Base = 48.46g	0.180M Tris = 10.90 g
0.105M Citric Acid H ₂ O = 22.06 g	0.100M L-Histamine = 7.758 g
pH adjusted to 8.0 with citric acid. Made up volume up to 1 litre in distilled water. Used without dilution.	pH adjusted to 8.0 with HCl. Made up volume up to 0.5 liter in distilled water. Used by diluting 15 ml of the above stock to 300 ml in distilled water.

Slicing

After electrophoresis, the gel was removed from the refrigerator and rectangular slabs were prepared with the anodal and cathodal parts starting from the origin of migration. A diagonal slash was made on the upper right corner of the anodal slab and the lower right corner of the cathodal slab to later trace back the initial arrangement of the samples. A slab was placed on an acrylic slicing bed, and a wire was drawn horizontally through the gel to cut a 1 mm slice. The upper part of the gel was then placed on another slicing bed and the accessible slice was transferred to a stain box. This procedure was repeated until the desired number of slices was prepared.

Staining

Zones of enzymatic activities were revealed by immersing the gel slice into a staining assay (Table 3). The stain boxes chosen were only slightly larger than the slices so that 100 ml of solution was sufficient to stain a slice. Some assays may have specific requirements such as total darkness, incubation at 40°C, immediate scoring, or overnight staining. The staining solution was specific for the individual enzyme. When slice was deepened in specific staining solution, after few minutes (30 minutes, 45 minutes, 60 minutes or overnight) the bands were appeared.

Table 3. Staining solution for five enzyme systems (for 100 ml of each enzyme)

SN	Staining solution	Adh	Est	Pgd	Prx	Got
1	Distilled Water	90 ml	75 ml	95 ml	80 ml	80 ml
2	0.5M Tris, pH 8.5					20 ml
3	1M Tris, pH 8.0			5 ml		
4	1M Tris, pH 9.1	10 ml				
5	Ethanol	5 ml				
6	NAD ⁺	0.04 g				
7	NBT/MTT	0.02 g		0.01 g		
8	PMS	0.003 g		0.003 g		
9	0.4M Na Phosphate, pH 6.2		25 ml			
10	1% of 1-Naphthyl Acetate in 50% Acetone		3 ml			
11	Fast Blue RR Salt		0.1 g			
12	Fast Blue BB Salt					0.15 g
13	6-Phosphogluconic Acid Na ₃ Salt			0.04 g		
14	NADP			0.01 g		
15	Benzidine				0.1 g	
16	1M Sod. Acetate, pH 5.6				20 ml	
17	30% Hydrogen Peroxide				0.04 ml	
18	1-Ketoglutarate					0.1 g
19	Aspartic Acid					0.2 g
20	Pyridoxal-5-PO ₄					0.01 g

Scoring

The most anodal zone of enzyme activity was assigned as 'locus 1', the next 'locus 2', etc. Like wise at each locus, most anodal allozyme (allele) was given alphabetical code 'a', the next 'b', etc. The zone without band was considered as 'null'. The presence of enzymes and its locus was identified according to Glaszmann et al 1988. Each band was considered as isozymic character and scored as '1' for presence and '0' for absence. Dendrogram were constructed using NTSYS pc.

RESULTS

Alcohol dehydrogenase (Adh)

Gels stained for Adh displayed two distinct bands at two activity zones (Figure 1). Band 'A' type occurred most frequently (95.8%) followed by 'B' type (4.17%) (Table 3). The bands could be corresponded to Adh 1 with two alleles according to the migration on gel. Type 'B' allele with least frequency could be a rare allele. Type 'A' allele was common in all test except entry no. 17 (ARC 10679).

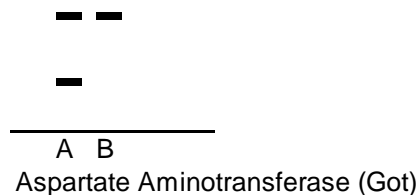
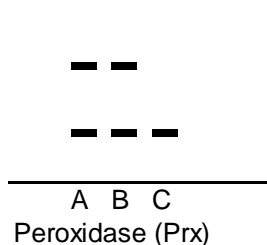
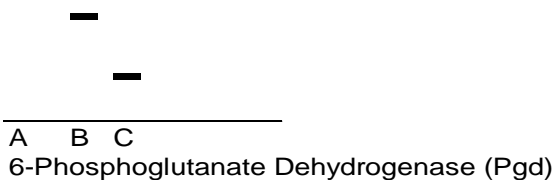
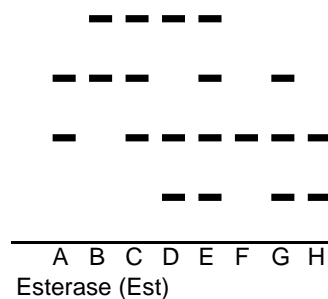
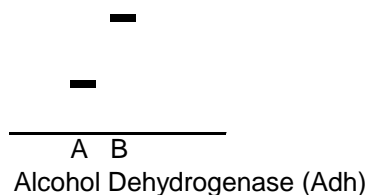


Figure 1. Types of zymogram observed in 24 populations of fine and aromatic rice for five enzyme systems

Esterase (Est)

Three loci encoded for Est 1, Est 2 and Est 9 were detected. Est 1 exhibited two alleles including null alleles. Est 2 coded for three alleles including null alleles. Est 1 and Est 2 represented anodal locus whereas Est 9 exhibited cathodal locus with three alleles including null alleles. Variety 23 (PK 1501-9-2-B-1) showed null allele in all three loci for Est 1, Est 2 and Est 9. Zymogram showed 8 different types with highest frequency of 'C' types (47.83%) (Figure 1, Table 4).

6-Phosphoglutanate Dehydrogenase (Pgd)

A total of three alleles (excluding null allele) were revealed in population studied for Pgd encoding two loci in anodal position. Pgd 1 was the polymorphic locus with two alleles and null allele that is quite frequent. Pgd 2 was present in all 24 populations with single allele. Pgd zymogram showed three band types in which 'A' type occurred most frequently (66.67%) in the populations (Table 4).

DISCUSSION

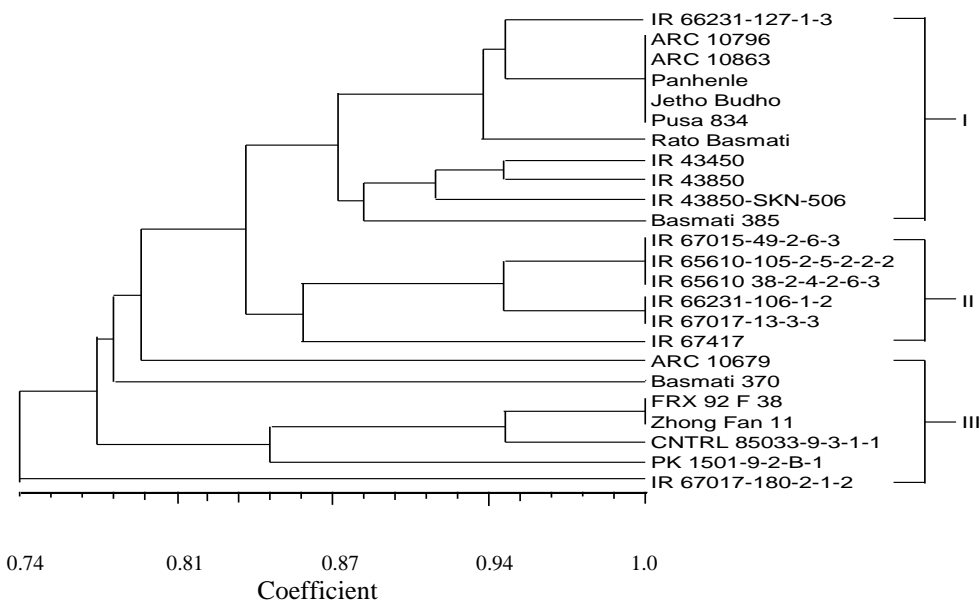
Isozymes are being increasingly utilized in rice genetics and breeding. The populations under study collected from IRRI, India and Nepal exhibited wide range of agronomic characters in maturity, height, yield grain size and aroma (Table 1). The five enzyme systems resolved 18 different band types in the zymogram (Figure 1). We have resolved 10 loci in the present study such as Adh 1, Est 1, Est 2, Est 9, Pgd 1, Pgd 2, Prx 1, Prx 2, Got 1 and Got 3 with 15 alleles excluding null alleles. All the loci except Pgd 2, Prx 2 and Got 3 were polymorphic. Type 'A' bands for Adh and Prx in the zymogram were more frequent. It is interesting to note that Variety ARC 10679 showed a very rare allele for Adh 1 locus (Glaszmann et al 1988). This variety could be a marker line for Adh 1 locus. All other loci identified in the present study were frequently occurring in the rice genome. Present study also indicated that esterase enzyme had a wide variation and could be used as genetic

markers to estimate the genetic diversity (Nakagahra 1977) of cultivated fine and aromatic rice.

The variations under study did not clearly differentiate in the dendrogram (Figure 2); however, at 84% similarity level three clusters could be predicted. Cluster 1 represented 11 populations (45.8%), cluster 2 with six populations (25%) and cluster 3 with seven populations (29.2%) (Figure 2). These groups included varieties with diverse agronomic characters (Table 1), thus distinction of groups based on agronomic characters could not be established. Interestingly, the varieties in second group that also included diverse agronomic characters came out to be the origin from IRRI. Similarly, the rice varieties from Nepalese origin, Rato Basmati, Pahenle and Jetho Budho grouped in one cluster (Figure 2) indicating of similar genetic base for 5 enzyme systems, however, Rato Basmati with null allele for Got-1 locus differed from other two varieties. This allele could also be a marker locus in Rato Basmati. Pahenle and Jetho Budho were local landraces originated from Pokhara valley whereas Rato Basmati was from Terai belt of Nepal. This showed the evidence to confirm the genetic similarity of Nepalese varieties within the group. However, some IRRI varieties were also present in groups 1 and 3. The distribution of IRRI and Indian varieties in three clusters showed their broad genetic base for the studied enzyme systems, which is understandable due to multiple crosses. The loci we investigated are only a small part of the genome. The distinction between varietal groups, we observed, did exist but they certainly did not represent all the elements of the actual genetic structure of the fine and aromatic rice.

Table 4. Frequency (%) of zymotypes for 5 enzyme systems

Adh		Est		Pgd		Prx		Got	
Zymotype	Frequency	Zymotype	Frequency	Zymotype	Frequency	Zymotype	Frequency	Zymotype	Frequency
A (23)	95.83	A (1)	4.35	A (16)	66.67	A (21)	87.5	A (14)	58.33
B (1)	4.166	B (5)	21.74	B (7)	29.17	B (1)	4.17	B (10)	41.67
		C (11)	47.83	C (1)	4.17	C (2)	8.33		
		D (1)	4.35						
		E (1)	4.35						
		F (2)	8.69						
		G (1)	4.35						
		H (1)	4.35						
		8types							

**Figure 2. Dendrogram illustrating genetic relationship among 24 populations of fine and aromatic rice generated by the UPGMA cluster analysis**

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Effects of Different Levels of Boron on Cauliflower (*Brassica oleracea* var. *botrytis*) Curd Production on Acid Soil of Malepatan, Pokhara

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ABSTRACT

Experiments were conducted in two consecutive years (2000 and 2001) at Agricultural Research Station, Malepatan to evaluate the effects of boron levels on cauliflower curd production. A randomized complete block design with three replications was employed. Six levels of boron (0 kg, 5 kg, 10 kg, 15 kg, 20 kg and 25 kg borax ha⁻¹) were tested. Fertilizers and manures were applied at the rate of 120:60:40 kg N:P₂O₅:K₂O and 10 tons of compost per hectare in all the plots. The variety used in the experiment was Kibogiant. The growth (plant height, leaf numbers, leaf length and fresh biomass production) was affected by the boron levels. The maximum plant height (42.05 cm) was observed when the crop was supplied with 25 kg borax ha⁻¹ which was almost 13.95 percent higher than that of non-treated control crop. Maximum leaf numbers (12.73 plant⁻¹) and leaf length (38.91 cm) were observed when the crop was fertilized with 10 kg borax ha⁻¹. The maximum biomass production (1.06 kg plant⁻¹) was obtained with the crop treated with 25 kg borax ha⁻¹. The curd size (diameter) was increased with increasing levels of borax upto 15 kg ha⁻¹. The maximum curd diameter (10.28 cm) was produced when the crop was treated with 25 kg borax ha⁻¹. Highly significant effect of boron levels were observed on the curd production. The two years mean showed an increasing curd production trend with increasing levels of borax application. The maximum curd weight (10.9 t ha⁻¹) was observed when the crop was supplied with 25 kg borax ha⁻¹. However, nonsignificant differences on curd production were observed between 15 kg, 20 kg and 25 kg borax application per hectare.

Key words: Boron, *Brassica oleracea* var. *botrytis*, curd production

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) can be grown in all types of soil with good soil fertility and good water regime. Because of over mining of the plant food elements by the crops, most of the micronutrients become in short-supply to the crops and some disorders appear resulting in low yields (Joshi 1997). Some of the micronutrients required by cauliflower crop become unavailable if the soil condition is acidic, such as molybdenum. In cauliflower (*Brassica oleracea* var. *botrytis*) boron deficiency has been reported very frequently (Som and Maity 1986). At the time, external symptoms of boron deficiency is not apparent. The first sign is the appearance of small water soaked areas in the center of the curd. In later stages and in seriously affected plants, the stem becomes hollow with water soaked tissue surrounding the walls of the

cavity. In more advanced stages, pinkish or rusty brown area develop on the surface of the curd which is known as Red rot and cause low curd yield. This may be controlled by applying borax or sodium borate at the rate of 20 kg ha⁻¹ (Chatterjee 1986). He further reported that boron and molybdenum increased the curd size and weight. Ghimire (1991) reported that the highest yield (15.45 t ha⁻¹) was obtained when the crop was supplied with 22.5 kg borax ha⁻¹. In another experiment conducted at Agriculture Research Station, Malepatan, Pokhara, maximum curd yield (15.23 ton⁻¹) was produced by snowball-16 cauliflower when the crop was supplied with 15 kg of borax ha⁻¹ (ARS 1992). Similar study was conducted at Agricultural Research Station, Malepatan and highest curd yield (12.95 t ha⁻¹) was obtained in the variety Kibogiant when the crop was fertilized with 25 kg of borax ha⁻¹ (ARS 2002). A normal crop usually contains only a

fraction of a pound of boron per hectare. The symptoms show mostly on young leaves because boron is relatively non-mobile in plants (Thompson and Troeh 1957). The requirement of boron quantity by the crops depends upon the variety and soil fertility status of the area. Therefore, it has been necessary to determine the rate of boron application to the cauliflower. So this experiment was conducted with an objective of evaluating the application of different levels of boron on the production of the cauliflower curds.

MATERIALS AND METHODS

For evaluating the effects of different boron levels on the cauliflower curd production field experiments were conducted for two consecutive years (2001 and 2002) at Agriculture Research Station Malepatan, Pokhara in acid soil (pH 4.6) at an altitude of 848 masl. A randomized complete block design with three replications was employed. Six levels of boron (0 kg borax ha⁻¹, 5 kg, 10 kg, 15 kg, 20 kg and 25 borax ha⁻¹) were taken for the study. The plot size was 3.6- × 3-m, a total of 10.8 m² and the crop was transplanted in November at a spacing of 60- × 60-cm. Ten tons of compost plus 100:60:40 kg ha⁻¹ of N:P₂O₅:K₂O was applied in all the plots. Half Nitrogen was applied as basal application and the other half as top dressing after 45 days. The crop was harvested in February. Ten plants per plot excluding boarder rows, were taken into the study. Plant growth and yield characters were recorded and analysed statistically by least significant difference test (Gomez and Gomez 1984). The curd production per plot was converted to t ha⁻¹ by simple arithmetic calculation.

RESULTS AND DISCUSSION

Two years mean plant growth results (Table 1) revealed that minimum plant height (36.18 cm) was observed with non- treated control plot whereas the maximum plant height (42.05 cm) was obtained by the crop supplied with 25 kg borax ha⁻¹ which was 13.95% higher than that of control. Plant height was increased approximately by 10 % when the crop was

supplied with 5 kg or 10 kg of borax ha⁻¹. Plant height was observed increasing with increasing levels of borax application. Maximum plant height (42.05 cm) was observed when the crop was supplied with 25 kg of borax ha⁻¹ which was almost 13.9% higher than those with non-treated control crop (36.18 cm). In another study conducted at ARS, Malepatan, maximum plant height was recorded with the application of 22.5 kg of borax ha⁻¹ which justify and support the result of this investigation (ARS 1992). Leaf numbers (12.73) were increased to maximum when the crop was fertilized with 10 kg⁻¹ of borax. Lowest leaf numbers (11.4) were produced by non-treated crop whereas maximum numbers (12.73 leaves) were produced by the crop treated with 10 kg borax ha⁻¹ which was higher by 10.13% as compared to those produced by the crop at zero level of borax application. The leaf numbers were observed to be decreased with increased level of borax application beyond 10 kg borax ha⁻¹ (Table 1). Similar results were also observed in the increase of leaf length. Highest leaf length (38.91 cm) was observed when the crop was supplied with 10 kg ha⁻¹ of borax which was 11.48% higher than those produced by non-treated crop (34.44 cm). Borax applied at 15 or 20 kg ha⁻¹ did not produce increased leaf length (36.43 cm and 37.63 cm, respectively), however, 25 kg of borax application increased the leaf length (38.43 cm) by 10.38% as compared to those produced at zero level of boron application (Table 1). The maximum biomass (1175.2 g plant⁻¹) was observed in the first year when the crop was fertilized with 25 kg borax ha⁻¹, whereas it was maximum (1037.5 g plant⁻¹) in the second year when it was supplied with 20 kg of borax ha⁻¹ (Table 2). The highest mean biomass production (1061.4 g) was obtained when the crop was supplied with 25 kg borax ha⁻¹.

Significant effect of boron levels on the production of curd height was observed in the first year (2001) whereas it was observed non-significant in the second year (2002) (Table 2), which is probably due to the residual effect of boron applied in the first year. The curd height was observed increasing with increasing levels of boron in the first year (2001) but in the second

Table 1. Effects of boron levels on the plant growth of cauliflower during 2001 and 2002

Boron kg ha ⁻¹	Mean plant height, cm	Increment, %	Mean leaf plant ⁻¹ , n	Increment, %	Mean leaf length, cm	Increment, %
0	36.18	0.00	11.44	0.00	34.44	0.00
5	40.25	10.11	11.98	4.50	36.39	5.35
10	40.38	10.40	12.73	10.13	38.91	11.48
15	40.87	11.47	12.69	9.85	36.43	5.46
20	41.53	12.88	12.23	6.45	37.63	8.61
25	42.05	13.95	12.38	7.59	38.43	10.38
Mean	40.21		12.24		37.03	
SD	1.90		0.44		1.49	

The data were mean of 2001 and 2002.

Table 2. Effects of boron levels on the biomass production and curd size of cauliflower during 2001 and 2002

Boron kg ha ⁻¹	Biomass, g plant ⁻¹		Mean Biomass, g plant ⁻¹	Curd height, cm		Mean Height, cm	Curd diameter, cm		Mean curd diameter, cm
	2001	2002		2001	2002		2001	2002	
0	454.4	363.4	408.90	5.17	5.68	5.42	6.33	5.97	6.15
5	800.1	833.6	816.85	7.29	7.21	7.25	10.13	8.20	9.16
10	852.4	821.3	836.85	7.66	7.58	7.62	10.60	9.13	9.86
15	908.4	969.3	938.85	8.09	6.98	7.53	10.83	9.03	9.93
20	1039.3	1037.5	1038.40	8.50	6.58	7.54	11.23	8.61	9.92
25	1175.2	947.6	1061.40	9.23	6.55	7.89	12.00	8.56	10.28
CV, %	8.74	16.91		3.83	13.1		2.84	17.4	
F value	**	**		**	ns		**	ns	
LSD _{0.01}	197.25	362.73		0.75	1.61		0.74	2.62	

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

year (2002) it was only increasing up to 10 kg borax ha⁻¹ (7.58 cm). The curd height was observed decreasing after 15 kg of borax applied to cauliflower plants with increasing levels of boron (15 kg, 20 kg and 25 kg ha⁻¹). However, the two years mean indicated that maximum curd height (7.89 cm) was observed when 25 kg borax ha⁻¹ was applied (Table 2). The curd size (diameter) was also influenced by the boron levels. The increasing levels of boron increased curd size (diameter) in the first year (2001) whereas it was increasing only upto 10 kg of borax in the second year (2002) and was non-significant. The mean results on curds size revealed that maximum curd size (diameter) was obtained (10.28 cm) when the crop was supplied with 10 kg of borax ha⁻¹.

The personal data from Table 3 showed that maximum curd yield (12.95 t ha⁻¹) was observed in the first year when the crop was supplied with 25 kg borax ha⁻¹ which was higher than the control plot (3.21 t ha⁻¹). Non-significant difference were observed among 5 kg, 10 kg and

15 kg borax ha⁻¹. Similarly, non-significant difference between 20 kg and 25 kg borax was observed in the first year. Significant response of boron levels over control plot was observed in the second year. The curd weight was increasing upto 20 kg of borax application, however non-significant differences among the levels of borax were observed in the second year. The two years mean yield result (Table 3) showed a sharp response of increasing levels of boron on curd production. A minimum of 2.7 t ha⁻¹ curds were produced by non-treated crop whereas the

Table 3. Effect of different boron levels on cauliflower curd production in two consecutive years

Boron, kg ha ⁻¹	Curd weight, t ha ⁻¹		Mean curd weight, t ha ⁻¹	Increment, %
	2001	2002		
0	3.21	2.22	2.70	0.00
5	8.43	7.66	8.04	297.77
10	8.85	7.93	8.39	310.74
15	9.79	8.73	9.26	342.96
20	11.09	9.33	10.21	378.14
25	12.95	8.86	10.90	403.70
CV, %	11.09	20.43	10.47	
F value	**	**	**	
LSD _{0.01}	2.59	4.85	2.236	

**, Significant at 0.01 level.

maximum curd yield (10.9 t ha^{-1}) was obtained when the crop was supplied with 25 kg ha^{-1} of borax which was 403.7% higher than that of the control plot (Table 3). A minimum of 297.7% yield increment (8.04 t ha^{-1}) over control plot was observed when the crop was supplied with $5 \text{ kg borax ha}^{-1}$. However non-significant differences were observed among 15 kg , 20 kg and 25 kg ha^{-1} of borax application.

Plant growth (plant height, leaf number, leaf length and biomass production) were observed to be affected by the different boron levels applied to the cauliflower plants. Maximum biomass ($1061.4 \text{ g plant}^{-1}$) was produced when the crop was fertilized with $25 \text{ kg borax ha}^{-1}$. 10.9 t ha^{-1} of curds could be produced when the crop was supplied with 25 kg of borax ha^{-1} which is 403.7% higher than the control plot (2.7 t ha^{-1}). Non-significant difference in curd production were observed among 15 kg , 20 kg and $25 \text{ kg borax ha}^{-1}$ application. However it seems that application of $25 \text{ kg borax ha}^{-1}$ could be economical in acid soil condition.

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RESEARCH NOTE

Effect of Time of Weeding and Levels of N and P₂O₅ Fertilizers on the Grain Yield of Maize

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Maize is among the world's three most important cereal crops. The importance of weed competition in maize depends on the crop growth stage, the amount of weed present, the level of water, nutrient stress and the weed species. The first few weeks are critical for controlling weed in maize. Even small weeds during the first week after emergence can reduce the grain yield substantially (Aldrich et al 1986). It was considered that yield loss due to weeds is 7% in Europe and 16% in Africa (Broadbent 1978). A diagnosis survey of the farming system in Kasipul, Oyugis division of Rachuonyo district (Kenya) revealed a significant gap between potential and actual maize yields in farmers' fields (CMRT 1995). This was attributed to biological and socio-economic constraints particularly weed crop completion and yield losses.

The main objectives of the study were a) to determine the effect of timing of the first weeding on grain yield of maize and b) to determine the effect of fertilizer application and timing of the first weeding on weed growth and grain yield of maize.

Yield loss due to weeds, insect pests and poor storage facilities was as high as 60% in Kenya (CMRT 1995). It is accepted that 10% loss of agricultural crops can be attributed to the competitive effect of weeds. It was reported that there was a marked responses of Nitrogen and Phosphorous to the grain yields of maize particularly when they were applied together (Bennet et al 1979).

The experiment was conducted during March-July, 2000 at long rain cropping season on sandy

loam soils at three farmers' field sites of Oyugis (Kasipul) Division of Rachuonyo District of Kenya. Improved maize variety H 513 was planted by hand at a row spacing of 75 cm and plant to plant distance was 60 cm. Two plants per hill were maintained after thinning. The trial was laid out in Randomized Complete Block Design with three replications. First weeding was done on five different dates: 14 days after maize seedling emergence (DAE), 28 DAE, 42 DAE, 56 DAE and 70 DAE in two levels of fertilizers (0:0 and 60:60 N:P₂O₅ kg ha⁻¹).

First weeding after 14 DAE and 28 DAE showed significant difference on weed biomass ($P < 0.01$), plant stand count at harvest ($P < 0.01$), plant height ($P < 0.05$), crop biomass ($P < 0.01$), number of ear per hectare ($P < 0.01$) and grain yield ($P < 0.01$). First weeding on 14 DAE produced the highest plant stand (32/7.2 m⁻²), plant height (190 cm), crop biomass (8.1 t ha⁻¹), the number of ears (38888 ha⁻¹) and grain yield (4.3 t ha⁻¹). Weeding time after (70 DAE) produced the highest weed biomass (517 gm 0.25 m⁻²) (Table 1) but grain yield of maize was the lowest (1.1 t ha⁻¹) when weeding was done after 56 days. Weeding at later stages of crop growth was found to suppress the crop biomass and grain yield of maize significantly.

There was significant difference with and without application of chemical fertilizers (N:P₂O₅) on plant height ($P < 0.05$), crop biomass ($P < 0.05$), number of ear per hectare ($P < 0.5$) and grain yield ($P < 0.01$), while it did not show significant result on weed biomass and plant stand. Application of nitrogen and phosphorus combined gave the highest yield (3.3 t ha⁻¹) (Table 2).

Table 1. Effect of weeding time, weed biomass, plant stand, plant height, crop biomass, numbers of ears and grain yield of maize in 2000

Weeding time (DAE)	Weed biomass, g 0.25 m ⁻²	Plant stand, n 7.2 m ⁻²	Plant height, cm	Crop biomass, t ha ⁻¹	No of ears ha ⁻¹	Grain yield, t ha ⁻¹
14	292	32	190	8.1	38888	4.3 a
28	250	26	179	6.1	36111	3.8 ab
42	175	21	158	4.0	19444	2.1 bc
56	483	27	146	2.8	27083	1.1c
70	517	24	141	3.1	25000	1.3c
LSD (0.05)	56.5	4.0	18.4	1.3	5.94	0.9

DAE, Days after emergence.

Table 2. Effect of Nitrogen and Phosphorous on weed biomass, maize plant stand, maize plant height, crop biomass, number of ears and grain yield of maize in 2000

N:P ₂ O ₅ , kg ha ⁻¹	Weed biomass, g 0.25 m ⁻²	Plant stand, n 7.2 m ⁻²	Plant height, cm	Crop biomass, t ha ⁻¹	Number of ears ha ⁻¹	Grain yield, t ha ⁻¹
0:0	353.3	27	150.2	3.6	27778	1.8
60:60	333.3	25	175.8	6.0	31944	3.3
LSD (0.05)	-	-	18.2	0.25	2400	0.16

It is concluded that the most appropriate time for the first weeding was 14 or 28 DAE. The application of nitrogen and phosphorus @ 60:60 kg ha⁻¹ gave the highest yield. However, the environment and soil types in Nepal may not be similar to that of Kenya. Thus, similar trials need to be conducted with more treatments in Nepal so that recommendation regarding the first weeding time and levels of fertilizers could be given for improvement in maize productivity.

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RESEARCH NOTE

Rosellinia Rot: A New Record of Potato Disease in Nepal

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Rosellinia rot disease of potato has been reported from Latin American countries such as Bolivia, Columbia, Peru and Chili, Costa Rica and Ecuador (Turkensteen 1990). The disease is reported to be common in places where temperate and humid climate are prevalent during potato growing season.

Potato, which is grown from March/April to Aug/Sept, is the main crop in hills (2000-3000 masl) of Nepal. In 1997 and 1998, potato crop was surveyed for diseases during growing and harvesting periods in the farmer's fields at Rolkhani (ca. 2700 masl), Dolakha district. Besides blight and wart diseases, a new disease was observed at Rolkhani and it was a serious problem in potato in some farmer's fields. At Rolkhani, the prevailing climate is temperate and humid during potato growing season.

The disease symptoms were quite different from other known diseases. The farmers named the disease as "Sogtle", because it caused potato plants stunted, flaccid and ultimately wilted. While removing the diseased plants from soil, the underground parts were observed brownish to black covered with whitish mats of loose mycelia (Figure 1). The soil was rhizomorphs like white strands of fungal hyphae at the site of infection. The infected tubers were partially or completely covered with whitish mats of loose mycelia (Figure 2). Early infected tubers were observed rotting. In some farmer's fields, the estimated rotted tubers were 10-30 percent. According to farmers of Rolkhani, non-infected tubers also gradually rotted at storage place.

Infected plants, tubers and the infested soil with whitish strands of the fungal mycelia were

collected and examined at the laboratory of Plant Pathology Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur Nepal. The symptoms and signs were studied with the help of cited literatures, and the diseased tissues were examined through stereo and compound microscopes. The morphology of mycelium was keenly noted. A characteristic pyriform swelling of hyphae at septa was recorded (CAB, 1972, Figure 3) and this pyriform swelling is the most characteristic feature of the genus *Rosellinia* spp. and the disease was identified as *Rosellinia* rot.

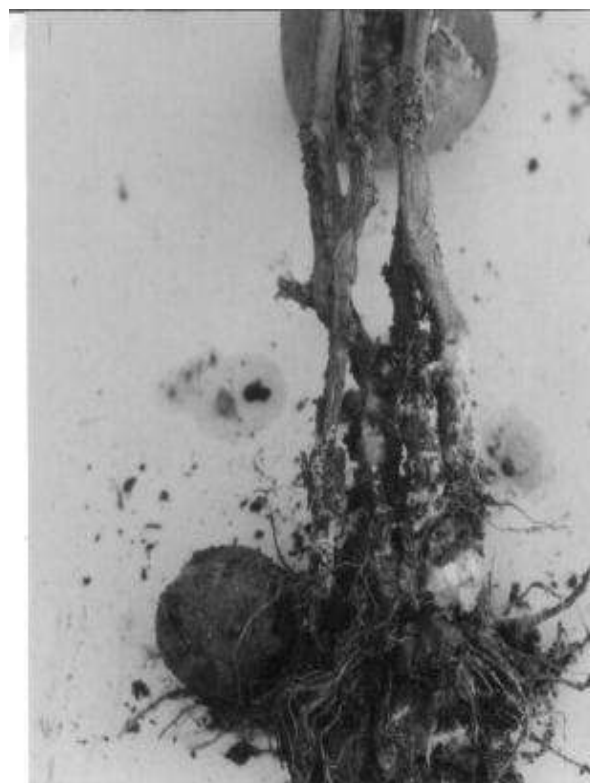


Figure 1. Underground parts of potato plants covered with whitish loose mycelium



Figure 2. Potato tubers covered with whitish loose mycelium

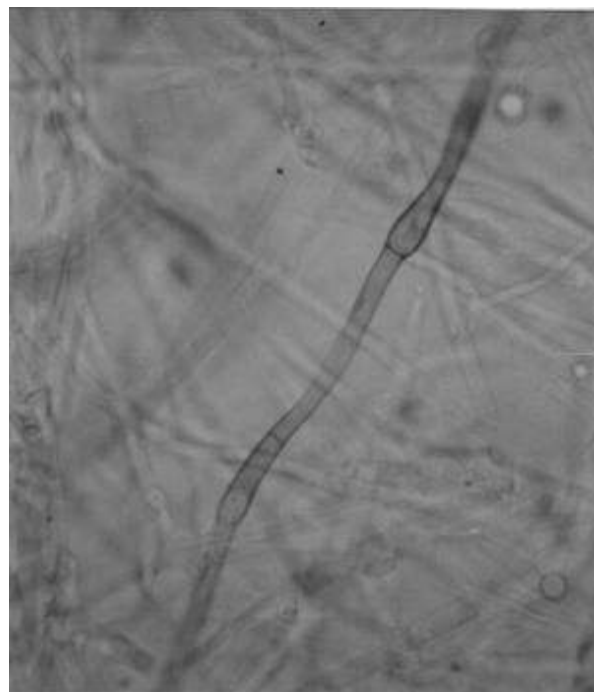


Figure 3. Hypha of *Rosellinia* sp. showing pyriform swelling at septa

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REVIEW ARTICLE

Red Listing of Agricultural Crop Species, Varieties and Landraces

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ABSTRACT

Red listing mechanism has been developed for wild fauna and flora. There are several documents illustrating red listed wild fauna and flora. But there is a lack of information on the red list and red listing criteria of agricultural crop species, varieties or landraces. For initiating on- farm, in situ and ex situ conservations, red listing is helpful in locating region of crop species, varieties or landraces diversity. The paper reviewed the red listing criteria used for the categorization of wild fauna and flora. Categorization of on-farm crop species, varieties and landraces is based on population, ecological, social, modernization and use criteria. Among them ecological, social and modernization criteria are useful in selecting location for sampling materials for ex situ conservation and appropriate sites for in situ conservation. Modernization and use criteria are suitable for categorization of crop genotypes. Combinations of these criteria are proposed for red listing crop genotypes and areas.

Key words: Agricultural crops, conservation, on farm, red list category, red-listing criteria

INTRODUCTION

Genetic erosion of crop diversity is reported worldwide. Many crop species, varieties or landraces are being lost (Brush 2000). Importance of plant genetic resources is recognized worldwide to cope up with the biotic and the abiotic stresses. Genetic erosion is the common threat to the sustainable use of plant genetic resources to meet the present needs and aspiration of future generations (Chang 1985). There are many examples of genetic erosion in Nepal, even though it is rich in agricultural biodiversity. There are 200 cultivated species, 500 wild edible plants and 120 cultivated plants species reported in Nepal (Upadhyay and Joshi 2003). Tauli, Marsi and Thapachinia, the popular rice varieties of Kathmandu valley are no longer available (Upadhyaya 1995). The spread of high yielding varieties has contributed to the gradual disappearance of landraces besides loss of

habitats, market forces and population pressure. Wild progenitors and other wild species depict the same story. Sherchand et al (1998) reported a loss of 145 rice landraces from Bara district alone. Chaudhary et al (2003) reported that genetic erosion was measured in terms of changes in the number of farmers growing each landraces and the areas covered by a landrace. Rijal et al (1998) reported 11 rice landraces under threat and 11 landraces have been lost in Seti River valley. Deforestation, land encroachment and urbanization have further increased the pace of genetic erosion. Realizing the plausible sites of the genetic resources for crop improvement, the concept of red listing of agriculture crop species, varieties or landraces are being proposed. Different genotypes have different values, which resulted in imbalance distribution. Realizing the importance of crops genotypes in present and future, different conservation and utilization strategies were developed. For effectiveness of

these strategies different treatments should be applied to different landraces, varieties or crop species. Therefore categorization of crop species, varieties or landraces in term of their extent and distribution is necessary for locating sites to better in situ management and to identify crop species, varieties or landraces for ex situ management.

NI Vavilov and H Harlan respectively in the 1920s and 1930s noticed that traditional crop varieties or landraces were lost from the fields and gardens around the world (Brush 2000). For the subsequent 60 years scientific efforts to conserve plant genetic diversity focused on collecting materials and placing them in ex situ storage. Institutions were created gene banks were constructed and millions of accessions were accumulated and preserved in low temperature low humidity gene banks. Many sampling strategy were developed for ex situ conservation. There is meager study about on-farm conservation. Criteria of landraces categorization under different groups were not reported. We have many survey data on crop varieties/landraces related to socio-cultural aspects. Lost landraces are indicated based on name of genotypes. Study on frequency distribution of landraces is not common.

Red list is the list of crop species, varieties or landraces whose population are in decreasing trend (the nature of rarity) due to many factors and if such trend continue, these genotypes will disappear in future. A typology of rare species or variety is based upon the geographic range, habitat specificity and local population size (Rabinowitz 1981). Basis of categorizing agricultural crop species, variety or landraces whether these are under red list is necessary to develop strategy for initiating in situ, on-farm and ex situ conservation appropriately. Important consideration for making the red list of crop landraces is amount and distribution of genetic diversity, process used to maintain diversity, people who maintain diversity and factors that influence farmer's decision making maintaining diverse variety (Sthapit and Jarvis 2002). Red list categorization study is more common in wild fauna and flora. Since agricultural crops

contribute economically more, their loss could lead to agricultural crises.

Under the red list, there may be many categories such as extinct, endangered, rare, endemic, no risk, etc. Here different criteria are discussed and simple method of categorizing agricultural crop genotypes is proposed as similar to wild flora and fauna. Such system of categorizing crop genotypes will be useful for developing conservation and utilization strategy.

Categorization of wild fauna and flora

The World Conservation Union (IUCN), Convention on International Trade in Endangered Species of wild flora and fauna (CITES) and Birdlife International have developed their own criteria for wild fauna and flora for red listing (BPP 1995). They have studied many wild species and listed in respective categories. IUCN classifies species in 9 categories. These are extinct, extinct in the wild, critically endangered, vulnerable, conservation dependent, low risk, data deficient and not evaluated. CITES which aims to establish worldwide control over trade in the endangered wild life has listed species within three categories, Appendix I, Appendix II and Appendix III. Appendix I included all species threatened with extinction, which are or may be affected by trade. Appendix II includes those species although not necessarily threatened with extinction now, may become so if the trade on those species is not subject to strict regulation. Additionally CITES classifies species as near threatened if in the near future, they could appear on any of the three lists. Birdlife International at a workshop held in Coimbatore, India 1995 classified the birds of South Asia into three types, 1. Candidate threatened species. 2. Possible candidates for threatened status and 3. Species excluded from candidate list. There are also other institutions that have their own categorical system for red listing. This classification is however difficult to use in on-farm management of cultivated crop varieties.

Categorization of on farm crop landraces

In situ team working in the global project (Strengthening the scientific basis of in situ conservation of agricultural biodiversity – Nepal component) has developed a method of

classifying crop landraces based on number of farmers and areas growing such landraces in particular Village Development Committee (VDC). Rana et al (2000) classified the rice landraces of Kachorwa VDC, Bara into four different cells depending on the average area cultivated and the number of households (HHs) cultivating them (Figure 1). The cut off point for average area used by Rana et al (2000) was less than or more than 0.2 ha (derived from overall average of all landraces at Kachorwa) and the number of HHs was less than or more than five HHs (derived from average of all landraces). The idea behind this categorization was that at least

one representative each from four cells would be included in the participatory plant breeding program (Joshi et al 2000). Sthapit et al (2001) used this method to understand the farmers' rationale of allocating land area for each variety and distribution pattern based upon socio-economic and ecological factors. Khatiwada et al (1999), Joshi et al (2000), Yadav et al (2003a) and Chaudhary et al (2003) in rice, Yadav et al (2003b) in sponge gourd, Tiwari et al (2003) in finger millet have used this system to categorize landraces. Similar system of landraces and crop species classification was used in Vietnam (Hue et al 2003, Hien and Nguyen 2003).

		Area	
		Large	Small
Farmer	Many	1	2
	Few	3	4

Figure 1. On farm landrace categorization

Population criteria (Based upon distribution patterns)

Population criteria described by Brush (2000) based on sampling design discussed by Marshall and Brown (1975) are also useful to categorize landraces. This is similar to the method of categorizing on-farm crop landraces. Population criteria are based on the measurement of variation and the number of population to be sampled (Figure 2). Marshall and Brown (1975) identified two critical population parameters, i. the extent of genetic divergence among population and ii. the level of genetic variation of a population. The basis of describing divergence among populations is frequency and distribution of alleles, leading to four different types of alleles. A population with locally common alleles is the primary targets for collection and conservation. Common and widespread alleles

are likely to be found wherever a crop is grown and the rare alleles are hard to capture given the limits of collecting. These guidelines may be additional way of classifying crop landraces.

		Distribution	
		Wide	Local
Frequency	Common	1	2
	Rare	3	4

Figure 2. Genetic divergence among population/s

Ecological and social criteria

Brush (2000) has summarized ecological and social criteria by integrating them in a single matrix that is useful in selecting location of in situ conservation areas (Figure 3). Ecological criteria are expressed as complex. Places where altitudes, soil and biomes are varied with seasonally and the pressure of wild crop relatives would be judged maximally complex, while locations without these would be classed as having limited complexity. Likewise cultural autonomy and subsistence orientation can be expressed as local vs non-local social integration.

The locations for in situ conservation using ecological and social criteria are local socio cultural integration and ecological complexity. These selection criteria can then be weighed against two other criteria ie crop population and logistical criteria (physical and social access to the farm region). The selection of regions for an on farm conservation program is suggested with conservation of the population, ecological and social criteria. These ecological and social criteria can also be useful to classifying landraces in the red list.

		Sociocultural integration	
		Local	Non local
Ecological complexity	Maximum	1	2
	Limited	3	4

Figure 3. Ecological and social criteria for selecting in situ sites

Modernization criteria

Modern technology directly influences the diversity of landraces and continuation of cultivating local landraces. If availability of modern technology is high, there is more likely to replace local technology. Similarly, landraces cultivated by poor farmers are more likely to be replaced by modern technology than the landrace grown by rich farmers. These criteria (wealth status of farmers and availability of modern technology) are also helpful to classify landraces that are or may be endangered (Figure 4). Another criterion is the existence of specific production environments. The pattern of changing the land use system should also be considered to identify the landraces that are likely to be endangered. Some landraces evolve to adopt to specific environment eg Bhathi rice landrace to water logged areas of Bara in situ site.

Use criteria

Value given by farmers to each landrace is an important factor for maintaining landraces. If landrace is tightly linked to socio- cultural system, such landrace is likely to continue in cultivation, provided social-cultural systems are valued. Crop varieties having multiple use value may have less chance to extinct. Similarly landraces with unique traits adapted to specific environment, unless the environment is changed would not be replaced. Ex situ conservation and use in breeding program are also important criteria for listing landraces under threatened group. Landraces conserved ex situ or used in breeding program may be considered as no risk. With use criteria, Smale et al (2001) proposed least cost sites for on-farm conservation (Figure 5) based on Smale and Bellon (1999) concept. We can relate this similarly as previous criteria to classify crop landraces, varieties or species.

		Wealth status	
		Rich	Poor
Options of modern technology	Low	1	2
	High	3	4

Figure 4. Modern technology and wealth status criteria

		Crop genetic diversity (public value)	
		High	Low
Farmer utility (private value)	High	1	2
	Low	3	4

Figure 5. Least cost sites for on farm conservation (redrawn from Smale et al 2001)

Proposed red list categories for agricultural crop species, varieties, landraces

Single or combinations of above discussed criteria are being proposed for classifying crop genotypes. Based on the criteria, following categories are proposed to classify landraces, varieties or crop species under the red list data.

Practical analogy of the red list category

1. Extinct (Seed is locally not available for exchange or planting)
2. Endangered or threatened (Few HHs growing varieties in a small areas)
3. Conservation dependent (Many HHs growing variety in a small areas or vice versa)
4. No risk (Commonly grown by many HHs)
5. Not evaluated or data not available

1. Extinct

Landrace is extinct when there is no reasonable doubt that its last individual has died. This is generally reported based on farmer's perception of particular area and landraces. Landrace available in past for many years but no more available in present in a particular area of a VDC is considered an extinct. If such landraces are being conserved ex situ these fall under conservation dependent. For example Thapachini variety is extinct from Kathmandu but it is still grown in small areas in Pokhara valley.

2. Endangered or threatened

A genotype is endangered when it is facing a very high risk of extinction in particular area in the medium term. Such genotypes are supposed to be conserved ex situ and/ or use in breeding program. A genotype, which falls

under, the cell number 4 of the Figure 1, 2, 3, 4 and 5 is considered as endangered. Among the 4 cells of these Figures, last cell number 4 is considered risky from most of the factors that affect negatively the survival of the genotypes.

3. Conservation dependent

A genotype, which is not, endangered but little effort for on farm conservation can conserve effectively is conservation dependent. The genotypes, which fall under cells number 2 and 3 of Figure 1, 2, 3, 4 and 5 are conservation dependent. Awareness program or value addition is to be necessary for conservation.

4. No risk

A genotype is no risk when it has been evaluated and does not qualify for any of the categories. Crop species, varieties or

landraces, which comes under the cell number 1 of Figure 1, 2, 3, 4 and 5 are considered as No risk.

5. Not evaluated or data not available

A species, variety or landrace is not evaluated when it has not yet been assessed against the criteria.

One example of categorization of on-farm crop landraces based on their areas and number of HHs growing is cited from Rana et al (2000) in Figure 8. There were 6 landraces under endangered category, 10 under conservation and 5 under no risk.

		Area	
		Large	Small
Farmer	Many	Mutmur, Nakhisaro, Muturi, Nakhi and Lalkafaram No risk	Basmati, Satwa and Sathi Conservation dependent
	Few	Mansara, Batsar, Bhati, Dudhraj, Ashanni, Karma and Nat Musari Conservation dependent	Lalka Basmati, Sokan, Sarho, Satraj, Lajhi, Rango, Gajar, Gaur, Ratrani, Katush, Latongad, Matura, Dushisaro, Lalka Kartik, Gudhani, Anadi, Khera, Mansari and Anga Endangered

Figure 6. Rice landraces categorized under four groups based on area and number of households growing them

Assessing status of agricultural crop species, varieties or landraces is necessary to take action against the genetic erosion or to develop site specific or genotype specific conservation strategy. Among different criteria, need based suitable criteria can be used to categorize crop genotypes. Most common criteria would be based on categorization of on-farm crop landraces. Farmers' response is prerequisite and scientific

assessment of agricultural crop resources should be added for red listing. For the simplicity and practicality, four categories are being proposed to group the genotypes, which help proceed further for conservation and utilization. In Nepalese context, landrace can be categorized based on areas and number of farmers growing landraces within village development committee or agroecological zones of each district.

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