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नेपाल सरकार
कृषि विकास मन्त्रालय
राष्ट्रिय कृषि अनुसन्धान तथा विकास कोष
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FOREWORD

National Agricultural Research and Development Fund (NARDF), since its inception, is working under the principle of Competitive Grant System (CGS). NARDF works with research and development partners to carry out sole research or development projects as well as both mixed projects. It is promoting a demand-driven and pluralistic approach, providing grants that are designed to uplift the standard of living of farmers and capacity building of the participating institutions. It is also giving support grant to masteral and doctoral candidates of agricultural institutions to conduct their thesis research since 2008.

Under thesis grant support, students prepare thesis proposal as per the guidance of their respective institution. The research grant is provisioned for all branches of agricultural fields like agriculture, animal science, and agro-forestry, post harvest technology and several other related topics. A good number of students are benefitted and are going to benefit by this thesis grant system. It is also expected that agricultural knowledge system is enriched by their research and end-users are benefitting from the results.

This Technical Publication (collection of thesis research findings) Series 01, is expected to be useful for advanced farmers, extension workers, researchers and interested others. I would like to thank all the student researchers who contributed in this publication. I would also like to thank Mr. Ishwari Pd. Neupane, Senior Agriculture Extension Officer and Mr. Madhav Dhakal, Agriculture Officer for their effort to bring this publication. Likewise, all other officers and support staffs helped from their corner. To mention separately, Mr. Sameer Gautam managed the articles doing tedious computer works. Thanks are also due to all those who gave direct as well as indirect in this publication. There might be many technical and editorial errors for which I apologize and beg your comments and suggestions to make the future publication better.

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(Suresh Babu Tiwari)
Member Secretary, NARDF
July 2015

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RESPONSE OF LATE CAULIFLOWER (BRASSICA OLERACEA L. VAR. BOTRYTIS) CULTIVARS TO DIFFERENT SOURCES OF NITROGEN AT CHITWAN, NEPAL

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ABSTRACT

The study entitled "Response of late cauliflower cultivars to different sources of nitrogen in Chitwan, Nepal" was conducted at horticultural farm of IAAS, Rampur, from November, 2012 to March, 2013 to evaluate the efficacy of the different sources of nitrogen (inorganic-urea and organic-FYM) on the performance of late varieties of cauliflower. The experiment was laid out in two factorial randomized complete block design (RCBD) with 12 treatment combinations replicated thrice. The first factor was the combinations of three different sources of nitrogen (100% N-urea, 50% N-urea + 50% FYM and 100% N- FYM). The second factor was four varieties (Snow Mystique, Snow Crown, Snow Dome and Madhuri) of cauliflower. The highest plant height (58.28 cm) and thickest stem diameter (3.24 cm) were from 50%N-Urea + 50%N - FYM at harvest. The longest leaf length (51.68cm) was observed from Madhuri whereas the maximum curd height (6.93cm), curd weight (0.67kg) and the highest economic yield (24.82tha^{-1}) were observed from 50%N-Urea+50%N-FYM. Madhuri variety gave the highest B:C ratio (3.24) compared to other varieties. It can be suggested that the open pollinated variety Madhuri can be grown with the combination of 50% N from FYM and 50% N from Urea in the late season under Chitwan condition.

Key words: Nitrogen, Late variety etc

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.), queen of winter vegetables, is an important winter vegetable widely grown in Terai and mid hills of Nepal (APP, 1995). It is highly preferred vegetable crops can be successfully grown from the terai to high hills in normal and offseason period with appropriate technologies and varieties as requirement. In Chitwan, it covers an area of 613 ha with a total production of 8459 mt and average

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productivity of 14 mtha^{-1} (MoAD, 2012/013). Farmers of large and small markets of Nepal generally grow cauliflowers in normal and offseason for fetching high income.

The productivity of cauliflower depends on use of balanced fertilizer and if not adequately fertilized, considerable yield losses are apparent (Chatterjee, 1993; Thakur et al., 1991). Sub-optimal supply of nitrogen led to delay in maturity and caused reductions in yield and quality of cauliflower crops (Rahn *et al.*, 1993). Plant growth is adversely affected due to deficiency of nitrogen and it is constituent of enzymes, chlorophyll and proteins (Reddy and Reddy, 2002).

Variety selection and crop management practices are the main factors that contribute to growing profitable cauliflower (Zerkoune, 2000).The detrimental impact on the soil, environment and human health and rapid increase in prices of chemical fertilizers urged the farmer for adoption of integrated plant nutrient that offers the soil fertility and sustainable crop production (Sentiyangla *et al.*, 2010). Integrated use of organic and inorganic fertilizers can improve crop productivity and sustain soil health and fertility (Satyanarayana *et al.*, 2002). There is higher positive effect on microbial mass from the use of organic and chemical fertilizer compared to addition of organic fertilizer alone which result better soil health (Dutta *et al.,* 2003).The concept of integrated nutrient management system has been adopted to conserve and improve the soil fertility as a further response to economic recession (Quamruzzaman, 2006). Integrated use of inorganic fertilizer and organic manure increase important yield attributes like plant height, number of primary branches per plant, and total soluble solid contents (Patil et al., 2004).

MATERIALS AND METHOD

The field experiment was conducted at the vegetable farm of the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal during November, 2012 to March, 2013. The altitude of the experimental site is about 256 meter above mean sea level and geographically it is situated at 27° 37' to 27° 46' North latitude and 83° 35' to 84° 48' East longitude.The experimental soil was sandy loamy in texture with pH 5.57. The soil was low in organic matter (2.04), high in available Nitrogen (1.14), high in available phosphorous (85.68 kg/ha), medium in available potassium (165.99 kg/ha). The maximum to minimum temperature (30.2^{0}C to 5.9^{0}C) and maximum relative humidity 95.1% observed during the crop growing season. The highest rainfall recorded 29.5 mm during the experimental period. The experiment was laid out in two factors Factorial Randomized Complete Block Design (RCBD) with three replications. The first factor was combination of three different sources of nitrogen (100% N-urea, 50% N-urea + 50% FYM and 100% N- FYM). The second factor was four varieties (Snow Mystique, Snow Crown, Snow Dome and Madhuri).

There were a total of 36 plots. Individual net experimental plot area comprised 3m×2.25m ($6.75m^2$) with 25 plants. The laboratory analysis of FYM was done at Central Soil Science Laboratory of Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal (Table 1).

Table 1. Laboratory analysis of FYM

S.N.	Particulars	Instrument used	Observed value
1	Total nitrogen (% by weight)	Kjeldhal digestion	1.05
2	Total phosphorus (µg/g)	Spectrophotometer	0.21
3	Total potassium (% by weight)	Atomic absorption Spectrophotometer	0.8

The recommended dose of nitrogen, phosphorous, potash was supplied by using urea, single super phosphate (SSP), and muriate of potash (MOP) at the rate of 150:60:60 kg NPK $ha^{-1.}$ Growth parameters such as plant height, stem diameter at harvest, no. of leaves per plant, length and width of the leaves, canopy diameter and yield parameters like curd height and diameter, fresh weight of the curd, curd quality characters, biological yield, economic yield and harvest index were recorded. Soil analysis was done before the completion of experiment. All the collected data were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT) for mean separation using MSTAT-C.

RESULTS AND DISCUSSION

Plant height and Stem diameter

There was a significant difference was observed on the effect of nitrogen sources on plant height and stem diameter of cauliflower cultivars at harvest. The tallest plant was observed in Madhuri (59.52cm) at harvest, while the shortest in Snow Crown (40.77cm) at harvest. Similarly, the highest plant height (58.28cm) was from 50%N-Urea+50%N-FYM at harvest. Likewise, the thickest stem diameter at harvest was observed from Madhuri variety (3.14 cm) and the thinnest (1.88 cm) stem diameter was from Snow Dome at harvest (Table 2).

Number of leaves per plant and Canopy diameter

The highest numbers of leaves per plant (15.06) was recorded from Madhuri and the lowest (10.88) from Snow dome at harvest. The highest number (13.93) of leaves per plant at harvest was from 50%N-Urea+50%N-FYM, while the lowest (12.03) was recorded from FYM only (100% N-FYM). The highest canopy diameter at harvest was observed from Madhuri (74.39 cm) which was similar to Snow Mystique (71.94cm). (Table 2)

Table 2. Effects of nitrogen sources on plant height of cauliflower cultivars at Rampur, Chitwan, Nepal, 2012/13

Treatments	Plant height at harvest (cm)	Stem diameter ·vest (cm)	Number of leaves per plant	Canopy diameter (cm)
Varieties (V)				
Snow Mystique (V1)	59.23[a]	2.878[b]	13.72[b]	71.94[a]
Snow Crown (V2)	40.77[b]	2.556[c]	12.46[b]	66.08[b]
Snow Dome (V3)	54.40[a]	1.878[d]	10.88[d]	66.22[b]
Madhuri (V4)	59.52[a]	3.144[a]	15.06[a]	74.39[a]
SEM±	2.60	0.07	0.35	1.23
LSD	7.63**	0.21**	1.04*	3.77**
Sources of Nitrogen (N)				
100% N-Urea (N1)	52.37[ab]	2.675[b]	13.12[a]	74.44 [a]
100% N-FYM (N2)	49.79[b]	1.925[c]	12.03[b]	57.23 [b]
50% N-Urea+50% N-FYM (N3)	58.28[a]	3.242[a]	13.93[a]	77.30 [a]
SEM±	2.25	0.06	0.31	1.11
LSD	6.61*	0.18**	0.90*	3.27**
CV %	14.59	8.03	8.15	5.54
Grand mean	53.48	2.61	13.03	69.66

Means followed by same letter(s) in a column are not significant at 5% level of significance as determined by DMRT.

Leaf length and leaf breadth at harvest

Highly significant variation was seen in effect of different sources of nitrogen and different varieties on leaf length and leaf breadth of cauliflower at the time of harvest (Table 3). The longest leaf length (51.68cm) was observed from Madhuri whereas the shortest (40.90cm) for Snow Dome at the harvest which was significantly lower than other varieties. The longest leaf was observed in 100% N-Urea (49.07cm) at harvest. The widest leaf was observed from Snow Mystique (15.06 cm) and the narrowest from Snow Dome (10.88 cm) at harvest. Similarly, the widest leaf was observed from 50% N-urea + 50% N-FYM (13.93cm) at harvest, while the narrowest from 100% N-FYM (12.03 cm).

Table 3. Effects of nitrogen sources on cauliflower cultivars leaf breadth of at various crop growth stages at Rampur, Chitwan, Nepal, 2012/13

Treatments	Leaf length at harvest (cm)	Leaf breadth at harvest (cm)
Varieties (V)		
Snow Mystique (V1)	46.69[b]	13.72[b]
Snow Crown (V2)	44.16[c]	12.46[c]
Snow Dome (V3)	40.90[d]	10.88[d]
Madhuri (V4)	51.68[a]	15.06[a]
SEM±	0.79	0.35
LSD	2.31**	1.038**
Sources of Nitrogen (N)		
100% N-Urea (N1)	49.07[a]	13.12[a]
100% N-FYM (N2)	42.23[b]	12.03[b]
50% N-Urea+50% N-FYM (N3)	48.77[a]	13.93[a]
SEM±	0.68	0.89
LSD	1.99**	0.31**
CV %	5.14	10.06
Grand mean	**45.86**	**21.587**

Means followed by the same letter(s) in a column are not significant at 5% level of significance as determined by DMRT.

Curd height, curd diameter and fresh weight of curd at harvest

Table 4. Effects of nitrogen sources on curd height, curd diameter and curd weight of cauliflower cultivars at Rampur, Chitwan, Nepal, 2012/2013

Treatments	Curd height (cm)	Curd diameter (cm)	curd weight (kg)
Varieties (V)			
Snow Mystique (V1)	6.73 [b]	16.81 [a]	0.58 [b]
Snow Crown (V2)	6.07 [c]	15.14 [b]	0.54 [b]
Snow Dome (V3)	5.53 [d]	13.38 [c]	0.31 [c]
Madhuri (V4)	7.52 [a]	17.20 [a]	0.75 [a]
SEM±	0.15	0.44	0.02
LSD	0.45**	1.30**	0.04**

Nitrogen Sources (N)			
100% N-Urea (N1)	6.46 [b]	15.84[a]	0.56 [b]
100% N-FYM (N2)	6.01 [c]	14.41[b]	0.40 [c]
50% N-Urea+50% N-FYM (N3)	6.93 [a]	16.66[a]	0.67 [a]
SEM±	0.13	0.384	0.01
LSD	0.39**	1.13**	0.04**
CV %	7.11	8.51	7.49
Grand mean	**6.46**	**15.63**	**0.55**

Means followed by the same letter(s) in a column are not significant at 5% level of significance as determined by DMRT.

The maximum curd height (7.52 cm) and curd diameter (17.20 cm) were recorded in Madhuri at harvest. (Table 4). Similarly, at harvest, the maximum curd height (6.93 cm) and curd diameter (16.66 cm) were recorded from 50% N-urea + 50% N-FYM which were significantly higher than those recorded at 100% N-urea and 100% N-FYM.

Economic yield, Biological yield and harvest index

Highly significant response was observed in effect of different sources of nitrogen and different varieties on economic yield, biological yield and harvest index of cauliflower (Table 5).The highest biological yield (61.19 tha-1) and economical yield (27.78 tha-1) was obtained from Madhuri which was significantly higher than the other varieties. Similarly, the highest economical yield was obtained from 50% N-Urea+50%N-FYM (24.82 tha-1) followed by 100% N-Urea (20.80 tha-1) and 100%N-FYM (14.94 tha-1). The effects of different sources of nitrogen on increasing biological yield was the highest (57.38 tha-1) from 50% N-urea + 50% N-FYM which was significantly ($p<0.01$) higher than those recorded at 100% N-urea (50.49 tha-1) and 100% N-FYM (38.18 tha-1).

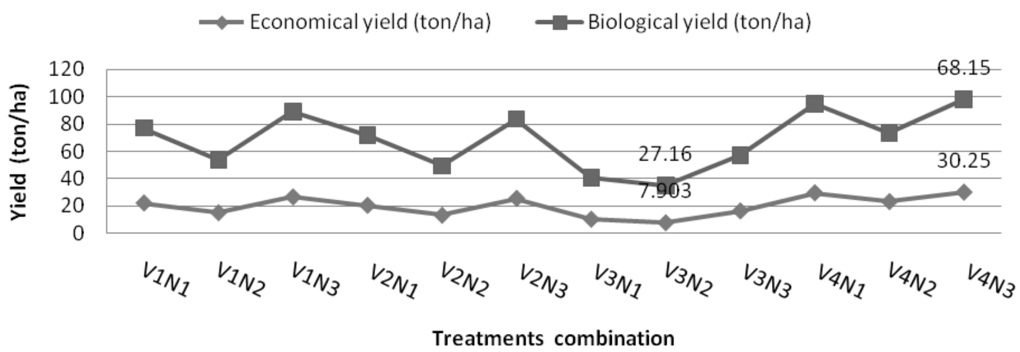
The highest harvest index was obtained in Madhuri (45.55 %) which was significantly higher than the Snow Mystique, Snow Crown and Snow Dome. Similarly, the highest harvest index was obtained from 50% N-urea + 50% N-FYM (45.55%) which was significantly ($p<0.05$) greater than those recorded from 100% N-urea and 100% N-FYM.

The interaction effects of different sources of nitrogen and varieties of cauliflower on economic and biological yield were significant (Figure 1).

Table 5. Effects of nitrogen sources on economic yield, biological yield and harvest index of cauliflower cultivars at Rampur, Chitwan, Nepal, 2012/2013

Treatments	**Economic yield (tha^{-1})**	**Biological yield (tha^{-1})**	**Harvest Index**
Varieties (V)			
Snow Mystique (V1)	21.44^{b}	52.06^{b}	40.87^{b}
Snow Crown (V2)	19.88^{c}	48.72^{b}	40.26^{b}
Snow Dome (V3)	11.65^{d}	32.76^{c}	34.75^{c}
Madhuri (V4)	27.78^{a}	61.19^{a}	45.55^{a}
SEM±	0.50	1.14	0.69
LSD	1.48*	3.35**	2.01**
Nitrogen Sources (N)			
100% N-Urea (N1)	20.80^{b}	50.49^{b}	40.26^{b}
100% N-FYM (N2)	14.94^{c}	38.18^{c}	34.75^{c}
50% N-Urea+50% N-FYM (N3)	24.82^{a}	57.38^{a}	45.55^{a}
SEM±	0.44	0.99	0.59
LSD	1.28**	2.904**	1.74**
CV %	7.49	7.04	5.11
Grand mean	20.19	48.69	40.36

Means followed by same letter(s) in a column are not significant at 5% level of significance as determined by DMRT.



Note: V_1= Snow Mystique, V2= Snow Crown, V3= Snow Dome; V4= Madhuri; N1=100% N-Urea; N2= 100%N-FYM; N3=50%N-Urea+50%N-FYM

Figure 1: Interaction effects of different varieties and sources of nitrogen on economic yield and biological yield of cauliflower at Rampur, Chitwan, Nepal, 2012/13

Effect on curd quality characters

Application of different sources of nitrogen and different varieties had shown significant ($p<0.05$) effects on curd quality using hedonic scale of 1 to 9 in which 1 being the poor and 9 being the excellent performance (Acedo and Bautista, 1991).The highest consumer acceptability (6.06) was recorded from 50% N-urea + 50% N-FYM which was significantly higher than 100% N-Urea. (Table 6)

Table 6. Effects of nitrogen sources on curd quality of cauliflower cultivars at Rampur, Chitwan, Nepal, 2012/2013

Treatments	**Taste (1-9)**	**Color (1-9)**	**Compactness (1-9)**	**Acceptability (1-9)**
Varieties (V)				
Snow Mystique (V1)	5.59 ^{a}	5.54 ^{a}	5.367^{b}	6.17 ^{a}
Snow Crown (V2)	4.74 ^{b}	4.56 ^{b}	5.122^{b}	6.03 ^{a}
Snow Dome (V3)	3.58 ^{c}	4.41 ^{b}	5.867^{a}	5.60 ^{b}
Madhuri (V4)	5.98 ^{a}	5.26 ^{a}	5.822^{a}	5.87 ^{ab}
SEM±	0.11	0.18	0.13	0.10
LSD	0.33**	0.53**	0.37**	0.31**
Nitrogen Sources (N)				
100% N-Urea (N1)	4.68 ^{b}	4.66 ^{b}	5.38 ^{b}	5.73 ^{b}
100% N-FYM (N2)	5.27 ^{a}	5.23 ^{a}	5.43 ^{b}	5.96 ^{ab}
50% N-Urea+50% N-FYM (N3)	4.88 ^{b}	5.03 ^{ab}	5.83 ^{a}	6.06 ^{a}
SEM±	0.10	0.46	0.32	0.09
LSD	0.29**	0.16*	0.11*	0.27*
CV %	6.83	10.98	6.80	5.31
Grand mean	**4.94**	**4.97**	**5.54**	**5.92**

Means followed by same letter(s) in a column are not significant at 5% level of significance as determined by DMRT.

ECONOMIC ANALYSIS

There were a significant interaction effects among different sources of nitrogen and varieties on Gross income, net profit and benefit cost ratio. (Table 7). The highest gross income (Rs.534.2 thousand ha^{-1}) and net profit (Rs 369.3. thousand ha^{-1}) were recorded from Madhuri variety.The highest B:C ratio (2.52) was from 50%N-Urea+50%N-FYM which was similar to 100%N-Urea (2.40) followed by 100%N-FYM (1.96). Likewise, Madhuri variety gave the highest B:C ratio (3.24) followed by Snow Mystique (2.57), Snow Crown (2.06) and Snow Dome (1.31).

Table 7. Effects of nitrogen sources on net profit, gross income and benefit cost ratio of cauliflower cultivars at Rampur, Chitwan, Nepal, 2012/2013

Treatments	Gross income (NRs.,000)/ha	Net profit (NRs.,000)/ha	Benefit cost ratio
Variety (V)			
Snow Mystique (V1)	394.5 b	232.3b	2.57b
Snow Crown (V2)	344.0 c	169.8c	2.06c
Snow Dome (V3)	216.4 d	45.18d	1.31d
Madhuri (V4)	534.2 a	369.3a	3.24a
SEM±	9.62	9.62	0.06
LSD	28.22**	28.22**	0.18**
Nitrogen Sources (N)			
100% N-Urea (N1)	237.0 c	136.0 b	2.40a
100% N-FYM (N2)	457.9 a	222.9 a	1.96b
50% N-Urea+50% N-FYM (N3)	421.9 b	245.4 a	2.52a
SEM±	8.33	8.33	0.05
LSD	24.44**	24.44**	0.15**
CV %	7.75	14.33	8.04
Grand mean	372.254	201.417	2.24

Means followed by same letter(s) in a column are not significant at 5% level of significance as determined by DMRT.

SUMMARY AND CONCLUSION

The growth attributing characters like stem height, stem diameter, leaf length, leaf breadth and canopy diameter had better performance from 50% N-urea +50% N-FYM with Madhuri variety compared to others. The highest plant height (58.28 cm) and thickest stem diameter (3.24 cm) were from 50%N - Urea + 50%N - FYM at harvest. The maximum curd height (6.93cm), curd diameter (16.66cm) and curd weight (0.67kg) were recorded from 50%N - Urea + 50%N - FYM. Similarly, Madhuri variety gave the maximum curd height (7.52cm), curd diameter (17.20cm) and curd weight (0.75kg). The highest economic yield (24.82tha^{-1}) and biological yield (57.38 tha^{-1}) were observed from 50% N-Urea + 50% N - FYM. Likewise, Madhuri variety gave the highest B:C ratio (3.24) which was followed by Snow Mystique (2.57), Snow Crown (2.06) and Snow Dome (1.31). This showed the interactive advantages of combining the organic (FYM) and inorganic sources (urea) of nutrients in integrated nutrient management have proved superior rather to use either of the components separately.

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PROFITABILITY AND RESOURCE USE EFFICIENCY OF COFFEE PRODUCTION IN PALPA DISTRICT, NEPAL

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ABSTRACT

This survey was conducted to assess the profitability and resource use efficiency of coffee production in Palpa district in 2013. The survey was conducted in Barangdi, Boughapokharathok, Madanpokhara and Khaseauli VDCs. A household survey of 110 coffee growers which includes 30 households each from first three VDCs and 20 from Khaseauli. Face to face interview, direct observation, FGD was conducted to collect primary data and other sources for secondary data collection and wasanalysed by using SPSS and Microsoft Excel. The GM was found Rs. 6636.52 and net profit of Rs. 4752.52 per ropani. Cobb-Douglas production function analysis showed that labour cost, expenses on organic manures and fertilizers and other associate costs contributed significantly to gross income of coffee at 1 % level of significance. The return to scale was found 1.09 and the resources used in the coffee production were all underutilized and should adjust the labour by 42.51% , manure and fertilizers by 66.15% and other costs by 71.39% . It was found that the BCR of 1.39, NPV Rs. 13582.07, IRR of 32.50% and less than 5 years of PBP of coffee production. It shows that the coffee business may be the suitable and financially feasible business in the mid hills of Nepal.

Key Words: Coffee, GM, Cobb-Douglas Production function, Resource use efficiency.

INTRODUCTION

Coffee is a high value low volume cash crop. This crop is economically more (nearly three times) profitable in the present context as compared to cash crops and 5 times than other cereal crops (Bajracharya, 2003; Dhakal, 2004 and Banjara, 2014). Some Districts like Gulmi, Palpa, Argakhanchi, Lalitpur, Tanahu, Kavre, Sindhupalchowk, Lamjung, Kaski, Gorkha, Syangja, Parbat, Baglung are successfully growing and producing Coffee beans and is increasing gradually (NTCDB, 2014).Among the various cash crops for commercialization, coffee is emerging as a likely agro-enterprise with great potential to provide farm employment and income generation opportunities in the mid hills of Nepal (CoPP, 2007).

Coffee is one of the important beverages in the world. Coffee which falls under Rubiaceaefamily and genus *Coffea*, has two major species *C. Arabica* and *C. robusta* and one minor species *C. liberica*. As the climate and soil in the mid and high hills of Nepal are found to be very suitable for Arabica coffee, the coffee planted in Nepal is all *Arabica* (Giri, 2006).

Coffee being a new crop in Nepal, coffee production and the technologies are still in a rudimentary stage. Coffee farming has been started since five decades but it has not been able to contribute in the economy of the farmers' as expected. Considering its potential for poverty reduction of rural hill people, both government and non-government organizations have initiated research and development works on coffee (Shrestha *et al.,* 2008).

This research survey was conducted to assess the profitability and resource use efficiency of coffee production in Palpa district. Coffee is high value cash generating crop for farmers of Nepal of mid hills (Khanal, 2003).

MATERIALS AND METHODS

Study area and sample size

Barangdi, Boughapokharathok, Madanpokhara and Khaseauli VDCs of Palpa were purposively selected as the study site. 30 growers from each first three VDCs and 20 growers from Khaseauli, altogether 110 coffee growers were selected. The field survey was conducted in September 2013. Face to face interview was conducted to fill up the semi structured interview schedule. Focus group discussions were conducted and key informant survey was carried out and secondary data were collected from different sources. The final analysis was done with the help of computer software Statistical Package for Social Science (SPSS), Microsoft Excel and STATA V.12.

Gross margin analysis

This is the difference between the Gross return (GR) and the Total Variable Cost (TVC). It is a useful planning tool in situations where fixed capital is negligible portion of the farming enterprise in the case of small scale subsistence agriculture (Olukosi and Erhabor, 1988).

Gross margin was calculated as:

$$GM = GR - TVC$$

Gross Margin (Rs.) = Gross return (Rs.) - Total variable cost (Rs.)

Net profit = Gross margin (Rs.) - Fixed cost (Rs.)

Where,

Gross return (Rs.) = Price of fresh cherry (Rs. /Kg) × total quantity sold (Kg.)

Total variable cost (Rs.) = Summation of cost on all variable inputs.

Analysis of contribution of different factors to gross income of coffee

The following form of Cobb- Douglas production function was used to determine the contribution of different factors on production and to estimate the efficiency of the variable factors of production of coffee.

$$Y = aX_1^{b1}\ X_2^{b2}\ X_3^{b3}\ e^u$$

Where,

Y= Gross Income (Rs./Ropani)

X_1= Labor cost (Rs./Ropani)

X_2= Expenditure on nutrients (Rs./Ropani)

X_3= other expenses (Rs./Ropani)

u = Random disturbance term

b_1 ...b_4 are the coefficient to be estimated.

The Cobb- Douglas production function in the form expressed above was linearised in to a logarithmic function with a view to getting a form amenable to practical purposes as expresses below.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + u$$

Where,

ln= Natural logarithm

a= constant

u= Error term

For the calculation of return to scale from coffee, Cobb-Douglas production function was used and calculated using formula;

$$RTS = \Sigma b_i$$

Where,

b_i = regression coefficient of i^{th} variables.

The sum of b_i from the Cobb-Douglas production function indicates the nature of return to scale.

Return to Scale decision rule: RTS<1: Decreasing return to scale,

RTS=1: Constant return to scale,

RTS>1: Increasing return to scale.

Table 1. Descriptions of the variables used in the Cobb-Douglas production function analysis

Variables	Unit	Description
Gross income from coffee (Y)	Rs./Ropani	It indicates the total income from fresh cherry of coffee in Rs.
Cost on labour (X_1)	Rs./Ropani	This includes the total cost on labour used in the coffee production process in Rs.
Expenditure on nutrients (X_2)	Rs./Ropani	It indicates the expenditure on nutrients including FYM, organic manure and other fertilizers.
Other expenses (X_3)	Rs./Ropani	It includes the expenses on plant protection chemicals, post-harvest chemicals, processing in early stage, irrigation cost and other cost.

RESOURCE USE EFFICIENCY

The efficiency of resource use in production of coffees was determined by the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) of variable inputs based on the estimated regression coefficients. The coefficients from Cobb-Douglas production are used in the resource use efficiency measurement (Naqui, 2013;Manjunath *et.al*, 2013). Following Rahman and Lawal (2003) and Manjunath*et.al* (2013) efficiency of resource use was calculated using formula;

$$r = MVP/ MFC$$

Where,

r = Efficiency ratio

MVP = Marginal value product of a variable input,

MFC = Marginal factor cost (Price per unit input).

The value of MVP was estimated using the regression coefficient of each input and the price of the output.

MVP= MPP x_i × Py (Unit price of output)

But,

$$MPPx_i = \frac{d_y}{d_{xi}}$$

$$bi = \left(\frac{Y}{x_i}\right)$$

Where; b_i= Estimated regression coefficient of input X_i

Y= Geometric mean value of output

x_i= Geometric mean value of input being considered

The prevailing market price of input was used as the Marginal Factor Cost (MFC).

MFC= Px_i Where, Px_i= Unit price of input x_i.

The decision rule for the efficiency analysis was as;

r =1; Efficient use of a resource

r >1; Underutilization of a resource

r <1; Overutilization of a resource

Again the relative percentage change in MVP of each resource required so as to obtain optimal resource allocation i.e r=1 or MVP= MFC was estimated using the equation below;

$$D = \left(\frac{MFC}{MVP}\right) = 100$$

$$\text{or, } D = (1 - r^{-1}) * 100$$

Where, D = absolute value of percentage change in MVP of each resource (Mijindadi, 1980; Manjunath *et.al*, 2013) and r= efficiency ratio

Financial Analysis of coffee plantations

For the financial analysis and profitability of the coffee plantations financial analysis tools were used as NPV, IRR, BCR and payback period.

Net Present Value (NPV)

In calculating the net present worth, the difference between the present value of the cost stream and present value of benefit stream were considered at a discount rate of 12 percent.

The general mathematical form of net present worth criterion is

$$NPV - \sum_{t=0}^{n}\left(\frac{Ct}{1+r^{t}}\right) - Co$$

Where,

t = the time of the cash flow (years)
n = the total time of the project (Years)
r =the discount rate (percent)
C_t = the net cash flow (the amount of cash) at time t. (Rs.)
C_0 =the capital outlay at beginning of the investment time (t = 0)

Benefit cost ratio (B:C Ratio)

It is the ratio of discounted cash flows to discounted investment. The BCR must be unity or more for a project investment to be considered worthwhile. The Benefit Cost Ratio (BCR) was worked out by using following formula.

$$\text{BC ratio} = \frac{\sum Bt/(1+r)^n}{\sum Ct/(1+r)^n}$$

Where,

B_t = Incremental benefit in the t^{th} year (Rs.)

C_t = Incremental cost in the t^{th} year (Rs.)

n = Economic life of the project (years)

r = Discount rate (percent)

$\sum$ = Summation

Internal Rate of Return (IRR)

The rate at which the net present value of project is equal to zero is Internal Rate of Return (IRR) to the project. It represents the average earning capacity of an investment from the project. The net cash inflows were discounted to determine the present worth following the interpolation technique.

The method of interpolation followed is as under

$$\text{IRR} = \text{LDR} + \text{D}\left(\frac{\text{NPV at LDR}}{\sum \text{NPV at TDRs (Sign ignored)}}\right)$$

Where,

IRR = Internal rate of return (percent)

LDR = Lower discount rate (percent)

D = Difference between two discount rates (percent)

TDRs= Two discount rates (percent)

NPV = Net present value (Rs.)

Pay Back Period (PBP)

Payback period represents the length of time required for the stream of cash proceeds produced by the investment to be equal to the original cash outlay. i.e., the time required for the project to pay for itself. In the present study, payback period was calculated by successively deducting the initial investment from the net returns until the initial investment was fully recovered and the cost up to third year was considered as establishment and maintenance cost and then after as the production cost up to 15 years of production period at a discount rate of 12 percent.

Table 2. Decision making framework of financial Tool

Investment criteria	Decision Criteria		
	Acceptance range	Indifference	Rejection range
B/C Ratio	I>1	Equal to 1	< 1
NPV	>0	Equal to 0	< 0
IRR	>Discount Rate (i)	Equal to i	<i
PBP	Shortest as the best	-	Very high

RESULTS AND DISCUSSION

Socio-demographic characteristics

Table 3 revealed that the male population were higher in the sampled household, male headed household were in majority (77.33 percent) with nuclear family of about 56 percent and the economically active family population was higher (60.37 percent) and the major occupation of the economically active population was agriculture (41.54 percent) in the sampled households. About 73 percent respondents were involved in group and majority of the growers have received training on coffee production.

Table 3. Socio-demographic characteristics of the sampled household.

Characteristics	Frequency
Population distribution of sampled household	
Male	416(51.61)
Female	390(48.39)
Sex of household head	
Male	85(77.30)
Female	25(22.70)
Family Type	
Nuclear	62(56.40)
Joint	48(43.60)
Age distribution of sampled population	
≤15 years	211(26.05)
16-59 years	489(60.37)
≥60 years	110(13.58)
Major occupation of economically active members	
Agriculture	204(41.54)
Daily wage	3(0.61)
Domestic service	79(16.08)
Service abroad	69(14.05)
Student	105(21.38)
Business	31(6.31)
Member in group	
Involvement in Group	80(72.73)
No involvement in group	30(27.27)
Training on coffee	
Received training related to coffee	93(84.55)
Training not received	17(15.45)

Figures in parenthesis are in percentage *Source: Field survey, 2013*

Gross and net margin analysis of coffee production

Gross margin of coffee was calculated by deducting the total variable cost from the gross return per ropani and gross margin per ropani was found Rs. 6636.52. By deducting the fixed cost the net profit per ropani was calculated and found Rs.4752.52.

Table 4.Profitability analysis of coffee production in the study area (2013)

Particulars (Rs.)	Mean	SD
Total variable cost	3261.90	1838.95
Fixed Cost	1854.00	1640.88
Total revenue	9898.42	6671.63
Gross margin (Rs./Ropani)	6636.52	5321.23
Net Profit (Rs./Ropani)	4752.52	

Bastola (2007) found that the Gross Return in coffee per ropani was Rs. 13093 and variable cost Rs. 4194.Poudel*et al.* (2007) found the gross margin of Rs. 4119.13 per farm. Pandit (2008) found the GM of Rs. 119129.70 / ha in Palpa District. Jeevarani (2005) in economic analysis of coffee in Karnataka found that the net return per acre was Rs. 15693.

Factors contributing to total revenue from coffee

The coefficient of multiple determinations (R^2) of the model was 0.727. R^2 value indicates that 73 percent of the variation in gross income from coffee was explained by the independent variables which were included in the model.

The F value of the equation was 94.24 which is highly significant at 1percent level of significance indicating that the variation of gross income mainly depends on the explanatory variable included in the model. The estimated coefficient and related statistics of Cobb-Douglas production function were presented in the table 5.

Table 5. Estimated values of coefficients and their related statistics of Cobb-Douglas production function of coffee production in the study area (2013)

Explanatory variables	Coefficient	Standard error	t-value	Sig.level
Constant	1.09	0.508	2.00	0.048
Labour cost (X_1)	0.635***	0.072	8.76	0.001
Expense on fertilizers and manure (X_2)	0.281***	0.045	6.16	0.001
Other expenses (X_3)	0.167***	0.036	4.63	0.001

*** significant at 1 percent level

Dependent Variable: log value of gross income from coffee

R^2 = 0.727, Adjusted R^2 = 0.719, F-value=94.24, return to scale=1.09

It was clear from the table that the coefficient of labour cost, expenses on fertilizers and manure and other associated costs were positive and significant also. The value indicates that keeping all factors constant 1 percentage increase in the labour cost will increase the gross income by 0.63 percent, which is significant at 1 percent level. The value indicates that the one percent extra expense on the manures and fertilizers, other things remaining constant increase the gross income by 0.28 percent. The coefficient indicates that the one percent more expense on these items will add positively 0.17 percent to the gross income which is also significant at the 1 percent level of confidence.

Similar case was found by Pandit (2008), that factor affecting the coffee production in Palpa was significant for labour at 1 percent level. Return to scale was found 1.09 from the analysis, which shows the coffee production was profitable in the area, similar case was found by Pandit (2008), as the return to scale in coffee production was 1.05 in Palpa district.

Resource use efficiency

Resource use efficiency was calculated from the elasticities of Cobb-Douglas production function analysis. The table estimates the resource use level and utilization of the inputs used in the coffee production in Palpa district.

Table 6. Estimated resource use efficiency and required adjustment in Marginal Value Product (MVP), 2013

Expenditure (Rs/Ropani)	GM	Coefficient	MVP	MFC	r	Efficiency	D
Labour	3140.22	0.66	1.74	1.00	1.74	Under utilized	42.51
Organic manure	644.35	0.23	2.95	1.00	2.95	Under utilized	66.15
Others	426.20	0.18	3.50	1.00	3.50	Under utilized	71.39

Table 6, revealed that, in coffee production for optimum allocation of human labor, expenditure on FYM and organic manures and other inputs such as irrigation, plant protection materials are required to increase by 42.51 per cent, 66.15 per cent, 71.39 per cent as all the resources were underutilized in the coffee production.

Financial analysis of coffee plantations

Different financial tools were used for the financial feasibility of the coffee plantations in Palpa district. From the analysis it was found that the B/C ratio was 1.39, NPV was positive and IRR of 32.50 percent and payback period of less than 5 years (table 7). It shows the coffee plantation business profitable and financially feasible. Similar case was found by Kumar (2004), Bastola (2008) and Poudel *et al.*(2008) in coffee plantations analysis.

Table 7. Summary of the financial analysis

Particulars	Unit	Value
B/C Ratio	-	1.39
NPV	Rs.	13582.07
IRR	percent	32.50
Payback Period	yrs.	4 years 5 months

CONCLUSIONS

Coffee is the newer crop and there was less management of coffee plants and productivity per plant was found also low. Gross margin per ropani and net revenue per ropani showed the coffee bussiness profitable. Labour cost, expenses on FYM and organic manure and other expenses contribute significantly on the gross income of coffee. The coffee business was profitable as shown by the return to scale analysis. The resources used in the coffee production were found underutilised and proper utilisation of resources is necessary. Investment analysis showed favourable result and investment agencies are suggested to invest on the coffee sector and promote organic coffee production because it is the profitable business and high market value in mid-hills of Nepal.

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NITROGEN MANAGEMENT IN RICE-WHEAT SYSTEM UNDER CONSERVATION AND CONVENTIONAL AGRICULTURE PRACTICES IN RAMPUR, CHITWAN, NEPAL

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ABSTRACT

A field experiment was conducted to evaluate the productivity and economics of rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) through nitrogen management practices under conservation and conventional agriculture practices in Rampur, Chitwan from July, 2012 to April, 2013. The experiment was conducted in strip-split plot design with two establishment methods (conservation agriculture and conventional practices), two rice varieties (improved variety Sabitri and hybrid Gorakhnath 509) and four nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) in rice. But the experiment of wheat was conducted in split plot design with two establishment methods and four nitrogen levels as in rice with Gautam variety. The research result revealed that grain yield of rice-wheat system was higher in CA of 6.75 t ha^{-1}. Gorakhnath 509 of rice followed by Gautam variety of wheat had higher system grain yield of 6.84 t ha^{-1} than Sabitri followed by Gautam with 6.48 t ha^{-1}. The highest system grain yield was obtained from 180 kg N ha^{-1} (8.13 t ha^{-1}) which was significantly higher than 0 and 60 kg N ha^{-1} but was statistically similar with 120 kg N ha^{-1}. The highest net return of NRs. 159.90 thousand ha^{-1} was obtained under CA using Gorakhnath 509 followed by Gautam with 120 kg N ha^{-1}. But the B: C ratio was highest (2.97) due to CA with Sabitri followed by Gautam variety and Gorakhnath 509 followed by Gautam with 120 kg N ha^{-1} (2.92). Thus, in Chitwan and similar niches in rice-wheat system either Sabitri followed by Gautam or Gorakhnath 509 followed by Gautam variety under conservation agriculture practices by applying 120 kg N ha^{-1} can be successfully grown by the farmers.

***Key words**:* Conservation agriculture, Conventional agriculture practices, varieties, nitrogen levels and grain yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is the first and wheat (*Triticum aestivum* L.) is third leading cereal crop of Nepal cultivated on 43.95% and 21.93% of total cultivated area with national average grain yield of 3.31 t ha^{-1} and 2.41 t ha^{-1} respectively (MoAD, 2012). Rice-wheat is one of the most prominent cropping systems in Nepal and accounts 0.56 million hectares area (Khanal et al., 2012). Rice alone contributes about 20% and wheat contributes 4.5% in AGDP (MoAC, 2012). Rice is grown during the monsoon season and wheat during the cold and dry winter season. There is a transition period of variable length between the harvest of wheat and the transplanting of rice, during which the land typically lies fallow.

Major cereals production in Nepal is constrained by many factors such as limited irrigation potential, low fertilizer availability, unavailability of quality seeds, inadequate weed management practices, weather stress, poor access to infrastructure and market, inappropriate government policy and less priority to agricultural research and development (Marahatta, 2008). These constrain also result the huge yield gap between potential and farmers' management (rice 2.76 t ha^{-1} and wheat 3.15 t ha^{-1}) (Amgain and Timsina, 2005). The present yield of both rice and wheat is very low as compared to nearby Asian countries. The rice-wheat system of terai and inner terai showed yield stagnation in the last two decades (Pathak et al., 2003).

Modern agricultural production requires efficient, sustainable, economically viable and environmentally sound management practices. If resource conserving technologies are practiced in terai area of Nepal, total production of RW will be increased at least by 1.3 million tons, which may help to reduce poverty and enhance food security in Nepal (Regmi et al., 2009). Under CA practices, no or minimum tillage with residue retention and proper N management has been an alternative option for sustainable crop production systems under rainfed as well as irrigated condition (Sayre and Hobbs, 2004; Govaerts et al., 2005).

Nitrogen is normally a key factor in achieving optimum rice grain yield (Fageria et al., 1997). It is one of the expensive inputs and if used improperly, can pollute the ground water. About 78% of the world’s rice is grown under irrigated or rainfed lowland conditions (IRRI, 1997). Soils under these conditions are saturated, flooded, and anaerobic having low N use efficiency. Under these situations, increasing rice yield per unit area through use of appropriate N management practices such as adequate amount, form and method of application is crucial (Fageria and Baligar, 2001). Hence this study was conducted to evaluate the productivity of rice-wheat system and to assess the economics of rice-wheat production system under different establishment methods and nitrogen levels.

MATERIALS AND METHODS

The experiment was conducted at the research block of IAAS, Rampur, Chitwan of Nepal from July 2012 to April 2013.The area located at 9.8 km South-West of Bharatpur, headquarter of Chitwan district. The site is located between 27^0 $37'$ North latitude and 84^0 $25'$ East longitude with an elevation of 256 meter above mean sea level (Thapa and Dangol, 1988). The monthly mean maximum temperature was 33.7 ^{0}C in August and minimum temperature was 7.5 ^{0}C in November during rice season and 1.83 ^{0}C in January and 34.56 ^{0}C in April during the wheat season. The maximum rainfall was observed in the month of July (485.5mm) and no rainfall at all in the month of November, December and February. Soil of the experimental site was sandy loam with acidic pH of 5.62.

The experiment was laid out in strip-split plot design for rice and split plot design for wheat. During rice season there were three factor of which two level of crop establishment methods (CA and Conventional practices) in a vertical strip in rice and as main plots for wheat, two level of varieties (Sabitri and Gorakhnath 509 of rice during summer and Gautam of wheat during winter) and four nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) in sub-sub plots. CA comprises dry direct seeded rice in summer followed by zero tillage wheat in winter whereas, conventional practices comprises puddled transplanted rice in summer followed by conventionally tilled wheat in winter. Mung bean (*Vigna radiata* L.), cultivated in previous season was used as source of residue for zero tilled rice. Residue of rice harvested 33 cm above the ground surface to retain the standing residue for wheat crop. The individual plot size was 15 m^2 (5 m × 3 m) with the total experimental area of 957 m^2. Two individual plots were separated by 1m along with bund and each replication was separated by 2 m along with bund. In direct seeded rice and wheat (conventional and zero till) was sown continuously in line with a row to row spacing of 20 cm but in conventional puddled transplanted rice, seedling were transplanted in 20 cm x 20 cm using 21 days seedling. Various levels of Nitrogen (0, 60, 120 and 180 kg ha^{-1}) were applied as per treatment and they were applied in 3 splits and entire amount of phosphorus and potash were applied as basal doses, at the rate of 40 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}. Recorded data were processed and analyzed by MSTAT software. Sigma Plot was used for graphical representation. Least Significant Difference (LSD) and Duncan Multiple range Test (DMRT), as mean separation technique was applied to identify the most efficient treatment (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

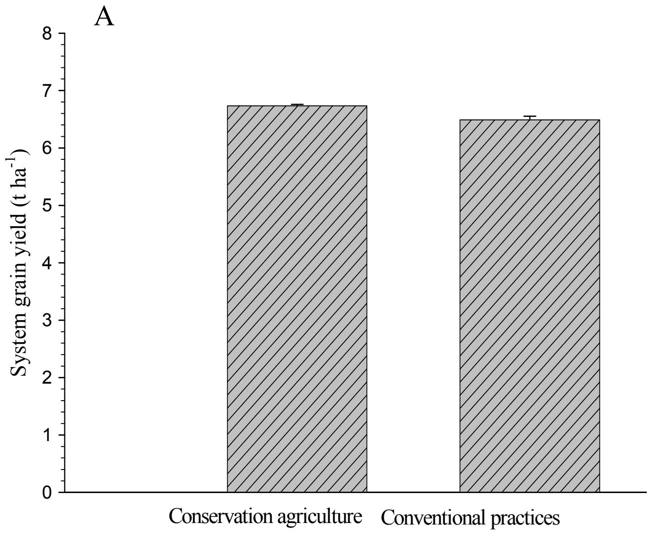
System productivity

Grain yield has been reported to be influenced highly by direct effects of total effective tillers, days to flowering, plant height, number of panicles, grains per panicle, biological yield, harvest index and thousand grains weight (Yang, 1986; Surek and Beser, 2003). But sum of individual crops is assigned as system yield.

Grain yield depends on production of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the extent of translocation into sink (grains) and also on plant growth and development during early stages of crop growth. Grain yield of rice-wheat system was significantly influenced by nitrogen levels but non-significant due to establishment methods and varieties. The mean grain yield was 6.66 t ha^{-1}. The highest grain yield was obtained in CA with 6.75 t ha^{-1} as compared to 6.56 t ha^{-1} in conventional practices (Figure A). Gorakhnath 509 of rice followed by Gautam variety of wheat had higher grain yield of 6.84 t ha^{-1} than Sabitri followed by Gautam variety of 6.48

t ha^{-1} (Figure B). This was due to significantly higher grain yield of Gorakhnath 509 than Sabitri variety of rice. The highest grain yield was obtained from 180 kg N ha^{-1} (8.13 t ha^{-1}) which was significantly higher than 0 kg N ha^{-1} (4.26 t ha^{-1}), 60 kg N ha^{-1} (6.11 t ha^{-1}) but was statistically similar with 120 kg N ha^{-1} (7.95 t ha^{-1}) (Figure C). More system yield was due to more grain yield of both rice and wheat in higher N level.

The higher system yield in CA might be due to use of crop residue as suggested by Becker et al. (2007) who obtained significantly higher system grain yield (4.99 t ha^{-1}) on mung bean incorporated plots than bare fallow (2.85 t ha^{-1}) plots. Similarly, Hobbs and Gupta (2004) obtained higher grain yield in CA on rice-wheat system in South Asia.



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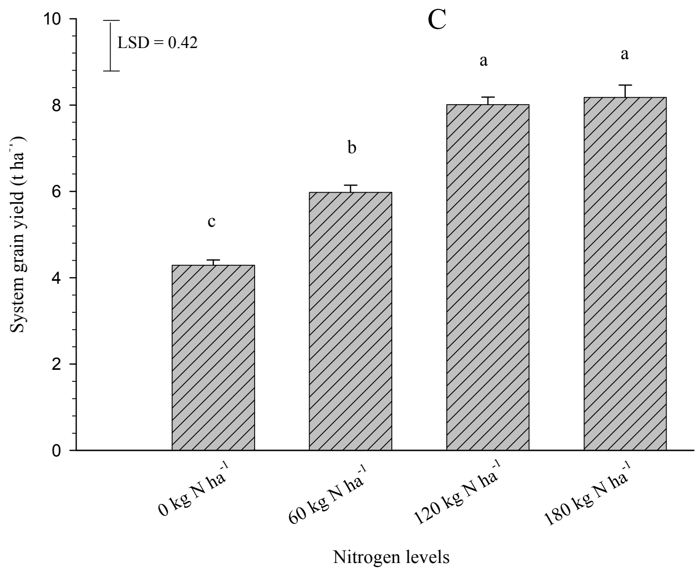

Figure 1. Effect of establishment methods (A), varieties (B) and nitrogen levels (C) on system grain yield of rice-wheat system at Rampur, Chitwan, 2012/13

ECONOMICS OF RICE-WHEAT SYSTEM

Production cost

Cost of production is the total expenditure incurred for raising crops in a particular cropping system. Cost of cultivation in our case was calculated on the basis of local charges/prices for different agro inputs viz. labor, fertilizer, compost, and other necessary materials. Cost of production was highest of NRs. 128.34 thousand ha^{-1} on Gorakhnath 509 variety of rice followed by Gautam variety of wheat in conventional practices with application of N @180 kg ha^{-1} and the lowest was recorded in CA with Sabitri variety of rice followed by Gautam variety of wheat in CA with the application of N @ 60 kg ha^{-1} with NRs. 68.81 thousand ha^{-1}.

System gross return (NRs.'000)

Gross return is the total monetary value of the economic produce and by products obtained from the crop and is calculated on the basis of the local market price (Reddy and Reddi, 2006). The average of system gross return from the experiment was NRs. 201.81 thousand ha^{-1} (Table 1). Gross return was not significantly affected by establishment methods and varieties but was affected significantly by nitrogen levels. However, gross return was higher in conventional practice (NRs. 202.15 thousand ha^{-1}) than CA (NRs. 201.46 thousand ha^{-1}). Also, significantly higher gross return was from 180 kg N ha^{-1} (NRs.

251.08 thousand ha^{-1}) than application of 0, 60 and 120 kg N ha^{-1}. Lowest gross return was from 0 kg N ha^{-1} (NRs. 131.86 thousand ha^{-1}).

Table 1. Effect of establishment methods, varieties and nitrogen levels on economics of rice-wheat system at Rampur, Chitwan, 2012/13

Treatments	**System gross return NRs. ('000) ha^{-1}**	**System net return NRs. ('000) ha^{-1}**	**Benefit cost ratio**
Establishment methods			
CA	201.46	117.16[a]	2.42[a]
Conv. practice	202.15	83.76[b]	1.72[b]
SEm (±)	0.47	0.47	0.01
LSD $_{(0.05)}$	Ns	2.86	0.05
Varieties			
Sabitri - Gautam	203.49	104.43[a]	2.14[a]
Gorakhnath 509 - Gautam	200.12	96.49[b]	2.00[b]
SEm (±)	0.87	0.87	0.01
LSD $_{(0.05)}$	Ns	5.30	0.04
Nitrogen levels			
0 kg ha^{-1}	131.86[d]	22.91[c]	1.25[d]
60 kg ha^{-1}	187.49[c]	99.34[b]	2.20[c]
120 kg ha^{-1}	236.80[b]	138.25[a]	2.48[a]
180 kg ha^{-1}	251.08[a]	141.32[a]	2.34[b]
SEm (±)	3.36	3.36	0.03
LSD $_{(0.05)}$	9.80	9.80	0.10
CV, %	5.76	11.57	5.57
Grand mean	**201.81**	**100.46**	**2.07**

ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

System net return

Net return represents the actual income of the farmer and it is obtained by subtracting cost of cultivation from gross return. It is a good indicator of sustainability of system since this represents the actual income of the farmer (Reddy and Reddi, 2006). In the net return was significantly influenced by establishment methods, varieties and nitrogen levels. The average net return from rice-wheat system was NRs. 100.46 thousand ha^{-1} (Table 1). Net return from CA was NRs. 117.16 thousand ha^{-1} and was higher than conventional practices with NRs. 83.76 thousand ha^{-1}. Sabitri - Gautam variety gave higher net return of NRs.

104.43 thousand ha^{-1} than Gorakhnath 509 - Gautam variety with NRs. 96.49 thousand ha^{-1}. Application of 180 kg N ha^{-1} produced significantly higher net return of NRs. 141.32 thousand ha^{-1} than 0 and 60 kg N ha^{-1} but was at par with 120 kg N ha^{-1}. The lowest net return of NRs. 22.91 thousand ha^{-1} was obtained from 0 kg N ha^{-1}.

Interaction effect of establishment methods, varieties and nitrogen levels on net return was significant (Table 2). Net return was significantly higher in both the varieties under CA with 120 kg N ha^{-1} and 180 kg N ha^{-1} than all the other treatment combinations. The highest net return of NRs. 159.87 thousand ha^{-1} under CA using Gorakhnath 509 - Gautam along with 120 kg N ha^{-1} which was at par with CA using Sabitri - Gautam variety with 120 kg N ha^{-1}(NRs. 155.68 thousand ha^{-1}) and CA with Gorakhnath 509 - Gautam varieties with 180 kg N ha^{-1}(NRs. 154.30 thousand ha^{-1}) and CA using Sabitri - Gautam varieties with 180 kg N ha^{-1} (NRs. 151.12 thousand ha^{-1}).

Table 2. Interaction effect of establishment methods, varieties and nitrogen levels on net return of rice-wheat system at Rampur, Chitwan, 2012/13

N levels	Net return			
	CA		Conventional practices	
	Sabitri - Gautam	Gorakhnath 509 - Gautam	Sabitri - Gautam	Gorakhnath 509 - Gautam
0 kg ha^{-1}	51.41^{e}	40.88^{e}	10.98^{f}	-11.62^{g}
60 kg ha^{-1}	128.65^{c}	95.33^{d}	82.93^{d}	90.45^{d}
120 kg ha^{-1}	155.68^{a}	159.87^{a}	119.21^{c}	118.22^{c}
180 kg ha^{-1}	154.30^{a}	151.12^{ab}	132.24^{bc}	127.63^{c}
SEm (±)	6.711			
LSD $_{(0.05)}$	19.59			
CV, %	11.57			

Treatments means followed by common letter (s) within column are not significantly different among each other based on DMRT at 5% level of significance

System benefit cost ratio

Benefit cost ratio is the ratio of gross return to cost of cultivation which can be expressed as returns in rupees per rupee invested. This index provides an estimate of the benefit from investment in adopting a particular system/technology. Farmers are safe to invest in agribusiness when they get Rs. 2.00 or greater value for every rupee invested (Reddy and Reddi, 2006). In the experiment B: C ratio was significantly influenced by establishment methods, varieties and nitrogen levels (Table 1). The mean B: C ratio was 2.07 which was higher in CA with 2.42 than conventional practices with 1.72. Among varieties Sabitri - Gautam had higher B: C ratio (2.14) than Gorakhnath 509- Gautam (2.00). Application of

120 kg N ha^{-1} gave significantly higher B: C ratio of 2.48 followed by 2.34 and 2.20 by 180 and 60 kg N ha^{-1} and the lowest of 1.25 was from control plots.

Interaction effect of establishment methods, varieties and nitrogen levels on B: C ratio of rice-wheat system was significant (Table 3). Highest B: C ratio of 2.97 was obtained in CA using Sabitri - Gautam variety with 120 kg N ha^{-1} followed by CA using Gorakhnath 509 - Gautam with 120 kg N ha^{-1} (2.92) and CA using Sabitri - Gautam with 60 kg N ha^{-1} (2.87). Lowest B: C ratio of 0.91 on conventional practices using Gorakhnath 509- Gautam on 0 kg N ha^{-1}. Thus, use of Sabitri variety of rice and Gautam variety of wheat under CA with the application of 120 kg N ha^{-1} was more beneficial than rest of the tested treatments.

Table 3. Interaction effect of establishment methods, varieties and nitrogen levels on benefit cost ratio of rice-wheat system at Rampur, Chitwan, 2012/13

N levels	Benefit cost ratio			
	CA		Conventional practices	
	Sabitri - Gautam	Gorakhnath 509 - Gautam	Sabitri - Gautam	Gorakhnath 509 - Gautam
0 kg ha^{-1}	1.57^{h}	1.44^{h}	1.09^{i}	0.91^{i}
60 kg ha^{-1}	2.87^{b}	2.31^{d}	1.80^{g}	1.84^{fg}
120 kg ha^{-1}	2.97^{a}	2.92^{ab}	2.05^{ef}	2.00^{efg}
180 kg ha^{-1}	2.72^{bc}	2.56^{c}	2.07^{e}	1.99^{efg}
SEm (±)	0.658			
LSD $_{(0.05)}$	0.192			
CV, %	5.57			

Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

CONCLUSION

Rice-wheat system yield was not affected by establishment methods but net return, B: C ratio was higher in CA than conventional practices. Gorakhnath 509 had higher grain yield than Sabitri variety of rice. Sabitri variety of rice followed by Gautam variety of wheat resulted higher net return and B: C ratio. Application of 180 kg N ha^{-1} performed better for growth parameters and yield attributes than 0, 60 and 120 kg N ha^{-1}. However, grain yield and net return was statistically similar with 120 kg N ha^{-1} and while application of 120 kg N ha^{-1} resulted highest B: C ratio. The highest net return of NRs. 159.90 thousand ha^{-1} was obtained under CA using Gorakhnath 509 - Gautam with 120 kg N ha^{-1}. But the B: C ratio was highest (2.97) due to CA with Sabitri - Gautam variety and Gorakhnath 509 - Gautam with 120 kg N ha^{-1} (2.92).

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DETERMINANTS OF OFF-SEASON VEGETABLE PRODUCTION IN OKHALDHUNGA NEPAL

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ABSTRACT

Mid-hills of Nepal is potential for off-season vegetable production but still the number of off-season vegetable growers is few and production is nominal which cannot even fulfill the internal demand. This paper examines the factors that influence farm households' decisions for adoption of off-season vegetable production. Household questionnaires were administered to 100 farmers of Okhaldhunga district of Eastern mid-hill of Nepal. Probit regression model is used to determine the factors. The result showed that years of schooling, years of vegetable production, access to extension services, training received are the factors that significantly influence technology adoption decisions of farm households' in the study area. It is concluded that farm households' off-season vegetable production depend on socioeconomic characteristics of farm household and institutional effectiveness. We recommend that policies should be formulated to take advantage of factors that positively influence farmers' adoption decisions and to mitigate the negative ones.

Key words: Off-season vegetable, mid-hill, Nepal, adoption, Probit model, farmer, Household.

INTRODUCTION

Agriculture is main economic activity of Nepalese people which provides employment opportunities to 66 % of total population and contributes about 35 % to National GDP (MoAD, 2013). According to NLSS (2011) the majority of households (76 %) are agricultural households of which three-fourths are male headed, 52% literate, 58 % in hills, 43% in terai and only 9% in mountains. The average size of agricultural land area is 0.7 hectares. The current vegetable growing area in Nepal is 2,46,392 ha. Total production throughout the country is 33,01,684 Mt. The productivity of vegetables has increased to 13.40 Mt/ha (VDD, 2012/13). However, the distribution of vegetables production is not uniform throughout the country, which is rather concentrated in the vicinity of large urban areas.

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Off-season vegetable farming refers to the production of vegetables in unusual seasons by adopting suitable technologies and farm inputs to meet the market demand throughout the year. In Nepal, the diversified climatic conditions are suitable to produce various types of crops, including vegetables during different seasons. At present, more than two hundred vegetable species are grown in different places under various climate zones of Nepal. Experiences have shown that commercialization of existing farming practices with adoption of technologies for off-season vegetables production can improve the livelihood of the farmers (Prajapati, 2007). In commercializing the agriculture sector, offseason vegetable farming has played a vital role contributing to enhancement of economic status of the farmers of the hills of Nepal. It has been providing regular employment and income to the marginal farmers and their family members throughout the year by bringing economic gains (Panta, 2001).

There is wide market within and outside the country for offseason vegetable. Even during the season our current production cannot fulfill the internal market demand and large amount of vegetable are imported. This case is very bad during offseason and our market is dominant with Indian vegetables. Nepal requires more vegetable production to meet its demand. It was estimated that the per capita annual vegetable consumption in the early 1980s was about 45 kg that reached to about 95 kg by the latest estimation. Still it is not sufficient to supply minimum requirement of 104 kg per person per year (VDD, Nepal). This demand can be met either by expanding vegetable cultivation area or by intensifying the production of vegetables, including off-season vegetables production all the year round.

The agro-ecological characteristics of Nepal provide good potential for the promotion of high value agricultural commodities. Considering the importance of horticultural crops in Nepal, Agricultural Prospective Plan (APP, 1995) has emphasized the development of this subsector in the kingdom based on comparative advantages under different bio-physical domains. The offseason vegetable production in hills is a categorically specified area in the APP. Eighth Five year plan also emphasized the offseason vegetable production in the mid hill followed by ninth, tenth eleventh and 12th five year plan.

This paper therefore examines factors affecting adoption of off-season vegetable production in Okhaldhunga district eastern mid-hills of Nepal.

METHODOLOGY

The survey

Altogether 100 samples were selected from different four VDCs of Okhaldhunga district. Samples were selected randomly. Household survey with the help of semi-structured interview schedule was used to collect information. Key informant interview was done to validate collected information. Collected data was analyzed using statistical software Strata version 12.

The analytical model: Probit model

Probit model was used to identify determinants of off-season vegetable production adoption decisions. In the Probit model, the households are assumed to make decisions based upon an objective of utility maximization. For a given decision, separate models are developed for each decision. The underlying utility function depends on household specific attributes *X* (e.g. age of household head, sex of the household head, education, membership to an agricultural association, access to credit, etc) and a disturbance term having a zero mean:

$$U_{i1}(X)=\beta_1 X_i+\varepsilon_{i1} \text{ for adoption} \quad (1)$$

$$\text{And } U_{i0}(X)=\beta_0 X_i+\varepsilon_{i0} \text{ for not adoption} \quad (2)$$

As utility is random, the *I* th household will select the alternative "adoption" if and only if $U_{i1}> U_{i0}$. Thus, for the household *i*, the probability of adoption is given by:

$$P(1) = P(U_{i1}> U_{i0}) \quad (3)$$

$$P(1) = P(\beta_1 X_i + \varepsilon_{i1} > \beta_0 X_i + \varepsilon_{i0}) \quad (4)$$

$$P(1) = P(\varepsilon_{i0} - \varepsilon_{i1} < \beta_1 X_i - \beta_0 X_i) \quad (5)$$

$$P(1) = P(\varepsilon_i < \beta_1 X_i) \quad (6)$$

$$P(1) = \varphi(\beta X_i) \quad (7)$$

Where, Φ is the cumulative distribution function of the standard normal distribution. The parameters β are estimated by maximum likelihood is *x′* a vector of exogenous variables which explains adoption. In the case of normal distribution function, the model to estimate the probability of observing a farmer using a new technology can be stated as:

$$P(Y_i = 1 \mid x) = \Phi(x'\beta) = \int_{-\infty}^{x'\beta} \frac{1}{\sqrt{2\pi}} \exp\left(-z^2/2\right) dz \quad (8)$$

Where P is the probability that the i^{th} household used the new technology, and 0 otherwise. Thus, the Probit regression model is expressed as;

Y(adopter=1)= $\beta_0 + \beta_1$*Age of HH head* $+ \beta_2$ *Sex of HH head*$+ \beta_3$ *Years of schooling*$+ \beta_4$ *Major occupation*$+ \beta_5$ *Total land holding (Ha)* $+ \beta_6$ *HH income from ag*$+ \beta_7$ *Economically active population*$+ \beta_8$ *Training*$+ \beta_9$ *Access to extension service*$+\ldots\ldots + \varepsilon_i$

Where, Y means adopters are those who grow offseason vegetables is dependent variable.

According to Nagler (2002) probit model contains the estimated probabilities to be between 0 and 1 and relaxes the constraint that the effect of the independent variable is constant across different predicted values of the dependent variables. This is normally experienced with the Linear Probability Model. The advantage of the probit model is that it includes believable error term distribution as well as realistic probabilities (Nagler, 1994).

Table 1. Different variables and their expected sign

Variables	Expected sign
Age of household Head (years)	-
Sex of household head (male = 1, female = 0)	+/-
Economically active member (number)	+
Years of schooling (years)	+
Major occupation (Agriculture = 1, else =0)	+
Irrigation facility (Yes = 1, No = 0)	+
Years of vegetable cultivation (Years)	+
Training (Received training = 1, Not received training = 0)	+
Access to extension (Yes = 1, No = 0)	+
Agricultural income of household (In NRs.)	+

RESULT AND DISCUSSION

Socio-demographic characteristic of the respondents

The total population of the sampled households was 521, out of which 54.31 % were female and 45.69 % were male. The average of the household head was 46.38 years which lies in economically active population. Of the total household 63 % were male headed and 37 % were female headed with average family size 5.21. Similarly, 57.96 % of the populations were economically active population. Majority of household head 79 % were engaged in agriculture as major occupation. Only 14 % of adopters were illiterate as compared to 34 % illiterate non-adopters in the study area. The average years of schooling of household head was 3.84 with standard deviation of 3.82. Among the household heads of the study area 56 % were participated in training related to agriculture. Of the total households 63 % had received extension services in different forms while 37 % lack extension services. The average land holding in the study area was 0.57 Hectare.

Table 2. Socioeconomic characteristics of the respondent in the study area

Demographic characters		**Frequency**	**Percent**	**total**
Population	Female	283	54.31	521
	Male	238	45.69	
Sex of HH Head	Female	37	37.00	100
	Male	63	63.00	
Major occupation	Agriculture	79	79.00	100
	Off farm income	21	21.00	
Education of HH head	Illiterate	23	23.00	100
	Literate	73	73.00	
Training related to agriculture	Received	56	56.00	100
	Not received	44	44.00	
Access to extension	Have access	63	63.00	100
	No access	37	37.00	

Variables	**Max.**	**Min.**	**Mean**	**Std. Deviation**
Age of HH Head	72	23	46	0
Family size	10	2	5.21	0
Years of schooling	16	0	3.84	±3.82
Land holding in hectare	3	0.05	0.57	±0.57

(Source: field survey, 2013)

Factors affecting off-season vegetable production

To identify the factors affecting off-season vegetable production in Okhaldhunga district, Probit regression model was used. Respondent was found either growing offseason vegetables or seasonal vegetable and at all not growing vegetables. The adopters were categorized based on binary response. The respondent growing off-season vegetables were designated as adopters = 1 and else were designated as non- adopter = 0.

Table 3. Summary statistics of probit regression analysis

Number of observation	**100**
Log likelihood	-9.802
LR $chi^2(10)$	117.58
Prob > chi^2	0.000
Pseudo R^2	0.851
Cases predicted correctly (%)	78.89

The Pseudo R^2 was 0.851 (Table 3) which implies that the variables included in the model are able to explain 85 % of probability of household decisions to adopt or not adopt off-season vegetable production. The Log-likelihood Ratio (LR) was found to be significant at 1 % level (Table 3). This means that all the explanatory variables included in the model jointly influence farmers' probability of adoption of off-season vegetable production. The model results also gave a predicted probability of adoption to be 0.7889. This means that there is about 79 % probability that farm household in the study area are willing to grow off-season vegetable provided some socio-economic and institutional bottlenecks that hinders adoption are addressed . Thus model can be said consistent and meaningful.

The dependent variable i.e. adoption of off-season vegetable production was regressed upon the ten independent variables namely age of household Head, Sex of HH head, Economically active members, Years of schooling, major occupation, Irrigation facility, Years of vegetable cultivation, training received, access to extension, agriculture income of household. Among these factors, probit regression analysis showed four variables namely Years of schooling, Years of vegetable cultivation, Training received and access to extension to be statistically significant for the adoption of off-season vegetable production on study area (Table 4).

Table 4. Factors affecting the off-season vegetable production in the study area (2013)

Variable	**Coefficients**	**P>|z|**	**Standard error**	**dy/dx**[b]	**S.E.**[b]
Age of household Head (years)	–0.010	0.823	0.044	-0.003	0.012
Sex of household head (male = 1, female = 0)	0.319	0.726	0.911	0.095	0.273
Economically active member (number)	–0.232	0.575	0.415	-0.067	0.128
Years of schooling (years)	0.218*	0.098	0.132	0.063	0.444
Major occupation (Agriculture = 1, else=0)	1.216	0.339	1.273	0.415	0.485
Irrigation facility (Yes = 1, No = 0)	0.140	0.894	1.048	0.041	0.323
Years of vegetable cultivation (Years)	0.367**	0.029	0.168	0.106	0.050
Training (Received training = 1, Not received training = 0)	2.102**	0.049	1.068	0.604	0.258
Access to extension (Yes=1, No= 0)	1.530**	0.025	0.684	0.478	0.251
Agricultural income of household (In NRs.)	0.000	0.133	0.000	0.001	0.000
Constant	**-5.492**	**0.060**	**2.925**	**-**	**-**

***Significance at P=0.01; ** Significant at P=0.05; *Significance at P≥0.1

[b] Marginal change in probability (marginal effect after Probit) evaluated at the sample means

The sign of Years of schooling was as expected and positively significant at 10 per cent level of significance ($P<0.10$) which implies that adoption increases with the increase in years of schooling. The coefficient of education was expected positive to decrease risk aversion behavior and increase adoption. From the Table 4, with 1 year increase in year of schooling the level of adoption off-season vegetable production increases by 6.3 % others things remaining constant. This is consistent with the literature that education creates a favorable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices (Waller *et al,* 1998; Caswell *et al*, 2001). Similarly the result is consistent with the findings of Adhikary (1994), Asfaw and Admassie (2004), Ward *et al.* (2009).

The coefficient of Year of vegetable cultivation (i.e. experience of farmers) was positive and significant at 5 % level. As the farmers gains knowledge, skill and experience from seasonal vegetable production then they start to shift towards off- season vegetables production. The more the experience of farmers in vegetable cultivation more is the level of adoption of off-season vegetable production. From the Table 4, with one year increase in vegetable cultivation the adoption of off-season vegetable production increases by 10.6 %.

Training received was found positively significant at 5 % level. It means that the level of growing off-season vegetable increases with training facilities. From the Table 4, the adoption of off-season vegetable production increases by 60.4 % if the farmers are provided training facilities. As most of the farmers growing off-season vegetable in the study area have received training from different institution. This reveals that off-season vegetable production is technology intensive and farmers need training to enhance skill to grow off-season vegetables. This result is in line with the Rosegrant and Cline, (2003) and Feder, (1987).

Access to extension services is critical in promoting adoption of modern agricultural production technologies because it can counter balance the negative effect of lack of years of formal education in overall decisions to adopt some technologies (Yaron *et al.,* 1992). Access to extensions services therefore creates the platform for acquisition of the relevant information that promotes technology adoption. Access to information through extension services reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time thereby facilitating adoption. Related to this is access to extension services which was also found to be positively related to the adoption of off- season vegetable production technologies and was found to be significant at 5 % level. This means that farm households are more likely to adopt off-season vegetable production technologies if they have access to extension services. As extension service popularizes the innovation by providing necessary information, knowledge and skills in order to enable farmers to apply innovation. Majority of the farmers in rural areas of Nepal have not been able to obtain technological information due to lack of know-how, transportation facilities, access to communication media and technical training. This finding is in conformity with other studies (Abebaw and Belay, 2001).

CONCLUSION

Off-season vegetable production is a profitable business and Nepal has a wide potentiality, so can be adopted as a tool to minimize poverty , improve food security and in broad view raise the standard of living of farming communities. Adoption of off-season vegetable farming is found to be affected by socioeconomic and institutional characteristic of the households. Mainly four factors i.e. years of schooling, years of vegetable cultivation, access to extension services and training received are found significant. Thus, we can conclude that educated people are attracted to off-season farming and experienced vegetable growers tend to shift towards off-season vegetable cultivation.

It is recommended to increase extension services and training related to agriculture for better adoption of off-season vegetable cultivation.

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MORPHOLOGICAL AND MOLECULAR STUDY OF GENETIC DIVERSITY IN NEPALESE FINGERMILLET USING RAPD AND SSR MARKERS

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ABSTRACTS

Morphological and Genetic diversity among forty finger millet genotypes was estimated using RAPD markers. For the morphological diversity field experiment was laid out in RCBD design having two replications which shows the significant variability among the various seven quantitative traits such as SPAD reading, plant height, days to flowering, finger number and finger length. Among these traits finger length and finger numbers were the major traits to contribute the morphological variability. Similarly, Molecular diversity through RAPD produces 57 fragments of amplified bands with 73.68% polymorphism. Nei'sheterozygosity for all the loci ranges from 0.03 to 0.85 with mean of 0.327 and polymorphic information content (PIC) ranged from 0.42 to 0.29 with mean value 0.34 and maximum nine bands were produced by OPA-16. UPGMA clustering separates the forty landraces into four clusters on the basis of early and late flowering.Thus this study shows the wide range of genetic and morphological diversity among the landraces. The result of the present study revealed the existence of variability in finger millet landraces for a number of traits that could be employed to develop appropriate strategies for the conservation, exploitation and utilizationof finger millet landraces.

Key words: Morphological, molecular, diversity, RAPD, SSR

INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn] is the minor crop in Nepal but with major importance. Finger millet is the fourth important cereal crops of the country, after paddy, maize and wheat in production and productivity among cereals. In Nepal finger millet is cultivated in 2, 78,030 hectares with production and productivity of 3, 15, 067M tons and 1.13 M tons per hectares respectively (MOAD, 2013). In Nepal finger millet is mostly cultivated in hilly and mid hills of Nepal, it is the staple food for the majority of the population at those regions.

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In Nepal genotypes being cultivated in Terai and in higher elevation vary in different agro morphological and physiological traits and their yielding ability. More to this, the genotypes also have difference in the time of their plantation flowering and harvest. As there is variation in the microclimate and the elevation in short span in our country similar variation could be observed in the crops being cultivated in this region. This research was conducted to identify the level of genetic difference present in the finger millet genotypes being cultivated in Nepal.

Diversity means the variation caused by various factors, which ultimately creates variation within and between populations. Generally, the morphological diversity is caused by environmental and climatic factor and molecular diversity is due to modification in genetic combination due to; wide assortment of genes and alleles over time through changing environments depends on their capacity to adapt to shifting external conditions. Such conditions creates the importance of crop genetic resources that realized with the expansion of breeding programme, as the success of these programme largely dependent on availability of wide genetic diversity.

Comparison of parents using differences in DNA markers such as random amplified polymorphic DNA (RAPD) may be one of the method by which breeders can increase the probability of selecting those parents with different gene sets. Williams *et al*. (1990) proposed the use of random amplified polymorphic DNAs (RAPDs) as an additional form of molecular marker. Salimath*et al.* (1995) experimented with three different DNA marker techniques, *viz.,* RFLP, RAPD (18 primers) and ISSR (6 primers) to analyze the diversity of 22 accessions belonging to 5 species of *Eleusine* producing 14, 10, and 26 per cent polymorphisms in 17 accessions of *E. coracana* from Africa and Asia and very low level of DNA sequence variability in finger millet.

Panwar*et al.* (2010) studied the genetic diversity of fifty two genotypes with respect to calcium content evaluated through SSR, RAPD and Cytochrome P450 based markers. These markers showed polymorphism and dendrogram developed by each markers produced different clusters on basis of calcium contents. They conduct comparative analysis evaluation of RAPD, SSR and Cytochrome P450 markers on basis of quality data output, indicated that comparing different marker were promising role in analysis of plant genome diversity study and use of different molecular marker.

RESEARCH METHODS

Forty one landraces of finger millet were collected from different ecological regions of Nepal retrieve from NGOs (Li-Bird). Lab experiment and field experiment was conducted in National Agriculture Genetic Resources center (Gene Bank), NARC, and IAAS, Rampur, Chitwan for the field experiment. Field experiment was conducted on simple

CRD in laboratory condition with 2 replications. *GERMINATION DATE, PLANT HEIGHT (CM), DAYS TO FLOWERING, FINGER BRANCHING, FINGER LENGTH (CM*)**,** *FINGER NUMBER, SPAD READING WERE THE SEVEN* parameters were considered for the morphological diversity study.

DNA extraction

The total DNA will be extracted from the leaf tissue of all genotype using the modified CTAB method (Saghai-Maroof*et al.,* 1984). DNA will be isolated from shoots of eight day old plants as protocol given by Deshpande and Ranjekar (1980), using modified CTAB (Cetyltrimethyl Ammonium Bromide) extraction buffer. The final aqueous phase will be transferred into 2/3 volume of chilled alcohol to precipitate the DNA. The DNA precipitate will be recovered with 70% ethanol, then dried for more than 1 hour and finally dissolved in 50 ul of the lXTE buffer (1 mM EDTA, 10 mMTris-HCl, pH 8.0) and stored at -20 ^{o}C.

DNA amplification

For RAPD amplification 9 RAPDand 5 SSR primers were used, as according to the method of Williams *et al.* (1990), with minor modifications carried out the RAPD profiling. DNA amplification will be performed in 20 ul reaction volume containing 1.5 mMMgCl, 10 mMdNTPs, 12 ng of primer, 1.5 U *Taq*DNA polymerase and 50 ng template DNA. PCR amplification was performed in M.J. Research Thermocycler (PTC 200) with following cycling conditions namely denaturation at 94ºC for 1 min, annealing at 37ºC for 1 min and elongation at 72ºC for 2 min for 40 cycles after an initial denaturation for 5 min at 94ºC. After finishing of amplification 18 ul aliquots of amplification products will be loaded in a 1% (w/v) agarose gel (Bioneer) for electrophoresis in 1X TAE buffer. Gels will be stained with Ethidium bromide (0.5 ug ml^{-1} for 30 min) and visualized under exposure of UV light. Band will be scored on the basis of present and absent of amplified fragment. There will be standard 1 kb Ladder (Promega) for comparing size of the band.

Data analysis

General mean, Range, Standard deviation (σ), Correlation coefficient were calculated for the morphological analysis and for the molecular data using MS-EXCEL, MSTAT XL-STAT software. The RAPD and SSR profiling were scored for the presence (1) or absence (0) of bands of various molecular weight sizes in the form of binary matrix. In this study, principle component analysis, dice similarity coefficient (Nei's 1978) and UPGMA clustering were performed from molecular data with the help of software MS-EXCEL, NTSYS-PC, POPGENE Version 1.32, GENALEX 6.5; GELQUEST will be used for the data analysis in a binary matrix form.

Results and discussions

Most of the morphological parameters show the highly significant results during study and range among the various traits, mean value, standard deviation and coefficient of variation were as shown in table below.

Table 1. Summary statistics for morphological parameter of finger millet at Rampur, Chitwan, Nepal, 2013

Parameters	Range	Mean	Standard deviation (SD)	Coefficient of Variation (%)
Germination (days)	3 to 7	5.69	1.29	18.42
SPAD Reading	21.0 to 39.1	30.27	4.71	11.30
Plant height (cm)	48.25 to 106.5	83.49	13.91	10.50
Days to flowering	84.00 to 74.25	94.32	7.31	0.93
Finger number	3.25 to 10.5	5.63	1.27	17.93
Finger length (cm)	3.25 to 10.25	4.98	1.30	11.65

Phenotypic correlation among different traits

Most of the trait studied here shows the significant correlation among each other result at both 5 % and 1% significant level at positive and negative level of significance at positive and negative level.

Table 2.Pearson's correlation coefficients for quantitative traits of 40 fingermillet cultivars

Quantitative Traits	Germination (DAS)	Flowering (DAS)	Plant height (cm)	SPAD	Finger Number	Finger length (cm)
Germination	1.000	-0.062	0.230*	0.286**	-0.109	0.203
Flowering		1.000	-0.760**	-0.749**	0.763**	-0.323**
Plant height (cm)			1.000	0.740**	-0.748**	0.463**
SPAD				1.000	-0.674**	0.304**
Finger number					1.000	-0.268*
Finger length						1.000

*Correlation is significant at the 0.05 level of significance (2-tailed); **Correlation is significant at the 0.01 level of significance (2-tailed);

Principal component analysis (PCA) shows the variance for first three component are about more than 70%. That is, days to flowering, finger number and finger length shows the maximun contribution on veriability among different finger millet accessions.

Molecular diversity

Nine RAPD primers generate 57 different bands fragments, with average of 6.33bands per primer and primers shows 73.68% polymorphism during amplification. Primer OPA-4 produced the highest numberof bands and lowest numbersof bands were produced by OPA-16 as shown in table 4. Nei'sheterozygosity for all the loci ranges from 0.03 to 0.85with mean 0.327±0.027, similarly unbiased heterozygosity was 0.335±0.028. Similarly, phylogenetic analysis based on UPGMA grouping with 57 loci generated by nine random primers separates 40finger millet cultivars into four major groups according to maturity indices in Nei's genetic distance of 40 finger millet accessions using UPGMA methods with bootstrap of 1000 replications

Table 3. Name of primers with amplified numbers bands, polymorphic information content (PIC) and standard deviation

SN	Random decamers	No of bands amplified	PIC	Standard deviation
1	OPA-03	7	0.27	0.23
2	OPA-16	3	0.28	0.20
3	OPA-08	7	0.45	0.08
4	OPA-04	9	0.40	0.15
5	OPA-13	5	0.15	0.18
6	OPC-06	5	0.27	0.21
7	OPC-14	8	0.33	0.20
8	OPB-01	6	0.42	0.05
9	OPA-10	7	0.26	0.23
	Mean	6.33	0.314	0.174

Das *et al.* (2007) also screened nine primers from twenty-five decamer primers were used (OPA4, OPA13, OPA16, OPC12, OPC18, OPD8, OPN7, OPN15 and OPN16) which were highly reproducible and developed more bands were selected for to analyzing the genetic relationship among the fifteen genotypes of finger millet. Among them OPA4 produces highest (8-9) bands, and OPA 13 was 100% polymorphic and OPA16 was 50% polymorphic in nature.

Babu*et al*. (2007) also found that the maximum number of bands by OPA-04, during diversity analysis and Sharma *et al.* (2002).

Nei'sheterozygosity for all the loci ranges from 0 to 0.5 with mean 0.331±0.015, similarly unbiased heterozygosity was 0.335±0.015. Which may be due to high genetic material transfer between different regions as a source of propagation. Shannon's information index was found to be 0.498±0.019 where number of alleles was 2±0.00 with effective number of alleles 1.559±0.032.

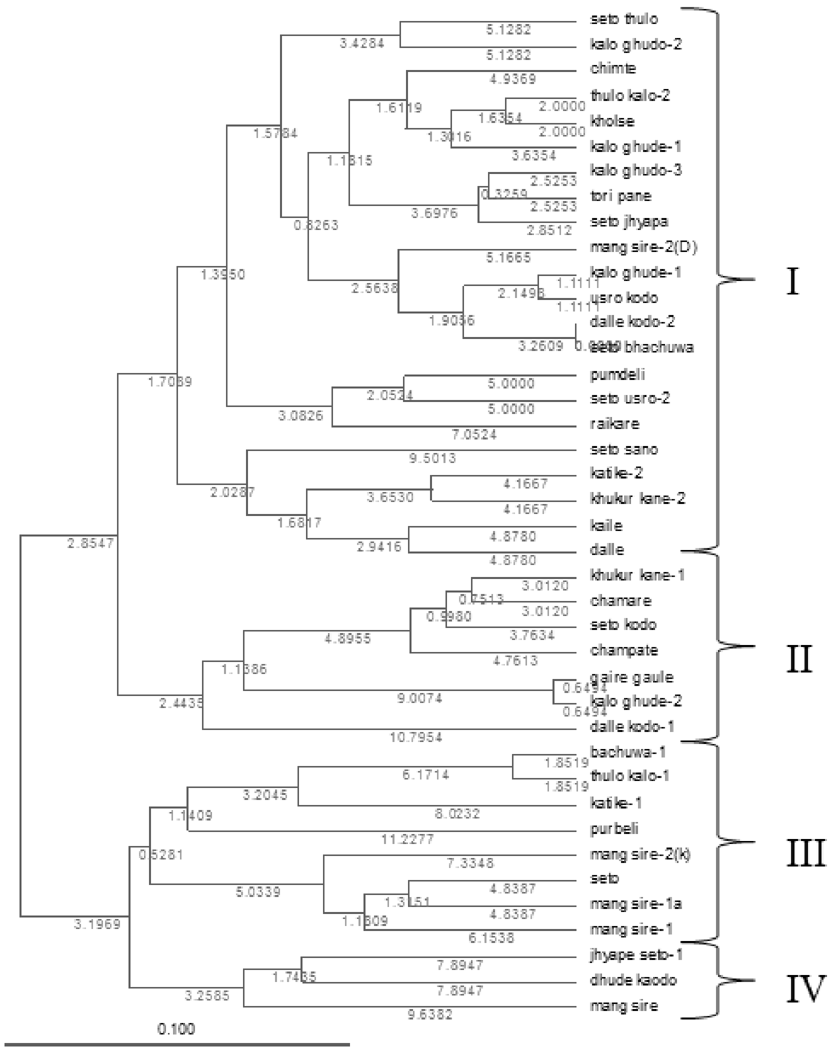

Figure 1. Dendrogram showing 40 finger millet accessions based on Nei's genetic distance using UPGMA methods with bootstrap of 1000 replications

Molecular analysis through SSR markers

Five SSR primers generate 39 different bands fragments, with average of 7.8 bands per primer and primers shows 87.18% polymorphism during amplification. Primer SSR-06 produced the highest number of polymorphic bands and UGEP-53 produces lowest band during amplification, as shown in the table.

Table 4. Name of Primers with Amplified numbers Bands, Polymorphic Information Content (PIC) and standard deviation

SN	Name of the primer	No of bands amplified	PIC	Standard deviation
1	SSR-06	15	0.32	0.18
2	SSR-08	8	0.34	0.09
3	UGEP-53	8	0.49	0.00
4	UGEP-10	1	0.35	0.16
5	UGEP-1	7	0.37	0.16
	Mean	7.8	0.37	0.12

Nei'sheterozygosity for all the loci ranges from 0.04 to 0.93 with mean 0.263±0.025, similarly unbiased heterozygosity was 0.267±0.025.The phylogenetic analysis based on UPGMA grouping with 39 loci generated by five SSR primers separates 40 finger millet cultivars into two major groups in Nei's genetic distance of 40 finger millet **a**ccessions using UPGMA methods with bootstrap of 1000 replicationsas in Figure 11. First group first group consists of twenty-four wild landraces and second group second group comprises of sixteen cultivable. The UPGMA grouping again two sub groups from each main group as shown in the Figure 2. Morphologically the genotype did not have any distinguishing character though during molecular diversity landraces are separated according to wild and cultivable species.

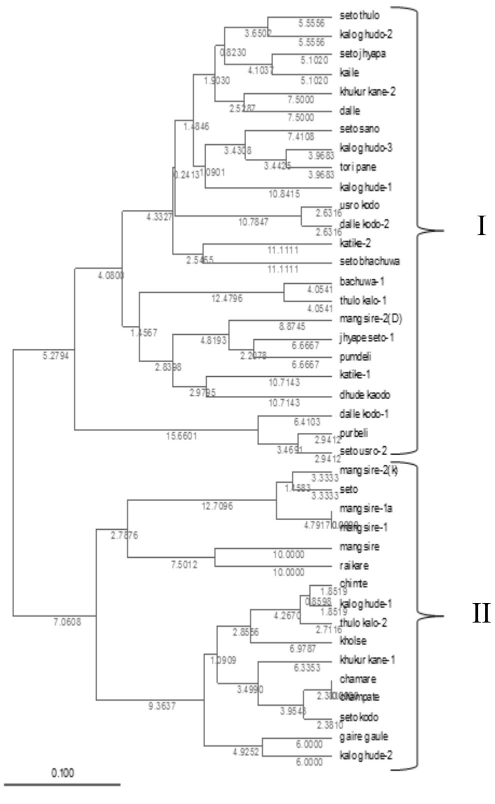

Figure 2.Dendrogram showing 40 finger millet accessions based on Nei's genetic distance using UPGMA methods with bootstrap of 1000 replications through SSR markers.

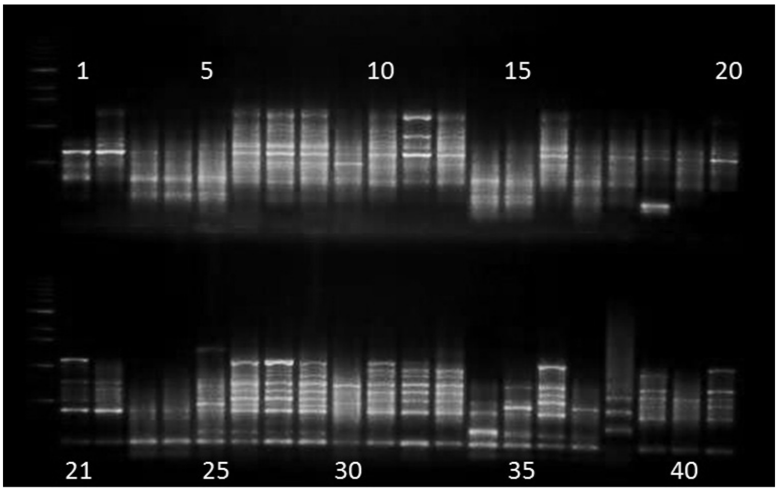

Figure 3. Fingerprint showing RAPD profile of 40 finger millet genotype generated by primer OPA-04

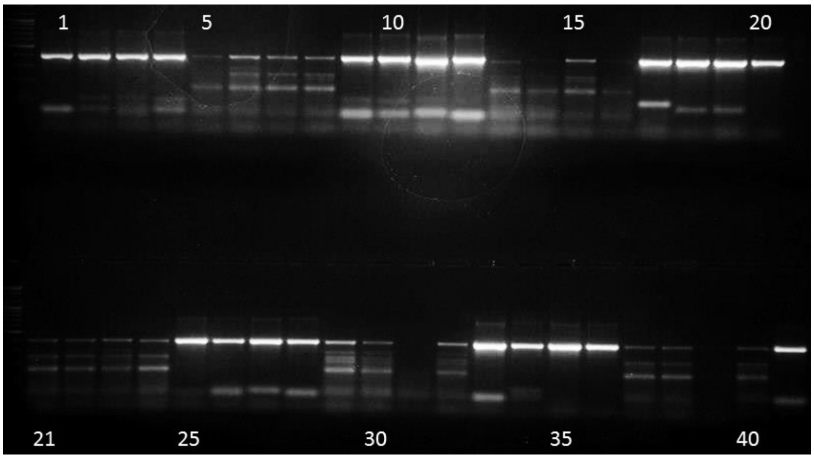

Figure 4. Fingerprint showing SSR profile of 40 finger millet genotype generated by primer UGEP-10

DISCUSSION

The combination of yield attributing traits as well as other important quantitative traits was used for the morphological diversity study of finger millet. Most of the traits analyzed, shows the significance F-value showing variability among the genotype in different traits.

Many scientists have studied the diversity of finger millet and other cultivars based on quantitative traits. Reddy et al (2009) studied morphological diversity of Eastern African finger millets based on quantitative and qualitative traits,which show significant result in breeding purpose. Selection of cultivars based on only yield will not be effective till the different traits contributing yield is studied. Therefore, it is necessary to characterize variation based on the important quantitative traits of the germplasm. Such analysis of quantitative traits will help plant breeder for improving crops based on transferring traits of economic important.

During molecular study through RAPD markers 40 Nepalese landraces of finger millet shows wide range of diversity among population, nine RAPD shows 73.68% polymorphism and 5 SSR markers were used, showing 87.18% polymorphism. Two SSR primers, SSR-06 and SSR-08 used for amplification represent the calcium content in finger millet and other SSR primers and all RAPD markers used were selected from previous experiments.

SSR markers show the large diversity between the 40 landraces of finger millet. During amplification, 39 polymorphic bands were produced from five SSR primers with average PIC value 0.38±0.16 where SSR-06 produces the maximum and UGEP-10 produce lowest number of bands. SSR primers show 87.18% polymorphic bands.

During UPGMA grouping five SSR primers separates 40 landraces into two major groups among them first groups represents the wild and second group represents the cultivable cultivars. Two SSR markers SSR-06 and SSR-08 used during amplification represents the gene relates to calcium content though these markers shows 15 bands with 3 monomorphic bands by SSR-06 and total 10 bands by SSR-08 with all bands polymorphic that implies the Nepalese landraces of finger millet were rich in calcium content though more exploration and further research activities were needed.

CONCLUSION

The molecular variability alone with morphological characterization was found to be the confirmative and accurate methods for diversity analysis. Morphological traits shows high level of significance in SPAD reading, plant height, flowering date, finger length and finger number. Morphologically, wide range of genetic distance from 0.027 to 0.853 was obtained by RAPD and 0.04 to 0.93 by SSR markers which show large diversity among Nepalese landraces. UPGMA grouping also separates landraces into different groups, RAPD markers separates landraces according to maturity indices into four groups and SSR primers separates 40 landraces according to wild and cultivable cultivars into two groups. Observed morphological and genetic variability among given forty landraces of finger millet can be utilized to develop appropriate strategies for the conservation, exploitation and utilization of finger millet landraces for improving yield and biomass of the crop.

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STUDY ON THE COLIFORM CONTAMINATION IN MILK AT VARIOUS FLOW LEVELS AND SEASONAL EFFECT ON ITS COUNT

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ABSTRACT

High microbial load associated with coliform bacteria in milk could lower their keeping quality and might be the sources of potential risk for milk epidemics. A prospective study has been carried out during the period July 2013 to January 2014 with the objective to understand the major steps involved in milk collection and processing and correlate it with the coliform load and milk hygiene in the milk chain system of a dairy plant (A) viz., farmer, collection centre, chilling centre, raw milk reception dock, and packaged milk of summer and winter season. The data were set in a complete randomized design statistical model having 10 treatments with 5 replications. The results showed that average coliform count of farmer, collection centre, chilling centre and reception at dairy of summer season were found to be 4.1820 $\log_{10}$, 5.074 $\log_{10}$, 5.44 $\log_{10}$, and 6.482 $\log_{10}$ cfu/ml respectively and the average coliform count of farmer, collection centre, chilling centre and reception of winter season were found to be 1.96 $\log_{10}$, 3.908 $\log_{10}$, 4.232 $\log_{10}$, and 5.360 $\log_{10}$ cfu/ml at dairy respectively. Results indicated that coliform load in milk is much higher than EU regulation (less than 2 $\log_{10}$ cfu/ml or less than 100 cfu/ml). Coliform count increases rapidly from just after milking to reception at dairy and the coliform load reduces drastically in winter season due to temperature effect. The average coliform count of packaged milk was found to be 1.034 $\log_{10}$ cfu/ml in summer and 0.7040 $\log_{10}$ cfu/ml in winter, which crosses the permissible limit of zero per ml (Nepal Gazette, 2001). The high coliform count was due to lack of personal hygiene, chilling facilities, and cleanliness of cattle/shed and improper handling of milk as revealed by the socio-economic survey. Results concluded that coliform load in milk in different flow levels and season differ significantly ($p<0.05$). The study provides vital information for all the milk handlers to get rid of high coliform load in milk in the milk chain system from farmer to consumer.

Key words: Coliform, VRBA, Milk Chain System, Seasonal effect

INTRODUCTION

Milk is defined to be clean lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows, 5 days after and 15 days before parturition, and containing the minimum prescribed percentages of milk fat and milk-solids-not-fat (De, 2011). Milk constituents include water (87.20%), protein (3.50%), fat (3.70%), milk sugar or lactose (4.90%), ash (0.70%) and dry matter (12.80%) (De, 2011).

Milk and milk products consist of high moisture, nearly neutral in pH and are rich in vitamins. Hence, milk easily favors the growth and multiplication of many bacteria, even pasteurized or refrigerated. These bacteria may significantly influence the quality of the milk and milk products. Milk is synthesized in specialized cells of the mammary gland and is virtually sterile when secreted into the alveoli of the udder. Beyond this stage of milk production, microbial contamination can generally occur from three main sources i.e., within the udder, the exterior of the udder and the surface of the milk handling and storage equipment (Godefay and Molla, 2000). Bacterial contamination of raw milk can originate from different sources: air, milking equipment, feed, soil, feces and grass (Coorevits et al., 2008). The number and types of micro-organisms in milk immediately after milking are affected by factors such as animal and equipment cleanliness, season, feed and animal health. It is hypothesized that differences in feeding and housing strategies of cows may influence the microbial quality of milk (Coorevits *et al*., 2008). Rinsing water for milking machine and equipment washing may also be responsible for presence of high number microorganisms including pathogens in raw milk (Bramley *et al.,* 1990). Gram-negative bacteria usually account for more than 90% of the microbial population in cold raw milk that has been stored (Buchanan *et al*., 1984).Although milk is known to posses several antimicrobial systems, bacterial numbers will double in less than 3 hours in unchilled milk. The rate of microbial growth will depend on initial numbers and the temperature at which milk is held after milking and thereafter (Kurwijila *et al*., 1992).

The increase in urban population during the present century and improvements in methods of milk preservation have led to large scale transportation of milk from the producer to the consumer areas (Mirkena, 2010). Raw milk collection and its transportation to the processing centers present a number of technical, economical and organizational problems in most developing countries in tropical regions (Mirkena, 2010). These have inevitably increased the risk of infection of many people from a common source. Lack of refrigeration facilities at the farm and household level, with high ambient temperature implies that raw milk will easily be spoiled during storage and transportation (Gilmour, 1999). Diseases that commonly spread from the milk to human beings are tuberculosis, brucellosis, salmonellosis, listeriosis, campylobacteriosis, yersinoses, and other bacterial pathogens transmitted to humans include *streptococcus agalactaciae*, *staphylococcus aures* and *Escherichia coli* (Hahn, 1996).

Milk in most places in Nepal is consumed raw. Milk products such as yoghurt and butter are also produced using raw milk as a starting material. Hence, there exists the possibility of consuming milk, which has been contaminated with disease causing organisms. Hygienic quality control of raw milk and milk products in Nepal is not usually conducted on routine basis. Apart from this, door to door raw milk delivery in the urban and peri-urban areas is commonly practiced with virtually no quality control at all levels. So this study was conducted to identify the microbiological contamination of raw and pasteurized milks from the selected milk processing plant.

METHODOLOGY

The samples required for this study were collected from a dairy having milk chain system of Kathmandu valley. A total of 50 samples were collected from farmers/milk producers and 5 samples were collected in each steps of milk chain system viz., collection centre (CO), chilling centre (CC), Reception (RP), Packaged milk (PM) of summer and winter season. A random sampling method was adopted during sample collection. As far as possible, the same lot of milk was used for analysis at different stages. The laboratory of Himalayan College of Agricultural Sciences and Technology (HICAST) was used for testing the samples. All samples were analyzed in the strict aseptic environment (spirit and flame sterilized). The milk samples were mixed thoroughly by gently inverting the milk vial 20 to 25 times. Serial dilution technique was applied prior to the pour plate technique to thin out the microbial population in the sample where it was necessary. Dilutions of milk sample were prepared by a series of sterile Quarter Strength Ringers Solution (QSRS). Enumeration of Coliform bacteria is based on the assumption that a single viable microbial cell forms a visible colony in VRBA media when diluted sample is incubated in optimum temperature. All colonies on plates were counted after incubation period. Every sample of milk had two plates of different consequent dilutions. The dilutions of the sample were selected such that the total number of colonies in one plate was between 30 to 300 (NDDB, 2001). The average Coliform count of all milk samples were expressed as log $_{10}$ cfu/ml. Number of colony forming units per ml (cfu/ml) was calculated as per NDDB (2001). Number of colony forming units (cfu/ml) = $\Sigma_{c\,/}\ v\ (n_1 + 0.1\ n_2)\ d$. Altogether there were 10 treatments viz., summer-farmer, summer-collection center, summer-chilling center, summer-reception, summer-packaged milk, winter-farmer, winter-collection center, winter-chilling center, winter-reception and winter-packaged milk. 5 replications were done for each treatment. The data obtained were statistically analyzed by using Genstat (3.4.2). Analysis of variance (ANOVA) was performed. The differences among sample means were separated by use of the least significant difference (LSD) test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Socio-Economic survey

Socio-Economic survey of farmers of Banepa revealed that 100% of the farmers did not get training related to milk production. 65% of the farmers did not have the knowledge of common disease and 100% of the farmer did not have the knowledge about coliform bacteria. 70% of the farmer sold last night milk and 67.5% of the farmers added unsanitized water in milk before selling. Only 45% of farmer trimmed their nails frequently while 100% of the farmers did not chill the milk after milking. Only 47.5% of farmers washed hands and utensils daily. 90% of the farmers washed udder before milking but 82.5% of the farmers did not wash udder after milking. Only 10% of the farmers cleaned their cattle daily.

Coliform count

Season	Flow level	Mean Colony Count (log10 cfu/ml)
Summer	Farmer	4.182
	Collection center	5.07
	Chilling center	5.44
	Reception at dairy	6.42
	Packaged milk	1.03
Winter	Farmer	1.96
	Collection center	3.90
	Chilling center	4.23
	Reception at dairy	5.36
	Packaged milk	0.70

Effect of season

The coliform load reduced drastically in winter season by 27% but not reduced to acceptable limits. The reason in high reduction of coliform count on winter season was due to temperature effect. Bramley (1990) reported that some species of the genera making up the coliform group of bacteria are psychrotrophic and constitute 10–30% of the whole group of micro-organisms; the majority of these coliforms are *Aerobacter* spp. (Salman and Hamad, 2011) did a similar study, the percentage of the highest count of more than 1100 cell/ml was higher in summer (17.1%) compared to 8.4% during winter. The coliform load in milk due to season differ significantly ($p<0.05$) (Table 1)

Table 1 : Effect of season

Treatments	Values ($\log_{10}$ cfu/ml)
Summer	4.44
Winter	3.23
P< 0.05	0.028
L.S.D	1.074

Effect of flow level

The coliform goes on increasing from farmer to reception at dairy. The time lag between farmers to collection centre, collection center to chilling center and chilling center to reception is major factor responsible for the milk contamination. Fresh milk drawn from a healthy cow normally contains a low microbial load (less than 1000 per ml), but the loads may increase upto 100 fold or more once it is stored for sometimes at normal temperatures (Mirkena. 2010*)*. After observing the milking practices at noon and evening, the researcher seriously felt the need of chilling vat and its lack was the major cause of milk degradation. Moreover, it was also found that milk had to be left for 10 to 15 hours at night before being transported to the chilling centre. Improper cooling and prolonged storage of milk can also influence bacterial count by increasing the rate of bacterial growth during storage of milk (Kagki *et al*., 2007). In most of the cases, the narrow opening utensils were in practice for milking, handling and transportation. Apparently it was seen that cleaning and washing such utensils was almost impossible because of inaccessibility. In majority of cases, part of spoiled milk that deposited in the milking utensils might have contributed greatly in milk contamination. The coliform load in milk due to flowlevel differ significantly at $p<0.01$ (Table 2).

Table 2: Effect of flow level

Treatments	**Values ($\log_{10}$ cfu/ml)**
Farmer	3.07
Collection center	4.49
Chilling center	4.84
Reception	5.92
Packaged	0.87
P<0.01	<0.001
L.S.D	0.827

Effect of treatment combination

The coliform count increase significantly from farmer to collection center. There is no significant increase in count from collection center to chilling center because milk immediately goes to chilling below 10^0C at chilling centre. Only psychotropic organisms grow at that temperature. There is a significant increase in count from chilling center to reception at dairy. The coliform count decrease drastically during pasteurization of milk at dairy. So, there is very little number of microorganisms in packaged milk. There is a significant difference in treatment combination (flowlevel*season) at $p<0.05$ (Table 3).

Table 3 : Effect of treatment combination

Treatments	Value (log_{10} cfu/ml)
Summer-Farmer	4.18
Summer-Collection	5.07
Summer-Chilling	5.44
Summer-Reception	6.48
Summer-Packaged	1.03
Winter-Farmer	1.96
Winter-Collection	3.90
Winter-Chilling	4.23
Winter-Reception	5.36
Winter-Packaged	0.70
P<0.05	0.03
L.S.D	0.78

CONCLUSION

The results obtained in this study concluded that raw Cow's milk available to consumers was highly contaminated with the coliform. High and strict preventive measures like regular washing and sterilization of dairy equipment, utensils, milker's hands, and animal udders, pasteurization of milk before distribution to consumers and eradication of diseased animals from the herd are highly recommended. In this respect pasteurization and immediate cooling to 5ºC of milk could be more effective. In the milk chain system, the bacterial load from collection centre to chilling centre was seen relatively similar. But other two different points were seen to be reformed urgently. Collection centre and its entire milking operation was questionable, similarly the chilling center's operation and tanker parties were also equally responsible for milk deterioration. Especially when the government or related authority tries to implement the quality based program, these two points need to be considered as the target in the milk chain system.

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SCREENING OF WHEAT (TRITICUM AESTIVUM L.) GENOTYPES WITH MORHPHO -PHYSIOLOGICAL TRAITS UNDER IRRIGATED AND RAINFED CONDITIONS IN RAMPUR, CHITWAN

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ABSTRACT

A field experiment was conducted in alpha lattice design at research field of IAAS, Rampur from November, 2012 to April, 2013 to screen the morpho-physiological traits related to post-anthesis drought in wheat (*Triticum aestivum* L.) genotypes along morpho-physiological traits, stress tolerant indices and heritability of stress tolerant traits. Thirty six wheat genotypes in two water regimes (i.e., rainfed and irrigated condition) with three replications for each trial were done. The plant material for the research study was taken from the Agriculture Botany Division NARC, Khumaltar, Nepal. The plant materials consist of twenty four Wheat Khumal (WK) lines, seven CIMMYT lines, one commercial variety, and other four genotypes as advances lines. Recording and observation of data was done by regular field visit for the morpho-physiological traits days to 50% booting, days to heading, days to 50% anthesis, days to 50% maturity, and grain yield. Data entry was carried out with the help of Ms –Excel 2007, and Analysis of variance was done by R.3.0 STUDIO Software packages for alpha lattice design and correlation study was done by SPSS 16. Significant difference was found between the genotypes and two watering regimes. Under irrigated condition WK2349 (1646.67 kg/ha) had lowest and highest grain yield were found in WK2373 (3281.67 kg/ha) followed by Danphe#2 (3231.67 kg/ha).

Key words: Drought, morphophysiological traits and heritability etc.

INTRODUCTION

The most important limiting factor for crop production is drought and it is becoming increasingly severe problem in many regions of the word. Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world providing staple food for 35% of the world's population and provides more calories and protein in the world's diet than any other cereals (CIMMYT, 2010). After rice and maize, wheat is the third important cereal crop of Nepal in terms of area, production and productivity (MoAD, 2012/13). It is grown under winter season in Nepal and cultivated from the Terai (60 Masl) to high mountain (3500

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Masl). At present, the wheat sown area in Nepal is 7, 54,243 ha with a total production of 17, 27,346 metric tons and productivity of 2.29 $Mgha^{-1}$ (MoAD, 2012/13). In Chitwan, wheat is cultivated on total area of 8750 ha with the total production of 30,125 mt and productivity of 3.443 $Mgha^{-1}$ (MoAD, 2012/13). Yield improvement in wheat varieties had not been substantial; the narrowly used of germplasm and some abiotic factor like climate change, drought, and heat stress had been considered the main reason. Production of wheat is dependent upon many factors like biotic and abiotic. At present Nepalese farmer are growing improved varieties of wheat mostly under irrigated condition but much area in hill and terai are grown under rainfed condition. Drought and high temperature had currently significantly affected the wheat productivity in developing country like Nepal and developed world. Climate change had been drastically decline in wheat production globally (CIMMYT Report, 2000). Water availability is the most important factor determining yield. Winter wheat grown in this region matures under the stressful conditions of decreasing water availability and increasing temperatures. In a water-limiting environment grain yield is dependent on the amount of water used by the crop, water use efficiency and harvest index (Passioura, 2002). Improvement of any one of the above factors in water-limited environment should result in increased yield. The present study was initiated to study and compare the drought related morpho-physiological traits of wheat (*Triticum aestivum* L.) genotypes under rainfed and irrigated conditions.

MATERIALS AND METHODS

This study was conducted at the research field of the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal, from November 2012 to June 2013. The field experiment was conducted in alpha lattice design. There were two conditions, fully irrigated and rainfed. Each condition was replicated 3 times. In each replication there was 4 blocks each consisting of 9 plots. Each plot was 1m in length and 1m in width. Each plot consisted of 4 rows with a spacing of 25 cm between rows and in a row plant was sown continuously. There was a gap of 0.5m between the blocks and plots was continuous in the block so net plot per replication was 36m2 so the net experimental field was 216m2. The plant materials for the research were taken from the Agriculture Botany Division NARC, Khumaltar, Nepal. The plant materials consist of wheat advance lines that consist of twenty four Wheat Khumal (WK) lines, seven CIMMYT lines, one commercial variety, and other four advance generation lines. The completed list of thirty six genotypes used in the experiment was presented in the Table 1.

Table 1. List of the genotypes used for experiment at IAAS, Rampur, Chitwan (2011/2012)

Entry No. Genotypes	Genotypes	Entry No. Genotypes	Genotypes
1	WK 2403	19	WK 2382
2	WK 2348	20	WK 2383
3	WK 2349	21	WK 2385
4	WK 2350	22	WK 2386
5	WK 2352	23	WK 2388
6	WK 1204	24	Munal #
7	WK 2356	25	WK 2389
8	WK 2363	26	WK 2408
9	WK 2368	27	30 ESWYT 104
10	WK 2369	28	30 ESWYT 107
11	WK 2373	29	30 ESWYT 102
12	WK 1481	30	Choute # 1
13	Danphe # 2	31	30 ESWYT 144
14	WK 2374	32	30 ESWYT 140
15	WK 2378	33	30 ESWYT 123
16	WK 2379	34	30 ESWYT 126
17	WK 2380	35	WK 2030
18	Chyakhura # 1	36	WK 1792

Sampling and observation was done on the following parameters for the study: days to booting (DTB), days to heading (DTH), days to anthesis (DTA), days to maturity (DTM) and grain yield (GY) and statistical analysis was done by data entry done in Ms –Excel 2007, Analysis of Variance was done by R.3.0 studio software packages in alpha lattice design. Correlation coefficient between various morpho-physiological, secondary and yield attributing traits were done by SPSS 16 software package.

RESULTS AND DISCUSSION

Days to booting

There was highly significant difference ($P \leq 0.001$) in the days to booting for environment and genotypes as shown by ANOVA. Mean number of days to booting were 77 and 79 days after sowing under rainfed and irrigated conditions respectively. At rainfed condition superior genotypes WK2379 (66) and WK1792 (67) booted earlier to check WK1204 (74) while, WK2382 (101) booted late were inferior to check. Similarly, at irrigated condition superior genotype WK1792 (68) and WK2379 (69) booted earlier to check WK1204 (76) while, WK2382 (103) booted late were inferior to check.

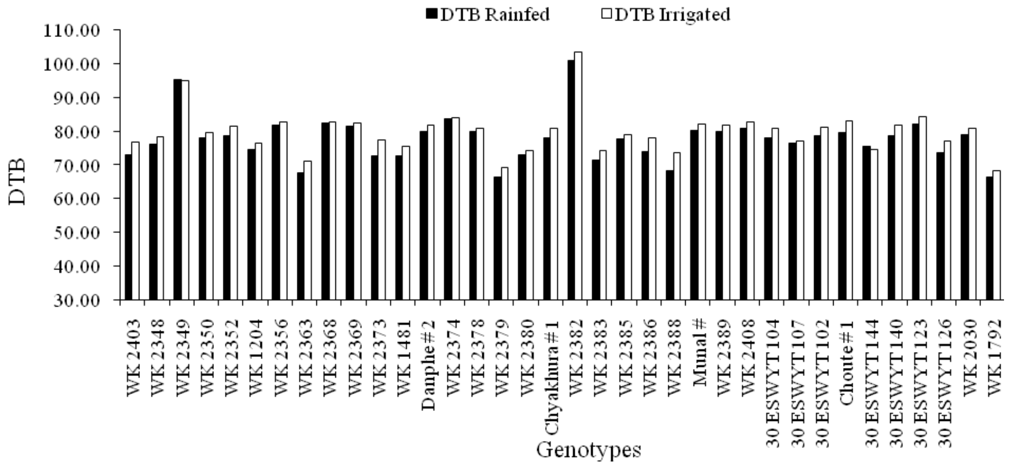

Figure 1. The graph showing the comparison between days to booting of different genotype under rainfed and irrigated conditions at IAAS, Rampur (2012/13)

Days to booting were negatively highly significantly correlated with number of grains per spike, weight of grains per spike, thousand kernel weights and grain yield under rainfed and irrigated conditions shown by correlation. This finding were in the agreement of with that the previous findings (Baral, 2011; Subhani and Chowdhry, 2000), who found that days to booting were negatively correlated with number of grains per spike, weight of grains per spike, thousand kernel weight and grain yield. This indicates that genotypes booting earlier had more grain yield than late booting genotypes due to more days of grains filling. Earlier booting is a chance to escape drought at later stage of grain filling period reported by Baral (2011). The decrease in days to booting in stress plants as compared to non- stressed wheat were reported by Reynolds et al. (1998); Ojha (2010).

Days to heading

Highly significantly difference ($P \leq 0.001$) in the days to heading for the genotypes as shown by ANOVA. The mean number of days to heading of wheat for irrigated and rainfed were 86 and 84 days after sowing, respectively. WK1792 (75) and WK2379 (76) genotypes headed earlier and were superior to check WK1204 (83) while, WK2382 (110) genotypes headed late and were inferior to check at irrigated condition. Similarly, WK1792 (71) and WK2379 (72) with earlier days to heading were superior to check WK1204 (82) while, WK2382 (106) with late days to heading were inferior to check at rainfed condition. Earlier days to heading genotypes were earlier in maturity and reduced number of grain filling duration and ultimately decreased in yield, but it can escape post-anthesis drought. Thus, selection should be made to those genotypes having earlier days to heading and higher yield. Days to heading were negatively highly significantly correlated with number of grains per spike, weight of grains per spike, thousand kernel weight and grain yield under rainfed and irrigated conditions. This result was supported by previous findings (Ojha, 2010; Baral, 2011). Kılıç et al. (1999) reported that reduction in number of days to heading, number of spike per m2, 1000 grain weight and grain yield of durum wheat in drought conditions. The decrease in heading days in stressed plants as compared to non-stressed wheat were reported by Reynolds et al., (1998); Olivares-Villegas et al. (2007); Ojha (2010). They have found reduction in days to phonological stages by the crop being reduced by 10% in stressed condition.

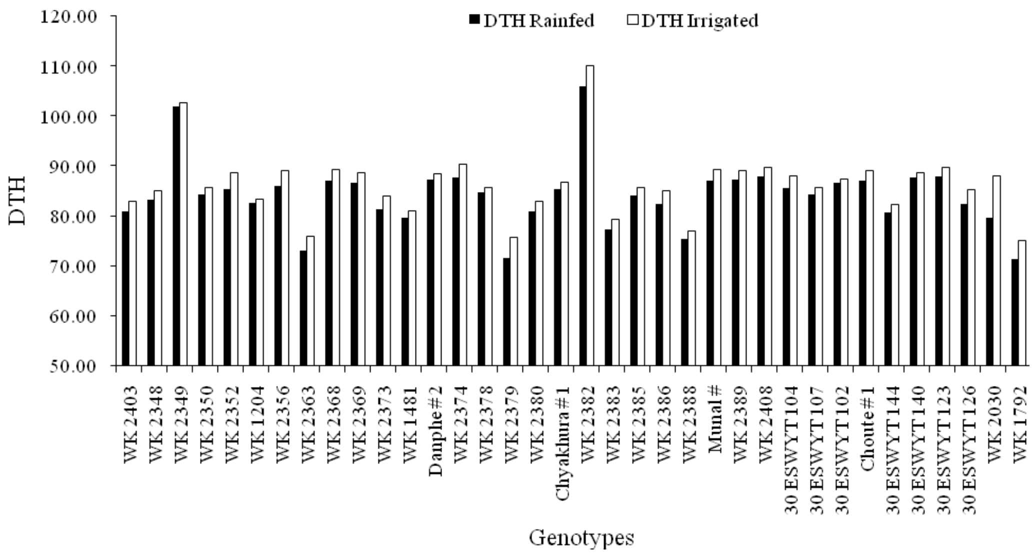

Figure 2. The graph showing the comparison between days to heading of different genotype under rainfed and irrigated conditions at IAAS, Rampur (2012/13)

Days to anthesis

There was highly significant difference ($P \leq 0.001$) in the days to anthesis for the genotypes and environment as shown by ANOVA. The mean number of days to anthesis for irrigated and rainfed conditions were 92 and 90 days, respectively. WK2363 (83) and WK1792 (84) genotypes anthesis earlier and were superior to check WK1204 (91) while, WK2382 (109) was inferior to check under irrigated condition. Similarly, WK1792 (79) and WK2388 (81) genotypes anthesis earlier and were superior to check WK1204 (88) while, WK2382 (109) was inferior to check at rainfed condition. Reduction in number of days to anthesis was due to the less physiological activity of plant under stress environment. Result showed that days to anthesis were reduced under stressed condition than non-stressed condition. This finding was in agreement with the finding of Leilah and Al-Khateeb (2005).

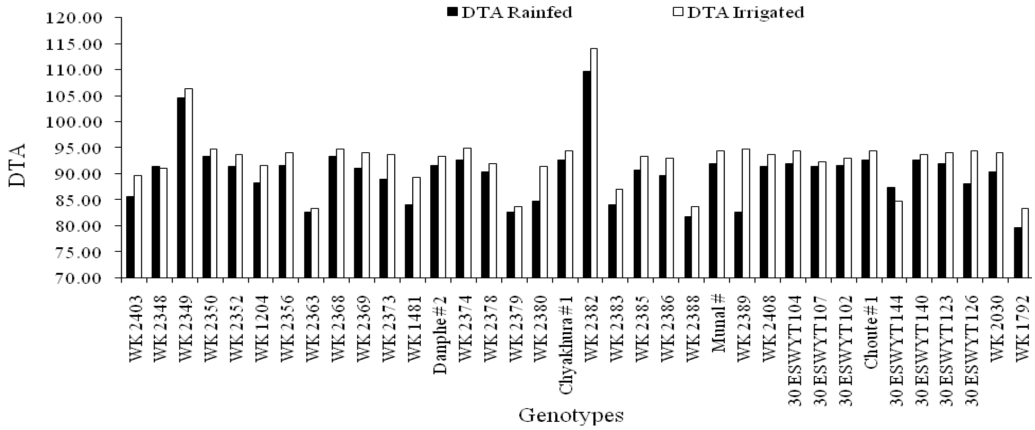

Figure 3. ***The graph showing the comparison between days to anthesis of different genotype under rainfed and irrigated conditions at IAAS, Rampur (2012/13)***

Days to maturity

There was highly significant difference (P≤0.001) in the days to maturity for the genotypes, environment and replication, respectively as shown by ANOVA. Mean number of days to maturity for irrigated and rainfed conditions were 124 and 121 days after sowing, respectively. Under irrigated condition, WK1792 (111) and WK2363 (119) mature earlier and were superior to check WK1204 (124). While, genotype WK2382 (137) was inferior to check. Similarly, under rainfed condition, WK1792 (103) and WK2379 (113) genotypes mature earlier and were superior to check WK1204 (121), while WK2349 (135) was inferior to check. Days to maturity are important character for development of drought tolerance genotypes in wheat. In Nepal, most of the area under wheat is grown during winter season after the harvest of rice under rainfed condition. Monsoon is starting late in recent years. Therefore, late planting of rice leads to delayed sowing of wheat. In this condition wheat perceives high temperature and water stress at grain filling period.

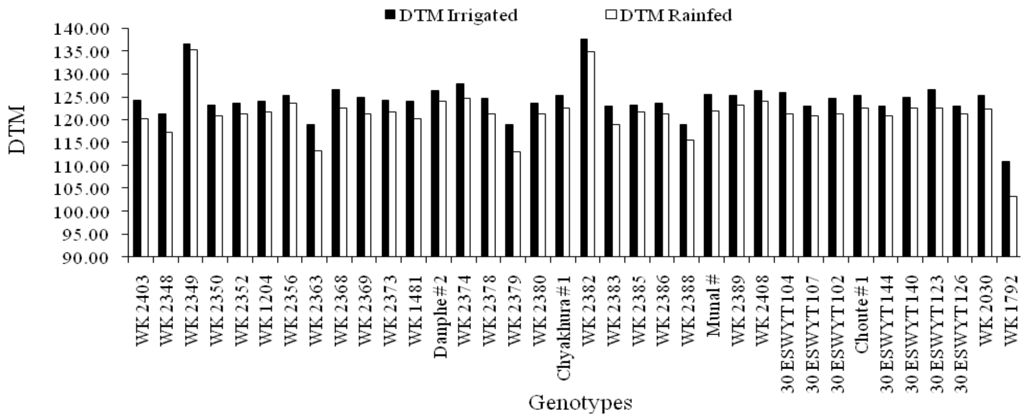

Figure 4. ***The graph showing the comparison between days to maturity of different genotype under rainfed and irrigated conditions at IAAS, Rampur (2012/13)***

Having early maturity genotypes with high yield should be considered during selection for this environment. This results was similar with the findings of Baral (2011), he found that maturity days under stress is contributed by the lower level of nutrients in plant and decreased chlorophyll due to lack of nitrogen in the leaves needed for the assimilate formation. Days to maturity were highly significant positive correlation with effective number of tiller, days to booting, days to heading, days to anthesis, days to flag leaf senescence, SPAD chlorophyll reading and spike length at both rainfed and irrigated condition. But it was negatively correlated with number of grains per spike, thousand kernel weight, and weight of grains per spike and grain yield. Similar findings were found by Mohammadi et al. (2012). According to Asif et al., (2004) days to maturity has the positive and direct effect on the grain yield.

Grain yield

There was highly significant difference (P≤0.001) in grain yield for the genotypes as shown by ANOVA. Mean grain yield under irrigated and rainfed conditions were 2511.56 kg/ha and 2286.56 kg/ha, respectively. At irrigated condition, WK2373 (3281.67 kg/ha) and Danphe#2 (3231.67 kg/ha) were superior genotypes to check WK1204 (2658.33 kg/ha). While, WK 2349 (1646.67 kg/ha) was inferior. Similarly, under rainfed condition, WK2373 (3035.00 kg/ha) and Danphe#2 (2991.67 kg/ha) were superior to check WK1204 (2556.66 kg/ha) and WK 2382 (1306.67 kg/ha) was inferior.

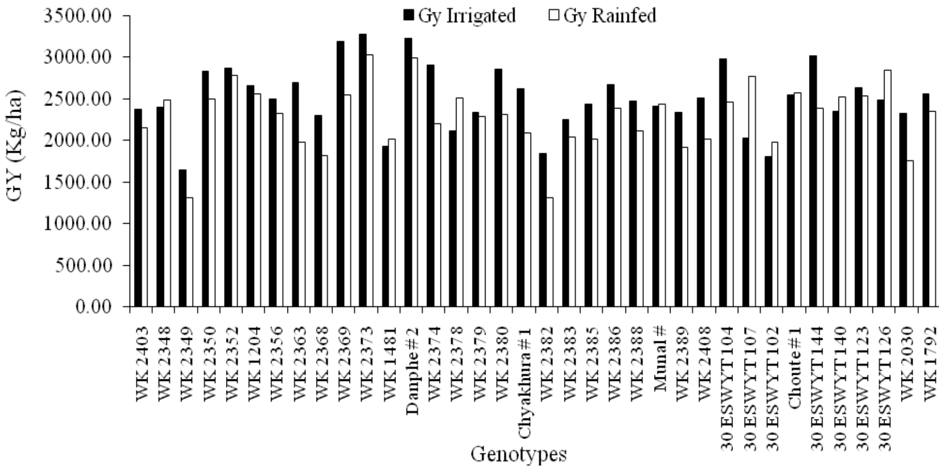

Figure 5. The graph showing the comparison between grain yield of different genotype under rainfed and irrigated conditions at IAAS, Rampur (2012/13)

Generally, under drought condition, grain yield is reduced than under non -stress condition due to the less water availability and uptake by plant during the grain filling period. The available water for plant is the main constrains in the production and productivity of wheat. From the finding of this research there was reduction in yield under rainfed condition than in irrigated condition. Giunta et al., (1993) found that severe drought stress caused reduction in all yield components of wheat, particularly in the number of fertile spikes per unit area (60%) and in the number of grains per spike (48%). Responses of different crop genotypes to drought during grain filling lead to differences in individual grain weight (Mogensen et al., 1985; Giunta et al., 1993; Lopez-Castaneda and Richards, 1994; Voltas et al., 1999). Grain yield was positively correlated with weight of grains per spike, thousand kernel weight, and number of grains per spike. This result was support by the findings of Bayounmi et al., (2008).

Correlation study under rainfed condition

Correlation study of different morpho-physiological, secondary and yield attributing traits under rainfed condition are presented in Table. Days to booting showed highly significant positive correlation with days to heading (0.933**), days to anthesis (0.857**). But it was highly significantly negatively correlated with grain yield (-0.337**). Similarly, days to heading were highly significant positive correlation with days to anthesis (0.832**) and days to maturity (0.865**). But, it is highly significantly negatively correlated with grain yield (-0.254**). Negative correlation was found between grain yield and other morpho-physiological traits this results was similar finding with the result found by Baral (2011).

Table 2. Pearson's correlation coefficient among different morpho-physiological, traits under rainfed condition, at IAAS, Rampur, Chitwan (2012/13)

Traits	DTB	DTH	DTA	DTM	GY
DTB	1	.933**	.857**	.865**	-.337**
DTH		1	.832**	.865**	-.254**
DTA			1	.759**	-.290**
DTM				1	-.211*
GY					1

*P≤0.05; **P≤0.01; DTB=days to booting, DTH=days to heading, DTA=days to anthesis, DTM=days to maturity, GY= grain yield.

Table 3. Analysis of variance (ANOVA) Days to booting, days to heading, days to anthesis, Days to maturity and grain yield

Source of Variations	df	Days to Booting (DTB)	Days to Heading (DTH)	Days to Anthesis (DTA)	Days to Maturity (DTM)	Grain Yield (GY)
Environment (E)	1	242.782**	262.2	392.04**	532.04***	117180
Replication (R)	4	10.866***	38.63***	9.33	6.69*	561117*
Genotypes (G)	35	257.001***	261.025***	188.48***	134.18***	723751***
Environment*Genotypes (E*G)	35	2.6	2.9	8.44	2.65	250073
Error (E*G*R)	140	1.91	4	6.49	2	229650
Mean		78.73	85.29	91.36	122.92	2234.75
CV (%)		1.75	2.34	2.78	1.15	21.44

SUMMARY AND CONCLUSIONS

A field research were conducted at IAAS, Rampur, Chitwan in 2012/13 in order to assess morpho-physiological traits and measures selection indices for identifying drought tolerant genotypes of wheat (Triticum aestivum).Significant difference was observed among the genotypes as well as for rainfed and irrigated condition for measured morpho-physiological traits and yield. There was highly significant difference among the genotypes for days to booting. WK 1792 booted earlier and WK 2382 booted last at irrigated condition but, under rainfed condition WK 2379 booted earlier and WK 2382 booted at last. Likewise, for days to heading, WK 1792 headed earlier and WK 2382 headed at last in irrigated condition but, in rainfed condition WK 1792 booted earlier and WK 2382 booted at last. Grain yield under irrigated conditions was lowest for WK 2349 (1646.67 kg/ha) while, highest grain yield was found in WK 2373(3281.67 kg/ha) followed by Danphe#2 (3231.67 kg/ha). Similarly, under rainfed condition WK2382 (1306.67 kg/ha) had lowest and WK 2373 (3035.00 kg/ha) had highest grain yield followed by Danphe#2 (2991.67 kg/ha).

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IMPACTS OF REMITTANCE EARNING AND OUT MIGRATION ON SOCIO-ECONOMIC CONDITION AND AGRICULUTURE PRODUCTION IN NEPAL

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ABSTRACT

This study tried to examine the impact of remittances earning on socio-economic condition and agriculture production in Nepal. Primary data were collected form random sample of 125 respondent comprising of 30 migrants and 31 non migrants from Dhading and 33 migrants and 31 non migrants from Nawalparasi district. The data were analyzed through descriptive statistics, Probit and income regression model. Result of analysis shows that remittance has increased the decision role of female on child education, financial transaction, agriculture production and marketing and livestock rearing. Migration has negative role in farm physical assets accumulation and rice productivity as data were they were statistically significant at 5 percent and 1 percent levels respectively as compared to non migrants. However out migration increase annual household. It also helps to reduce poverty. Concerning to household expenditure the average expenditure on agriculture was more for non migrants and expenditure on non food, purchasing land and building, and loan was more in migrant. Extension service had contributed about 37.6 percent for determinant on out migration in Probit model. Poor households had negatively and significantly contributed on out-migration and remittance earning. If household was poor, the received of remittance and determinant on out migration had decreased by 71 percent as compared to non poor household, migration status played significant but negative role on farm income. The farm income decreased by 358 percent among migrant households as compared to non-migrant household and it has statistically significant at 1 percent level.

Key words: Migrants, Remittance, Poor, Food security, Decision

INTRODUCTION

It is a well-known that remittance is both money and goods transmitted to households by household member (s) working away from their origin communities (Adams, 1991). Flows of international remittances have tremendously increased during the last decade exceeding all spending on development aid (Solimano, 2003).About 56% households received remittances in Nepal (NLSS III, 2011). Nepal's migration rate is 3.3 and Nepal rank 31st from migration point of view (CIA, 2014). Nowadays, Nepalese going abroad are not only for armies but also spread all over the world for work and mostly they are concentrated in Gulf areas in civilian front (Kshetry, 2003). Emigrants from Nepal are mostly unskilled

(Sharma, 1985). About 30 lakh of Nepalese worker have migrated for job in 77 countries. (Kantipur Daily News, 2013).Share of remittances on GDP is 23% (Kantipur Daily News, 2013).Currently, as a share of GDP, Nepal is among the top five largest remittance recipient countries in the world (World Bank, 2011). Remittance used by households in Daily consumption is 79 %, Loan repayment is 7 %, HH property is 5%, Education is 4%, Capital formation is 2.4 %, Remaining is only 3 % , 2011/12 (within 11 months), Nepal received remittances of amount NRs. 388 billions. The migrated people for foreign employment are found the age group of 20-44 years (economically active population). Remittances received by rural households are said to have both direct as well as indirect effects (Taylor and Wyatt, 1996).There was debate between researchers about the impact of remittances on agriculture. Out migration has either gain or loss. Loss of the remittances income could be social differentiation of household i.e. migrants and non-migrants (for example, Borrero, 2002), Land price increase (Carpio, 1992), lack of the community leader (Martinez, 2002). While in other way gain is increase in living standard of the people (Kyle, 2000), empowerment of women (Borrero, 2000) and improvement of the social status of the discriminated indigenous people (Camacho and Hernandez, 2009).Remittances reduce poverty through increased incomes, allow for greater investment in physical assets and in education and health, and also enable access to a larger pool of knowledge (Adams, 2011).Nutrition impacts might be positive, because remittances contribute to higher household income and therefore better access to food (Taylor *et al.,* 2003). But the impacts might also be negative, at least when controlling for total household income, as migration could potentially reduce household food availability due to reduction in family labor (Sesabo, 2001; Azam and Gubert, 2006). Findley and Sow (1998) stated that after satisfying subsistence needs, migrant remittances were used for investment purposes such as education, livestock, farming and small scale enterprise. In rural Pakistan, temporary migration was associated with higher female and total school enrolment (Mansuri 2006). Long runs the growth of remittance have a positive impact in increasing literacy rate which may lead to socio-economic development of our country (Islam, 2013).Gaudel (2006) concluded that remittances and grants were claimed as an important sources of increasing foreign exchange earnings in Nepal. Migration of highly skilled workers could result in a brain drain (Adams 2003; Docquier*et al.,* 2007) that could have a negative impact on the growth of the country in the long run. Acosta (2006) showed that remittances can increase the household budget and reduce liquidity constraint problems, allowing more consumption and investment in El Salvador.Parida (2010) stated that the individuals belonging to the lower caste households having some land assets are less likely to migrate compared those of the higher castes. He argued that within the land holding classes, people with marginal land holdings are more likely to migrate compared to others and with the increase in the household size the predicted probability of migration decreases for a given landholding class. When a foreign wage offer exceeds the reservation wage plus migration costs, the migrant moves abroad. Migration and remittances are generally part of risk-spreading and co-insurance livelihood strategies pursued by households and families. Thus this study was carried out to find the positive and negative impact of remittances on socio-economic condition and agriculture production in Nepal.

MATERIALS AND METHODS

The empirical analysis was based on a survey of 125 households (62 migrant and 63 Non migrants) from Nawalparasi and Dhading district. Purposive random sampling was done to select districts and VDCs while Simple random sampling was done to select sample households from respective VDCs.Migrant households and matching sample of non-migrant households were selected to undertake a comparative analysis of differences in socio-economic parameters and agriculture production. The survey wasconducted from August-September, 2013 and collected detailed information on household characteristics, agricultural production and employment, participation in decision making in farm and non-farm activities for both categories of households. However, migration related information including remittance and their use were collected from migrant households. The Probit model was used to find out determinants of migration while income regression model was used to assess the effect of remittance on income from farming sector. The Probit model and income regression model were given below.

Probit model

In this study, we assumed that farmers are risk-neutral and that their remittance earning and out migration is based on the comparison of their expected profit with and without out-migration for remittance earning

$$d_i^* \equiv E\left(\Pi_i^1\right) - E\left(\Pi_i^0\right) > 0 \qquad (1)$$

Where the latent variable, d_i^*, is not observed, and Π_i^1 and Π_i^0 are the profit with and without out migration and remittance earning, respectively. We assume that farm *i*'s expected net benefit from out-migration and remittance earning can be modeled as follows: $d_i^* = \mathbf{X}_i'\gamma + \varepsilon_i$, where the vector $\mathbf{X}_i$ includes characteristics of the household, farmer and its environment.

The decision model for farmer *i*is thus written as

$$d_i^* = \mathbf{X}_i'\gamma + \varepsilon_i \geq 0. \qquad (2)$$

And the probability that household *i* out-migration for remittance was estimated using the following Probit model:

$$d_i = F\left(\mathbf{X}_i'\gamma\right) + \nu_i, \qquad (3)$$

Where d_i equals 1 if the expected net benefit d_i^* is positive, and 0 otherwise. Function F is the cumulative distribution of the ε_i error term, assumed standard normal. Finally, the Probit

Model was as followed:

$$\text{Pro } (y=1|x) = \beta_0 + \beta_1 Age_i + \beta_2 \, Gender_i + \beta_3 \, Caste_i + \beta_4 \, Education_i + \beta_5 \, Household\ size_i + \beta_6 \, Land_i + \beta_7 \, Farm\ income_i + \beta_8 \, Poor_i + \beta_9 \, Extension_i + \beta_{10} Member_i + \beta_{11} District_i + \varepsilon_i$$

Where β_0 is constant, $\beta_1 \ldots\ldots\ldots B_{10}$are the coefficient and $\varepsilon_i$is the error term

Where y is probability for y to be 1, R is function which value strictly varies x_i is set of the predictor which affect y. Note if remittance earning y= 1 if not earning y=0.

Explanatory variable were socio demographic factor (like age, gender, education level, cast, household size, dependency ratio) institutional factor (training facility, extension visit, organizational membership) physical assets owned, gender issues, information etc.

Income regression model

$$Ln\ Y_i = a_0 + a_1 Migration_i + a_2 Poor_i + a_3 \, Gender_i + a_4 Training_i + a_5 Extension_i + a_6 Land_i + a_7 LSU_i + a_8 \, total\ farm\ physical\ assets_i + \varepsilon_I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where LnY_i = Annual household income from agriculture and livestock sectors (NRs. In Natural Log),a_0 is constant, $a_1 \ldots\ldots\ldots a_8$are the coefficients and $\varepsilon_i$is the error term.

RESULTS AND DISCUSSION

Socio-demographic characteristics household

Any change in the volume and flow of migration will change the social, economic and demographic structures both in sending and receiving areas (KC, 1998).The summary statistics of some of the socio-demographic variables the migrant remittance receiving and non-remittance receiving households were presented in Table 1. Out of 23 socio-economic variables only nine variable were statistically different among migrant and non migrants. Looking at significant variable we concluded that remittance receiving households head were relatively younger,have high number of family member, higher number of household member with secondary and intermediate education, higher number of educated female and have low farm income as compared to migrants. Similarly migrant have lower the percentage of male and poor while higher percentage of higher caste. The other variables like percentage of household head with some sort of skilled, Percentage of household with the joint family, and number of household member doing agriculture, total cultivated land, total physical assets, livestock standard unit was found less in migrant as compared to non migrants but these variables are not statistically significant. While year of schooling of household head, number of economically active HH member, total educated male in household, No of organization in which household is member participate and percentage of house hold member getting training, percentage of household getting easy access to training, percentage of household that had got membership to an organization was found more in migrant household as compared to non migrants but these variable are not statistically significant.

Table 1 Summery statistics of some socio-economic characteristics of migrants and non migrant households

Variable	Total (N = 125)	Migrants (n = 63)	Non migrants (n= 62)	Mean difference	T value
Age of the household head	42.07	40.20	43.92	-3.71	-1.77*
Gender of the household head (Male=1)	0.65	0.56	0.73	-0.17	-1.99**
Caste (Higher =1)[1]	0.58	0.65	0.50	0.15	1.71**
Skill of the household head (Skill=1)	0.45	0.41	0.48	-0.07	-0.79
Year of schooling of the household head (Year)	6.13	6.70	5.55	1.15	1.12
Family type (1= Joint)	0.54	0.51	0.56	-0.05	-0.63
Household size	5.84	6.35	5.32	1.02	2.24**
Number of member of age group between 15-59 (Economic active)	3.25	3.50	3.00	0.50	1.60
Number of the household member doing agriculture	2.25	2.10	2.40	-0.80	-1.20
Household member with secondary education	1.65	1.90	1.40	0.20	2.40**
Household member with intermediate education	0.65	0.80	0.50	0.50	1.90*
Total educated male in HH	2.15	2.30	2.00	0.10	1.30
Total educated female in HH	2.00	2.20	1.80	0.30	1.60*
No of organization in which household is member participate	1.11	1.21	1.00	0.21	1.29
Poor [2] (Yes=1)	0.43	0.19	0.68	- 0.048	-6.25**
Training (Yes=1)	0.18	0.17	0.19	-0.02	0.27
Extension service (Easily available=1)	0.30	0.34	0.24	0.10	1.31
Membership (Yes=1)	0.85	0.86	0.84	0.02	0.28
Total cultivated land (Ropani)	11.38	9.92	12.86	-2.93	-1.60
Physical asset (No.)	14.37	13.22	15.53	-2.31	-1.54
Livestock standard unit (LSU)[3]	5.93	5.53	6.33	-0.79	-0.91
Income from farm (from agriculture and livestock sector, NRs.)	33041.84	24079.84	42148.39	-18068.55	-2.87**

1 Brahmin, Chettri and Takuri are the higher castes in Nepal

2 Poor variable has been defined as those household member had less than USD 1 per day per person income (Less than USD 1/person/day income=1, 0=otherwise)

3 LSU is Livestock Standard Unit (based on cattle equivalent: 1 cow/cattle= 10 goats/lambs,= 4 pigs and = 143 chicken/ducks)

Food security condition of household

The study revealed that about 32.8 % of sample household were food insecure through own production. While comparing food insecurity among migrant and non-migrant the food insecurity were more prevalent in migrants household i.e. 42.9% as compared to non-migrant 22.6%. These data were significant at 5% level. (Table 2)

Table 2.Food security condition of the households by migrant status

Food security condition	**Type of household**		**Total (N =125)**
	Migrants (n = 63)	**Non migrants (n= 62)**	
Food insecure	27(42.9)	14 (22.6)	41 (32.8)
Food secure	36 (57.1)	48 (77.4)	84 (67.2)
Total	63(100.0)	62 (100.0)	125(100.0)

Person Chi-square value = 5.83** (P value = 0.016 at 1 df).

Annual household income of HH from different sector

The study found out that farm income, business income employment income and total income were significantly different among the migrants and non migrants. In migrant household total income were found more but farm income, business income, and employment income were found less as compared to non migrants household. (Table 3)

Table 3.Annual household income from different sectors (in NRs.)

Variable	**Full sample (n = 125)**	**Migrants (n = 63)**	**Non migrants (n= 62)**	**Mean difference**	**T value**
Farm income	44643.47	31050.64	58236.29	-18068.55	-2.169***
Off farm income	9419.9	13136.5	5703.2	7433	0.68
Business	20380.7	6896.8	33864.5	-26967.6	-1.715*
Employment	33598.5	13888.9	53308.1	-39419	-2.54***
Remittance income	210984	421968.3	0	-421968.3	10.311***
Other	211.98	214.29	209.68	4.6	0.028
Total income	**308789**	**480184.60**	**137393.44**	**342791.2**	**7.2*** **

Source: Field Survey, 2013,

Note: ***,**and * indicate significance levels at 1 percent, 5 percent and 10 percent respectively

Household expenditure pattern

Comparing among the migrants and non migrant's expenditure pattern the migrants shows more expenditure on purchasing land and building, education non food items and food as compared to non migrants while the total expenditure on agriculture was found more in non migrant households as compared to migrants. (Fig 1)

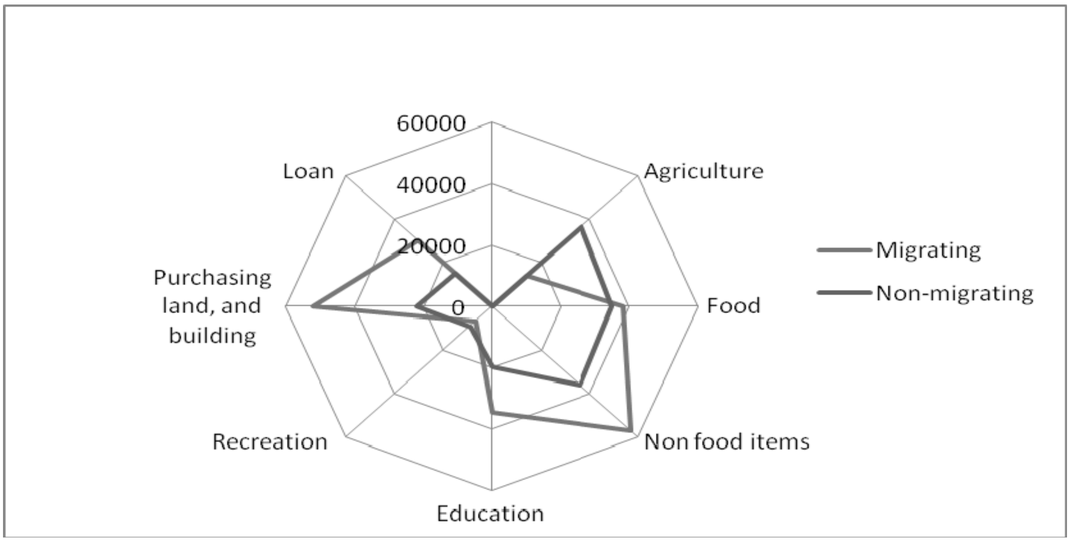

Fig 1. Household expenditure pattern of household

Gender Role: Contribution of Female

Decision role of female on education of children, health of family member, child birth and family planning financial transaction livestockrearing and agriculture production was statistically different among migrant and non migrant's households. Role of female in overall decision were found more in migrants household as compared to migrants as shown in table 3.

Table 3. Role of female in household decision

Role of female	Type of household		Total (N = 125)	Chi-square value
	Migrants (n = 63)	Non migrants (n= 62)		
Education of children	15 (23.8)	13(21.0)	28(22.4)	8.845**
Health of family member	26 (41.3)	18(29.0)	44 (35.2)	10.470***
Child birth and Family planning	11(17.5)	9(14.5)	20(16.0)	0.287
Financial transaction	35(55.6)	16(25.8)	51(40.8)	12.2***
Livestock rearing	38(60.3)	18(29.0)	56(44.8)	13.71***
Agriculture production and marketing	26(40.6)	23(37.7)	49(39.2)	9.01**

Characteristics of migrants

The study revealed that average age of migrants were 30.8 years, year of schooling of migrants were 9.3, average duration of stay abroad was 7.1, number of children was 2.1, first term expenditure was NRs 137857, number of month required to recover initial spending was 4.9 years and monthly salary of migrants was NRs 39327.5. Out of which only average age of migrants, number of month required to recover initial spending was found more while first term expenditure was found less in Nawalparasi district as compared to Dhading districts**.** Number of children and monthly salary of migrants was found more in Dhading district but it was not statistically significant. (Table 4)

Table 4. Characteristics of migrants

Category	Total (N=125)	Nawalparasi (n = 64)	Dhading (n = 61)	Mean Difference	T value
Average age of migrants	**30.8**	**32.6364**	**29.0111**	**3.62525**	**2.058***
Year of schooling	9.3	11.01	7.53	3.47	3.405***
Average duration of stay abroad	7.1	9.68	4.5	5.08	3.52***
Number of children	2.1	2.06	2.2	-0.13	-0.307
First term expenditure	**137857.0**	**93760**	**181954**	**-88193.41**	**-1.606***
Number of month required to recover initial spending	**4.9**	**5.84**	**4.035**	**1.80772**	**1.921***
Monthly salary	39327.5	35550	43105	-7555	-1.07

Determinants of remittance earning

Out of 11 variable used as explanatory variables, four are found to be statistically significant at 1%. From table 5 it is seen that farm income and poor have negative sign implying that as farm income and number of poor increases, the likelihood of receiving remittances declines. Similarly household size and extension services have positive sign implying that as household size and extension services increases, the likelihood of receiving remittances increases (table 5). Also study revealed that Extension service has contributed about 37.6% for determinant on out migration. When household size increases by 1 number, there is an increase about 11 percent in the probability that household member will decide to migrate.If household was poor, the received of remittance and determinant on out migration have decreased by 71% as compared to non poor household, If farm income from agriculture and livestock sectors increased by one percent, the probability to migrate decreases by 10.6 percent.

Table 5.Probit model results to determinant the remittance earning and out-migration of survey households

Migration	Coef.	Std. Err.	Z	P>z	dy/dx
Age	-.0216284	.015115	-1.43	0.152	-0.008
Gender	-.3900697	.3471139	-1.12	0.261	-0.143
Caste	.4886958	.3606184	1.36	0.175	0.185
Education	-.0055777	.0306185	-0.18	0.855	-0.002
HHsize	.2900425***	.0780271	3.72	0.000	0.109***
Land	.0168449	.0181068	0.93	0.352	0.006
Lnfarm income	-.281561***	.129841	-2.17	0.030	-0.106***
Poor	-2.121282***	.3722513	-5.70	0.000	-0.702***
Extension	1.15183***	.419372	2.75	0.006	0.376***
Member	.5604451	.4276946	1.31	0.190	0.219
District	-.4408763	.421462	-1.05	0.296	-0.165
Constant	2.025477	1.387171	1.46	0.144	-0.008

Number of obs = 125
LR chi2(11) = 81.40***
Prob> chi^2 = 0.0000
Log likelihood = –45.940807
Pseudo R^2 = 0.4697

Regression results for determinants of farm income (NRs. In Natural log)

Among eight explanatory variable only four variables were statistically significant. Out of which migration and poor have negative sign while extension and land have positive sign. The study revealed that farm income decreased by 358% among migrant households as compared to non-migrant household and it has statistically significant at 1% level. Poor household has 169 percent less annual farm income as compared to non-poor household. It was significant at 10 percent level. Household getting extension services have 187 percent more farm income than household not getting the extension services. It was highly significant at 1 percent level. Land also has positive significant impact on farm income. As the land size increases by 1 ropani the farm income will be increased by 0.10 units. This was significant at 1 percent level. (Table 6)

Table 6. Regression results for determinants of farm income (NRs. In Natural log)

Variable	Coefficient.	Std. Err.	T	P>t	Expected sign
Migration	-3.576123***	.8841057	-4.04	0.000	-
Poor	-1.688597*	.8910522	-1.90	0.061	-
Gender	-.0251404	.8100332	-0.03	0.975	+
Training	.8626959	.9816935	0.88	0.381	+
Extension	1.86868***	.8794386	2.12	0.036	+
Land	.1018564***	.0425733	2.39	0.018	+
LSU	.12531	.0993413	1.26	0.210	+
Physical assets	.0147375	.059048	0.25	0.803	+
Constant	8.024537***	1.213562	6.61	0.000	+/-
Summery statistics					
Number of obs =		125			
F (8, 116) =		4.10***			
Prob> F =		0.0002			
R-squared =		0.2203			
Adj R-squared =		0.1665			
Root MSE =		4.1774			
Variance Inflation Factor (VIF)		1.35 (Mean VIF)			

Note: ***, **and* indicate significant at 1 percent, 5 percent and 10 percent levels.

CONCLUSION

Result of analysis has shown that trend of out migration increasing day by day from last few decades. Out migrant were mostly found the economically active age group, mainly male, married, from joint family and mostly in gulf or India countries. It has increased the decision role of female on child education, financial transaction, community participation, agriculture production and marketing and livestock rearing among the migrant households and have found statistically significant different than non-migrants .Migration has negative and statistically significant role on farm physical assets accumulation and rice productivity whereas positively significant on annual total household income. Annual HH income from agriculture sector was found very low among the migrant HHs as compared to non-migrant and was found statistically significant different. Concerning to household expenditure the average expenditure on agriculture was more for non migrants and expenditure on non food, purchasing land and building, and loan was more among the migrant HHs and found statistically significant.

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EFFECT OF TILLAGE, RESIDUE LEVELS AND INTERCROPPING SYSTEMS ON YIELD AND YIELD ATTRIBUTING CHARACTERS OF MAIZE AND SOYBEAN IN CHITWAN, NEPAL

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ABSTRACT

A field experiment was conducted at National Maize Research Program (NMRP), Rampur, Chitwan, Nepal during rainy reason of 2013 to find out the effect of tillage, residue levels and intercropping systems on yield and yield attributing characters of maize and soybean in Chitwan Nepal. The results revealed that the grain yield of maize and soybean was significantly influenced by intercropping systems, but not by tillage system and residue levels. The grain yield of maize obtained under sole cropping (4.76 t ha^{-1}) was significantly higher than maize + soybean intercropping system (4.27 t ha^{-1}). Similarly, the grain yield of sole soybean was significantly higher (1.99 t ha^{-1}) than that of maize + soybean intercropping system (1.26 t ha^{-1}). There was 10 percent reduction of maize yield as compared to sole maize system due to intercropping systems. Similarly, reduction of seed yield of soybean under maize and soybean intercropping system was 37 % as compared to sole soybean system. Maize and soybean intercropping system produced higher gross return, net return and B: C ratio. Net returns and B: C ratio obtained from maize + soybean intercropping system under zero tillage residue removed condition was higher of NRs. 155478 and 2.77 respectively.

Key words: Intercropping, maize, soybean, tillage, residue, yield

INTRODUCTION

Maize is a traditional crop cultivated for human food, feed and fodder; and for raw material in various poultry and animal feed industries. It is used for hundreds of other industrial purposes because of its broad global distribution, low price as compared to other cereals and diverse grain type having wide range of biological and industrial properties. The rapidly increasing demand of maize in Nepal is mainly driven by its increased direct human consumption in the hills as a staple food crop and for livestock feeds in Terai and inner Terai areas (Pandey *et al.,* 2007). This is also due to the increasing demand for feed in poultry industry and the year round consumption for green maize cobs in the cities. Previous works suggest that major factors for poor performance of the system include degraded soil quality, expensive and unreliable fertilizer supplies, labor shortages, significant erosion in sloping areas, competing uses for crop residues and animal manures and the planting of poor quality seed (Paudyal *et al*., 2001). Maize and soybean intercropping is predominant in western and southwestern hills in relatively dry seasons, to avoid the risk of crop failure.

Soybean is considered as an ideal crop for intercropping with maize owing to its comparative tolerance for shade and drought, efficient light utilization and utilizes soil moisture efficiently (Wright *et al*., 1988).

In Nepal, soybean is one of the important leguminous crops selected for production and utilization for human food and feed for poultry. It has potential of fixing atmospheric nitrogen besides meeting its own nitrogen requirement and serves as a viable and low cost medium for soil fertility improvement (Muoneke *et al*., 2007). Soybean has the potential for improving human diet as well as animal feed by supplying high quality protein and serves as a good source of raw material base for agro-industries (Atungwu and Afolabi, 2001). Maize based cropping system using high intensive tillage is predominant in the sloping hill terraces. These sloping terraces suffer more soil runoff loss (Lal, 1983). Since, the problem of soil loss is partly natural and partly human induced, need of appropriate technological intervention based on land use suitability, have drawn attention of the researchers. Resource conservation technologies, for example, minimum tillage have shown better performance in most part of the world in restoring the organic matter and increasing crop yield in long run (Cassel *et al*., 1995). Decreasing soil fertility, increased soil erosion, poor water infiltration and increased soil compaction are the other major constraints of maize production system brought about by the conventional agricultural practice which is more labor intensive mainly for repeated land preparations and intercultural operations. Conservation agriculture may be a viable alternative to make maize farming sustainable while conserving the soil.

Reduced tillage, proper crop rotation and the residue management are the three basic working principles of conservation agriculture. which are considered the ultimate components to address the ever-burgeoning problem of soil degradation, labor scarcity and diminishing return of the maize based system in Nepal. The concept of cereal legume intercropping is not in vogue in agricultural sciences (Dahlmann and Von Fragstein, 2006). Presently, intercropping is gaining popularity day by day among small growers as it provides yield advantage compared to monocropping through yield stability and fulfilling diversified domestic needs (Nazir *et al*., 2002 and Bhatti *et al.,* 2006). Hence, this experiment was carried out in order to evaluate the effect of tillage, residue levels and intercropping systems on yield and yield attributing characters of maize and soybean.

MATERIALS AND METHODS

This study was conducted at National Maize Research Program (NMRP) farm, Rampur, Chitwan during summer season from May 2013 to November 2013. This location is situated in central Nepal with subtropical climate and is 10 km west from Bharatpur, headquarter of Chitwan district. Geographically it is located at $27^{0}37'$ north latitude and $84^{0}25'$ east longitude with an elevation of 228 masl. The type of the soil was sandy loam. The area received about 2014.30 mm of total rainfall during the entire growing season.

The experiment was laid out in strip- split design with twelve treatments and three replications. Treatments consisted of two different tillage methods namely conventional tillage (CT) and zero tillage (ZT) as vertical factor, two different levels of residue (residue kept and residue removed) as horizontal factor and three different levels of cropping systems namely sole maize, sole soybean and maize + soybean intercropping system as sub plot factor. Manakamana-3 and Puja were the variety of maize and soybean used for the experiment respectively.

The individual gross plot size was of 24 m^2 having the length of 6 m and width of 4 m. Row to row spacing for each plot was maintained at 100 cm so that every plot received 6 rows of maize where two outer rows were marked as boarder rows, next two rows were for destructive sampling and two inner rows were net plot. The number of rows of maize was fixed as six in each treatment and plant to plant spacing was of 50 cm and 2 plants per hill were maintained. On the other hand, the number of rows per plot of soybean was varied depending upon the row ratio of soybean and sole planting. It was 10 rows for 1:2 and 12 rows for sole planting. The spacing for both 1:2 ratio and sole planting was 50 × 10 cm^2 fixed in all treatments. The net plot of maize consisted of two central rows (8 m^2) and in case of soybean it was 4 rows in both 1:2 ratio and sole crop. However, the net harvesting area of soybean in all treatments was the same (8 m^2).

Weather condition during crop season

The mean maximum and minimum temperatures were 36.98 °C in May and 19.21 °C in November. Similarly, the mean minimum temperature ranged from 11°C to 29.35 °C. The area received about 2014.30 mm of total rainfall during the entire growing season. The relative humidity ranged from 85.37 % in November to 96.29 % in October (Figure 1**).**

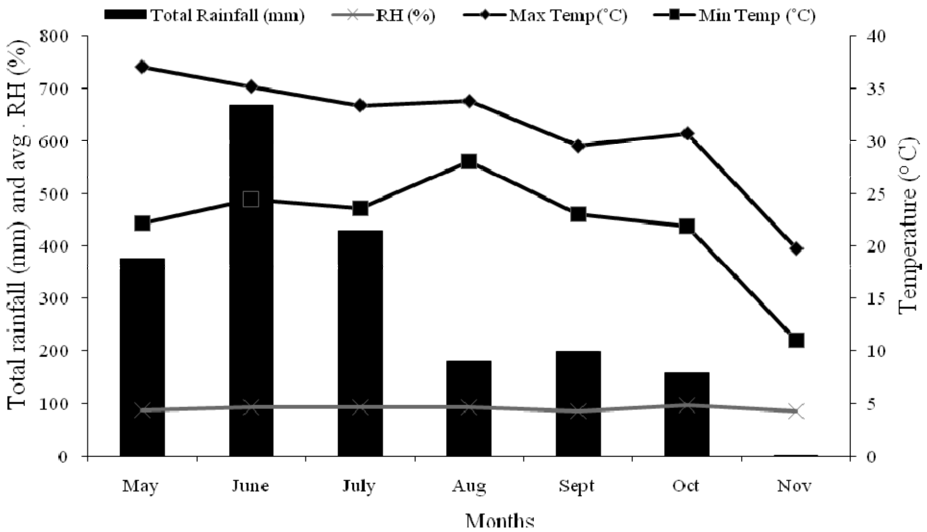

Figure 1. Weather condition during the course of experimentation in Chitwan, 2013 (Source: NMRP, 2013)

RESULTS AND DISCUSSIONS

Grain and Stover yield (t ha^{-1}) of maize

Tillage system and residue levels had no significant effect on grain yield of maize (Table 1). However, grain yield of maize was found higher in CT (4.53 t ha^{-1}) as compared to ZT (4.49 t ha^{-1}). Mashingaide *et al.* (2009) also reported that residue retention did not significantly increase maize and sorghum yields. Lower yield in residue kept plot might be due to the lodging of more number of plants caused by termite attack and infection on cob. This finding is also in line with Casa *et al.* (2003). Barzegar *et al.* (2003) reported that under a wide range of environment conditions crop yield obtained by no-till, reduced tillage, and stubble retention systems were equivalent or even a higher than those recorded under conventional tillage.

Intercropping system had a significant effect on grain yield of maize (Table 1). Significantly higher grain yield of maize (4.76 t ha^{-1}) was obtained in sole maize system as compared to maize and soybean intercropping system (4.27 t ha^{-1}). Under maize and soybean intercropping system, there was 10 percent reduction of maize yield as compared to sole maize system. Silwana and Lucas (2002) recorded 15 % yield decrease in the maize crop while growing as intercropping, whereas Ofori and Stern (1987) found 11 % declines in maize yield under intercropping system. Lower yield under intercropping system might be due to inter and intra specific competition for moisture, light, space and nutrients.

Tillage system as well as residue and intercropping systems showed non- significant difference on stover yield of maize (Table 1). The average mean of Stover yield was 6.75 t ha^{-1}.

Harvest index (HI) of maize

Harvest index of maize was not significantly influenced by tillage, residue and intercropping systems (Table 1). The average HI of the experiment was 0.41.

Table 1. Effect of tillage, residue and intercropping systems on grain yield, stover yield and harvest index of maize at Rampur, Chitwan, Nepal, 2013

Treatments	**Grain yield (t ha^{-1})**	**Stover yield (t ha^{-1})**	**Harvest index**
Tillage			
Conventional	4.53	7.28	0.39
Zero	4.49	6.21	0.42
SEm±	0.08	0.32	0.01
LSD	ns	ns	ns
Residue levels			
Residue removed	4.62	6.46	0.43
Residue kept	4.42	7.03	0.39
SEm±	0.14	0.51	0.02
LSD	ns	ns	ns
Intercropping system			
Sole maize	4.76^{a}	7.11	0.41
Maize + soybean	4.27^{b}	6.38	0.40
SEm±	0.12	0.47	0.02
LSD	0.40	ns	ns
CV%	9.46	24.18	17.22
Grand mean	**4.52**	**6.75**	**0.41**

Non-significant (ns). Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT

Yield and yield attributing characters of soybean

1000 seed weight (g)

Thousand-seed weight is an important yield contributing parameter that directly affects the seed yield of soybean. There was a significant effect of intercropping system on 1000-grain weight of soybean (Table 2). Higher value of 1000 seed weight was recorded under sole cropping of soybean (132.67 g) as compared to maize and soybean intercropping system (131.08 g). Increments in 1000-seed weight of soybean in sole cultivated pot are attributed to favorable growing conditions, which improved nutrient and water uptake. Undie *et al.* (2012) found similar results. But tillage management and residue levels had no significant effect on 1000-seed weight of soybean.

The equation of linear regression analysis (Figure 2) showed the trend of thousands grain weight and grain yield of soybean. It explained the 48 % variation in grain yield of soybean due to thousands grain weight of soybean. The simple linear regression equation was y = 0.204x - 25.25.

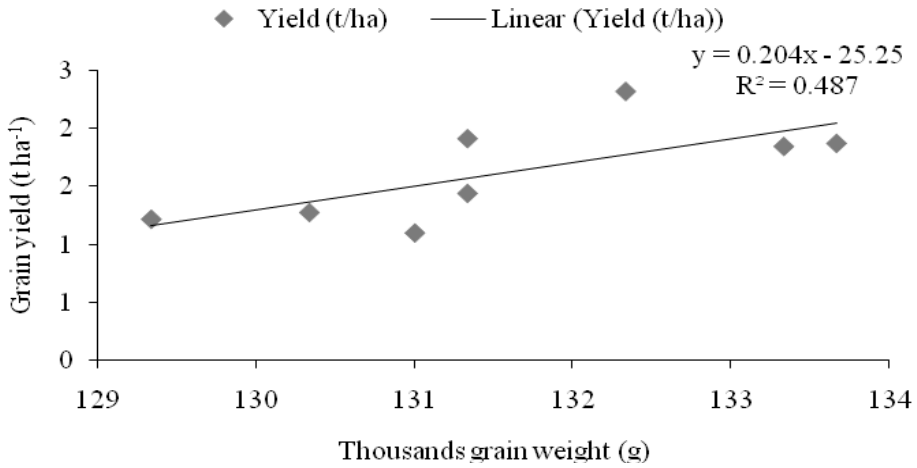

Figure 2. Relationship between grain yield and 1000-grain weight of soybean at Rampur, Chitwan, 2013

Seed and stalk yield (t ha^{-1})

Seed yield of soybean varied significantly in different intercropping systems; but effect of tillage and residue were found insignificant (**Table 2).**

Maximum seed yield of soybean (1.99 t ha^{-1}) was recorded in plots of sole soybean as compared with maize and soybean intercropping plots (1.26 t ha^{-1}). The reduction of seed yield of soybean under maize and soybean intercropping system was about 37 % as compared to sole soybean system. Thole (2007) also found reduction of soybean yield by 40-69 % under intercropping as compared to sole soybean system. The lower yield of soybean under intercropping might be due to inter specific competition depressive effect of maize, a C_4 species, on soybean, a C_3 crop. Similarly, Zhuang, L. and Yu-Bi (2013) reported that shading by the taller plants in mixture could reduce the photosynthetic rate of the lower growing plants and thereby reduce their yields. Stalk yield of soybean was not affected significantly by tillage and residue levels but intercropping systems had significant effect on it (Table 2). Sole soybean system recorded significantly higher stalk yield (3.25 t ha^{-1}), whereas maize and soybean intercropping system produced significantly lower stalk yield (2.46 t ha^{-1}).

Table 2. Effect of tillage, residue levels and intercropping systems on seed yield, 1000-seed weight, stalk yield and harvest index of soybean at Rampur, Chitwan, Nepal, 2013

Treatments	1000 seed wt (gm)	Seed yield (t ha^{-1})	Stalk yield (t ha^{-1})	Harvest index
Tillage				
Conventional	131.92	1.63	2.82	0.36
Zero	131.83	1.62	2.89	0.35
SEm±	0.50	0.10	0.17	0.01
LSD	ns	ns	ns	ns
Residue				
Residue removed	132.00	1.64	2.87	0.36
Residue kept	131.75	1.61	2.83	0.33
SEm±	0.18	0.06	0.07	0.005
LSD	ns	ns	ns	ns
Intercropping system				
Sole soybean	132.67^{a}	1.99^{a}	3.25^{a}	0.38^{a}
Maize + Soybean	131.08^{b}	1.26^{b}	2.46^{b}	0.34^{b}
SEm±	0.42	0.11	0.08	0.01
LSD	1.39	0.26	0.27	0.04
CV%	1.12	16.85	10.18	10.82
Grand mean	131.87	1.63	2.85	0.36

Non-significant (ns). Means followed by the common letter within each column are not significantly different at 5% level of significance by DMRT

Harvest index

Harvest index of soybean was not significantly influenced by tillage and residue but was affected significantly by intercropping system (Table 2). Sole soybean system recorded higher harvest index (0.38), whereas maize and soybean intercropping system produced significantly lowest harvest index (0.34).

Combined effect of treatments on economy of maize and soybean intercropping system

Among different intercropping systems, maize and soybean intercropping system produced higher gross return, net return and B: C ratio. Net returns obtained from maize + soybean under ZT residue removed condition was higher of NRs. 155478 than the other combination. Similarly, maize and soybean intercropping system produced higher B: C ratio under zero tillage (ZT) and no residue used condition (2.77) followed by ZT with residue used condition (2.53) (Table 3). Under conventional tillage (CT) with residue kept condition, B: C ratio was found lowest (2.19). Whereas under sole maize system, B: C ratio was found highest in ZT + residue removed plot (RR) (2.46), but in CT, residue removed plot produced lowest B: C ratio (2.09). Similar results were also found in case of sole soybean. Hence, we can conclude that in all intercropping systems, highest B: C ratio was found under ZT residue removed plot followed by ZT with residue kept (RK) plot followed by CT residue removed plot and then lowest was found in case of CT with residue kept plot.

Table 3. Combined effect of treatments on economy of maize and soybean intercropping system at Rampur, Chitwan, Nepal, 2013

Particulars	Treatments	Cultivation practices			
		CT+RK	**CT+RR**	**ZT+RK**	**ZT+RR**
Total cost ($NRs\ ha^{-1}$)	1. Sole maize	77065	69515	68815	61265
	2. Sole soybean	79905	72355	64655	64105
	3. Maize + soybean	103470	96270	95220	88020
Gross returns ($NRs\ ha^{-1}$)	1. Sole maize	154743	145607	149070	150870
	2. Sole soybean	187947	151575	149636	151266
	3. Maize + soybean	227061	233342	241027	243498
Net return s ($NRs\ ha^{-1}$)	1. Sole maize	77678	70692	80255	89605
	2. Sole soybean	108042	79220	84981	87161
	3. Maize + soybean	123591	137072	145807	155478
B: C ratio	1. Sole maize	2.01	2.09	2.17	2.46
	2. Sole soybean	2.35	2.09	2.31	2.36
	3. Maize + soybean	2.19	2.42	2.53	2.77

CONCLUSIONS

Our findings indicated that maize and soybean intercropping system in rainy season could be grown successfully and found more profitable over sole cropping system of either crop in Chitwan. Cost of cultivation under zero tillage was found lower than conventional tillage system. Similarly, net returns and B: C ratios were found higher under zero tillage maize and soybean intercropping systems. This study need to be further tested for one more season taking into account the overall qualities of soil along with growth and yield parameters of both the component crops in order to have the robust findings and recommendations to the farmers.

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WEED DYNAMICS AND PRODUCTIVITY OF SPRING MAIZE UNDER DIFFERENT TILLAGE AND WEED MANAGEMENT METHODS

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ABSTRACT

A field experiment was conducted during spring season of 2013 on sandy loam soil at Rampur, Chitwan, Nepal to study the effect of tillage and weed management methods on weeds dynamics and productivity of maize (*Zea mays* L.). Two tillage methods (zero and conventional) with six weed management methods (weedy check, weed free, atrazine @ 1.5 kg/ha as pre emergence, atrazine + glyphosate as pre emergence, atrazine + pendimethalin as pre emergence and atrazine + one hand weeding at 40 DAS) were tested in strip plot design with three replications. The experimental site comprised of eleven weed species belonging to seven families. The research result revealed that weed infestation reduced the grain yield of spring maize by 37.17 %. The values of total weed density and dry weight recorded in conventional tillage were significantly higher than that of zero tillage at almost all growth stages of the spring maize. All double combinations of atrazine were found significantly effective to reduce total weed density and dry weight as compared to its sole application and among them, the tank mixed application of atrazine with glyphosate at sowing was found significantly more effective than with pendimethalin and HW at 40 DAS. The grain yield of maize was not affected significantly by tillage methods, however, it was lower in conventional tillage (5.95 t ha^{-1}) in comparison to zero tillage (6.24 t ha^{-1}). The loss of grain yield due to weeds (WI) was significantly higher in weedy check (37.17%) and lower in the combination of atrazine and glyphosate (6.31 %) as compared to other weeding treatments. The grain yields obtained in double combinations of atrazine with glyphosate (6.69 t ha^{-1}), pendimethalin (6.24 t ha^{-1}) and HW at 40 DAS (6.48 t ha^{-1}) were comparable to each other but significantly superior over its sole application (5.51 t ha^{-1}). However, the tank mixed application of atrazine and glyphosate (6.69 t ha^{-1}) at sowing was only found equally effective as weed free condition (7.18 t ha^{-1}) in the formation of grain yield of spring maize. Thus, the maize can be successfully cultivated in zero tillage and combination of atrazine either with glyphosate or HW at 40 DAS can be used as alternatives of manual weeding to achieve higher grain yield in spring season.

Key words: spring maize, tillage, weed management methods, grain yield.

INTRODUCTION

Maize is an important and versatile cereal grown over diverse environment and geographical ranges for human food, feed and fodder for livestock and raw material for industrial products (Reddy and Reddy, 2012 and Arvaidya *et al.*, 2012). It ranks third in the world production after wheat and rice but in productivity it surpasses all cereals (Deshmukh *et al.*, 2009). In Nepal, maize is the second most important staple food crop both in terms of area and production after rice. Its area, production and productivity are 0.849 million ha, 2.00 million tonnes and 2.35 t ha^{-1}, respectively in Nepal (MOAD, 2013).

Among different factors, tillage and weed management are two important factors which influence remarkably on the growth and yield of maize. Tillage is an operation that distracts the soil through various operations to place seeds and grow crops. Appropriate tillage operations are desired for better crop yields and as a result of which the total production increases (Memon *et al.*, 2012). several studies have shown that tillage is one of the most essential operations carried out to improve soil structure, increase infiltration capacity, expand pore volume and aeration (Lio, 2006) that in turn increases crop growth and yield as a result of which the production boosts (Khurshid *et al.*, 2006; Rashidi and Keshavarzpour, 2007; Rashidi, *et al.,* 2008). The conventional tillage methods have been used to grow major crops including maize since long but they are now considered as expensive operations in terms of work and fuel consumption. a shift from conventional to conservation tillage methods (no- tillage) helps to conserve soil and water, save fuel energy and reduce soil erosion. Moreover, it also assists to reduce the cost of field preparation (Singh *et al.*, 2001) and yield returns are similar or even exceed in some cases (Memon *et al.*, 2012) to conventional tillage.

Weeds cause enormous damage to the maize crop and the magnitude of loss may vary from 30 to 50 % depending upon the growth and persistence of weed population in standing crop (Rout and Satyapathy, 1996). weeds reduce crop yield by competing for light, water, nutrients and carbon dioxide, interfere with harvesting and increase the cost involved in crop production depending on the type of weed flora and the intensity and duration of crop weed competition (Oerke, 2005). The yield loss in maize ranges from 28-93 % (Sharma and Thakur, 1998; Patel *et al.*, 2006; Lal and Saini, 1985) or 28-100% due to unchecked weed growth (Angiras and Singh, 1988). Karki *et al.* (2010) recorded 48% reduction of grain yield in maize due to weed infestation in the hills of Nepal.

Due to increased labor cost and inadequate supply of labor in time, it is necessary to develop cheaper method of weed control with either herbicides or their combinations with mechanical methods. Moreover, management of weeds through integration of tillage methods with herbicides can increase the productivity of the crop by decreasing the biomass of the weeds.

MATERIALS AND METHODS

Field experiment was conducted during spring season of 2013 at Research farm of National Maize Research Program (NMRP), Rampur, Chitwan (27^0 37' N latitude and 84^0 25' E longitude, 256 meter above mean sea level), Nepal. The soil of experimental site was sandy loam, with pH 5.6, low organic matter content (2.47%), medium total nitrogen (0.13%), medium available phosphorus (51.0 kg ha^{-1}), and medium available potassium (131.5 kg ha^{-1}). The total rainfall received during the crop growing period was 1107.10 mm. The experiment was laid out in strip plot design with three replications having vertical and horizontal factors. The vertical factors were zero and conventional tillage while horizontal factors consisted of 1) weedy check, 2) weed free, 3) atrazine @1.5kg a.i./ha as pre emergence, 4) atrazine @0.75kg a.i. ha^{-1} plus glyphosate @2.5 ml lt^{-1} of water (as pre emergence tank mixture spray), 5) atrazine @0.75kg a.i. ha^{-1} plus pendimethalin @2.0 ml lt^{-1} of water (as pre-emergence tank mixture spray) and 6) atrazine @1.5kg a.i. ha^{-1} as pre emergence plus one hand weeding at 40 DAS.

The field was ploughed 15 days prior to sowing using tractor in conventional tillage and treated with glyphosate@5ml lt^{-1} of water to make field free from weeds in zero tillage. Seeds of Rampur hybrid 2 were planted by jab planter in furrows at spacing of 25 cm opened 60 cm apart with the help of tractor drawn furrow opener on 12th February, 2013. In case of control plot, weeds were allowed to grow along with the maize crop throughout the crop cycle, whereas in other treatments respective herbicides were applied with the help of knapsack sprayer as pre emergence herbicides. In the weed free treatment, weeding was done manually to keep the plots free from weeds throughout the crop cycle. The crop was raised under irrigated condition as per the recommended package of practices.

Density and dry weight of weeds were recorded at 30, 60, 90 and at harvest. These data were subjected to square root transformation before analysis. Growth and yield characters were recorded as per standard procedures and calculated using standard formulas. Weed control efficiency and weed index were also calculated for each treatment. Economic analysis was done on the basis of prevailing market price of inputs used and the outputs obtained from each treatment. The analysis of variance of all parameters was determined using MSTAT software program and the analyzed data were subjected to DMRT for the mean separation.

RESULTS AND DISCUSSION

Effect on weeds

a) Weed density and dry weight

The overall weed infestation was comparatively more in conventional tillage than in zero tillage at 90 DAS. Total weed density recorded under conventional tillage

(18.38 no. m^2) was comparatively higher than zero tillage (15.84 no. m^2) at 90 DAS (Table 1) and which might be due to the poor emergence of weed seeds in zero tillage as the field was made free from weeds by applying glyphosate 15 days before planting maize. Weedy check recorded significantly higher weed density as compared to all other weeding treatments. However, application of herbicides assisted to reduce weed population and increased grain yield significantly. Thus, the sole application of atrazine decreased total weed density significantly in comparison to weedy check at 90 DAS as atrazine is a versatile pre emergence herbicide which is readily absorbed by weeds (Mundra *et al.*, 2002). All double combinations of atrazine were similar to each other with respect to total weed density which might be the reason for obtaining similar grain yield in all these double combinations of atrazine i.e. 6.69, 6.24 and 6.48 t ha^{-1} with glyphosate, pendimethalin and HW at 40 DAS, respectively (Table 2).

Total weed dry weight recorded under conventional tillage (10.78 g m^{-2}) was significantly higher as compared to zero tillage (7.88 g m^{-2}) at 90 DAS (Table 1). Further, with respect to weed management practices the values of the total weed dry weight recorded in weedy check were significantly higher due to uncontrolled weeds growth and higher weeds population in comparison to all weed control treatments (Table 1). All double combinations of atrazine were significantly effective to reduce total weed dry weight as compared to its sole application and among them pre emergence tank mixed application of atrazine and glyphosate was found significantly more effective than that of pendimethalin and HW at 40 DAS at 90 DAS which is because of the fact that the efficacy of pre emergence atrazine improved when combined with glyphosate (Singh *et al.*, 2007) and reduced weed dry weight significantly in comparison to atrazine alone (Table 1).

b) Weed control efficiency and weed index

WCE was found significantly higher in zero tillage in comparison to conventional at almost all growth stages due to significant difference in total weed density and dry weight. All double combination of atrazine were significantly superior than its sole application with respect to weed control efficiency at all stages of crop growth. Moreover, significantly higher weed control efficiency was obtained in the combination of atrazine and glyphosate (42.67 %) at 90 DAS as compared to other chemical weeding treatments.

37.17 % of grain yield was reduced by the uncontrolled weeds growth in weedy check. The result was in corroboration with Arvadiya *et al.,* 2012 who observed 39.2 % reduction in grain yield due to uncontrolled weeds growth in rabi season planted maize at Navsari, Gujrat. Malviya and Singh (2007) reported that the grain yield of maize was reduced by 70.27 and 70.24 % as compared with weed free condition during 2005 and 2006, respectively due to season long crop weed competition during rainy season under rainfed condition at Faizabad, India. Among double combinations of atrazine significantly minimum reduction in yield due to weeds growth was recorded with the addition of glyphosate (6.31 %) as compared to pendimethalin (12.74%) and HW at 40 DAS (9.51 %) which also differed significantly.

Table 1. Effect of tillage and weed management methods on total weed density, weed dry weight, weed control efficiency and weed index in spring maize at 90 DAS

Treatments	**Total weed (no. m^{-2}) density at 90 DAS**	**Total weed dry weight (g m^{-2}) at 90 DAS**	**Weed control efficiency (%) at 90 DAS**	**Weed index (WI)**
Tillage methods				
Zero	15.84 (275.26)	7.88^{b} (73.39)	26.55^{a}	11.38^{b}
Conventional	18.38 (356.85)	10.78^{a} (136.67)	14.41^{b}	18.39^{a}
CD (P= 0.05)	NS	0.63	6.58	0.98
SEm±	0.78	0.10	1.08	0.16
Weed management methods				
Weedy check	24.90^{a} (620.67)	14.49^{a} (209.93)	-	37.17^{a}
Weed free (hand weeding)	1.00^{c} (0.00)	1.00^{f} (0.00)	-	0.00^{f}
Atrazine	20.23^{b} (411.45)	11.88^{b} (140.30)	17.85^{d}	23.58^{b}
Atrazine+Glyphosate	17.51^{b} (309.36)	8.32^{e} (68.89)	42.67^{a}	6.31^{e}
Atrazine+ Pendimethalin	20.13^{b} (409.39)	11.08^{c} (133.13)	24.66^{c}	12.74^{c}
Atrazine+ HW@40 DAS	18.89^{b} (373.19)	9.19^{d} (94.89)	37.70^{b}	9.51^{d}
CD (P= 0.05)	2.55	0.40	2.38	1.48
SEm±	0.81	0.13	0.76	0.47
Grand mean	**17.11**	**9.33**	**20.48**	**14.88**

Data subjected to square-root (√X+1) transformation; Figures in the parenthesis are original values; Mean separated by DMRT and columns represented with same letter (s) are non significant at 5 % level of significance. Note: DAS (days after sowing); HW (hand weeding); T (tillage methods); W (weed management methods)

Effect on crop

Tillage and weed management methods influenced the growth of maize depending on their effect on weed infestation. All the yield attributes and yield were not influenced significantly by the tillage methods, however, it was slightly higher in zero tillage as compared to conventional tillage due to higher total weed density and dry weight. This result was supported by Khan and Parvej (2010) and Singh et al. (2007). The higher yield obtained in zero tillage might be related to the slower rate of weed seeds germination or weeds growth in response to soil conditions which assisted to decrease crop weed competition and thus resulted in higher yield (Hendrix *et al.,* 2004).

Further, almost all yield attributes were significantly increased in weed free condition as compared to weedy check. This was due to the fact that the control of weeds growth either by hand weeding or by using herbicides assisted to enhance crop growth and development as result of which more photosynthates could be used in the formation of grains (Tahir *et al.*, 2009). These results are inline with those of (Tanveer *et al.*, 1999, Hussain *et al.*, 1998 and Baye and Bouchache 2007). Such trend was also marked with herbicidal treatment with respect to weight of ear with grains, weight of grains per ear and thousand grain weight. Significant differences between weeding treatments were prominent in thousand grain weight. The combined application of atrazine and glyphosate was found comparable to weed free condition which was also reflected in grain yield. Lower number of grains per ear recorded with sole application of atrazine was the main reason for obtaining significantly lower grain yield as compared to its combination with pendimethalin and HW at 40 DAS (Table 2).

The grain yield decreased significantly in weedy check as compared to other weeding treatments. On the other hand, removal of crop weed competition at critical growth stages by hand weeding assisted to improve growth parameters, yield attributes and consequently grain yield as compared to other herbicidal treatments. The grain yields obtained in all double combinations of atrazine were significantly higher than its sole application but only the tank mixed application of atrazine and glyphosate at sowing was found equally effective as weed free condition in the formation of grain yield of spring maize. This is because of the fact that the efficacy of pre emergence atrazine improved when combined with glyphosate (Singh *et al.,* 2007) and reduced total weed density and dry weight significantly in comparison to atrazine applied alone (Table 2).

Table 2. Effect of tillage and weed management methods on yield attributes and yield in spring maize

Treatments	Number of kernels row^{-1}	Number of kernels ear^{-1}	Weight of grains ear^{-1} (g)	1000 grain weight (g)	Grain yield (t ha^{-1})
Tillage methods					
Zero	29.55	453.80	133.4	291.3	6.24
Conventional	29.16	449.80	126.4	276.7	5.95
CD (P=0.05)	NS	NS	NS	NS	NS
SEm±	0.71	11.94	3.61	3.19	0.11
Weedy check	26.31^{b}	389.70^{b}	100.9^{c}	258.73^{d}	4.50^{d}
Weed free (hand weeding)	30.93^{a}	488.80^{a}	147.5^{a}	300.95^{a}	7.18^{a}
Atrazine	29.10^{ab}	443.20^{ab}	126.4^{b}	287.87^{b}	5.51^{c}
Atrazine+Glyphosate	30.30^{a}	461.40^{ab}	140.5^{ab}	302.52^{a}	6.69^{ab}
Atrazine+ Pendimethalin	30.06^{ab}	462.70^{ab}	130.8^{ab}	272.39^{c}	6.24^{b}
Atrazine+ HW@40 DAS	29.41^{ab}	465.10^{ab}	133.4^{ab}	281.66^{bc}	6.48^{b}
CD (P=0.05)	3.66	78.14	17.96	12.96	0.61
SEm±	1.16	24.80	5.70	4.11	0.19
Grand mean	29.35	451.81	129.91	284.02	6.09

Mean separated by DMRT and columns represented with same letter (s) are non significant at 5 % level of significance. Note: HW (hand weeding), DAS (Days after sowing)

CONCLUSION

Thus, in the humid subtropical region of western Chitwan, Rampur, the maize can be successfully cultivated in zero tillage and the combination of atrazine either with glyphosate or HW at 40 DAS can be used as alternatives of manual weeding to achieve higher grain yield from maize cultivation in spring season.

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STUDY ON MORPHO-PHYSIOLOGICAL DIVERSITY AMONG THE DIFFERENT GERMPLASM OF MAIZE (ZEA MAYS L.) AND CORELATION OF DIFFERENTS COMPONENTS ON YIELD BY USING PATH ANALYSIS IN CHITWAN NEPAL

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ABSTRACT

A experiment for the study of morpho-physiological diversity and association between yield and yield related traits among the fifteen genotypes of maize, was laid out in RCBD design with three replication at National Maize Research Program, Rampur, Chitwan, Nepal in winter season from 5th October 2012 to 5th February 2013. The result of analysis revealed that SPAD reading, ear girth and hundred kernel weight showed positively and highly significant correlation with grain yield ha^{-1}. Grain yield ranged from 2226 kg ha^{-1} to 3589 kg ha^{-1} shown by CEL-0HGYA/ CEL-0HGYB and RPOP-1respectively. Days to physiological maturity ranged from 143 DAS to 162 DAS shown by S97TLYGH"AyB" (3) and TAKFA-S-9536 respectively. The results of analysis revealed that all the traits like ear girth, ear length, number of kernel row^{-1}, ear height, 100 kernel weights and grain yield ha^{-1} were significantly affected due to various maize genotypes. On path coefficient analysis comparatively ear girth (0.472), ear length (0.230), hundred kernel weights (0.199) and number kernel row^{-1} (0.091) showed direct and positive contribution on grain yield ha^{-1}. Hence, morpho-physiological diversity has been observed among the tested genotypes so that selection is possible by evaluating the ear girth, ear length, hundred kernel weight, ear height and number kernel rows^{-1}; it helps to improve the yield for the plant breeding program.

Key words: Morpho-physiological diversity, path coefficient analysis, correlation, heritability, germplasm.

INTRODUCTION

Maize (*Zea mays* L.), with a remarkable productive potential among the cereals, is world's three most important cereal crops. After Paddy, Maize is the second important cereal crop of Nepal in terms of area, production and productivity (MoAD, 2012/13). At present, the

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Maize sown area in Nepal is 8, 49,635 ha with a total production of 19, 99,010 Mt. and productivity of 2353 Kg ha^{-1} (MoAD, 2012/13). In Chitwan, maize is cultivated on total area of 3,490 ha with the total production of 10,500 metric tons and productivity of 3,009 Kg ha^{-1} (MoAD, 2012/13). Area under summer, spring and winter maize are 73.9%, 14.2% and 11.9% respectively (MOAC, 2011. The study was carried out to find out the genotypic diversity, association between yield and yield related traits and their heritability among the fifteen genotypes of maize.

Yield is a complex character, which is the product of multiplicative interactions of a number of its component characters (Grafius, 1959), cannot be improved to a greater extent on its own. Hence, a clear picture of contribution of each component in final expression of complex character is essential (Sandeep Kumar *et al.,* 2011). This variability is a key to crop improvement (Welsh, 1981). Abayi *et al.* (2004) observed significant genetic variation in important agronomic traits especially earliness to sufficiently justify the initiation of selection program. Besides that, the correlations between the traits are also of great importance for to achieve the goals in breeding programs. Analysis of correlation coefficient is the most widely used one among numerous methods (Yagdi and Sozen, 2009). Path analysis is simply the standardized partial regression coefficient, which splits the correlation coefficient into direct and indirect effects of the yield components on yield as suggested by Wright (1921) and elucidated by Dewey and Lu (1959).The analysis of genetic diversity provides maize breeder and researchers with useful information for germplasm preservation and the identification of group of inbred lines and other breeding materials that may be exploited by the production of highly heterotic hybrids. Grzesiak (2001) observed considerable genotypic variability among various maize genotypes for different traits. Ihsan *et al.* (2005) also reported significant genetic differences for morphological parameter for maize genotypes. This variability is a key to crop improvement (Welsh, 1981). Therefore, in order to improve grain yield, genetic diversity and effective selection can be practiced for the characters having high direct effects and for the characters through which indirect effects are mainly exerted on grain yield.

MATERIALS AND METHODS

The present study was conducted to study morpho-physiological diversity, association between yield and yield attributing traits and heritability among the fifteen genotypes of maize at National Maize Research Program (NMRP), Rampur, Chitwan, Nepal, during winter 2012. The experiment was laid out in randomized complete block design (RCBD) with three replications. The genotypes were grown on plot size 5.0 m × 3.0 m with inter and intra row spacing of 75 and 25 cm, respectively. NPK was applied @ of 120:60:40 kg ha^{-1} and manure @ of 6 tons ha^{-1}. Standard cultural practices were followed from sowing till harvesting during the entire crop season.

Table 1. Means for yield and yield attributing traits of fifteen genotypes in Rampur, Chitwan Nepal, 2012/13

Genotypes	Mean				
	EL (cm)	**EG (cm)**	**NKPR**	**HKW (g)**	**GY/H (kg ha^{-1})**
SIN-IBP-UTYF	15.17^{bcde}	13.75^{ab}	26.33^{bcd}	24.07^{b}	2311^{c}
RPOP-3	14.50^{cdef}	14.19^{ab}	26.00^{bcd}	24.57^{b}	2477^{c}
POZARICA 9531	13.57^{f}	14.05^{ab}	28.00^{ab}	27.07^{ab}	2869^{abc}
S97TLYGH"AyB" (3)	14.50^{cdef}	12.56^{c}	23.93^{d}	24.10^{b}	2603^{c}
TAKFA-S-9536	15.32^{bcd}	13.41^{bc}	25.73^{bcd}	26.20^{ab}	2219^{c}
RPOP-4	14.02^{ef}	14.37^{ab}	25.10^{cd}	31.37^{a}	3017^{abc}
RPOP-1	14.01^{ef}	14.83^{a}	26.80^{bc}	30.87^{a}	3589^{a}
RPOP-2	14.12^{def}	14.64^{a}	27.90^{ab}	29.07^{ab}	3007^{abc}
TAKFA-S 9624	14.92^{bcde}	13.93^{ab}	26.33^{bcd}	28.43^{ab}	2316^{c}
ACROSS 9331 RE	16.58^{a}	13.93^{ab}	29.33^{a}	28.30^{ab}	3537^{a}
FS'LOC. CHECK	15.12^{bcde}	14.65^{a}	26.67^{bc}	30.47^{a}	3552^{a}
RAMPUR COMPOSITE (ST. CHECK)	15.61^{abc}	14.63^{a}	26.20^{bcd}	30.67^{a}	2821^{abc}
CEL-0HGYA/ CEL-0HGYB	14.75^{bcdef}	13.95^{ab}	26.33^{bcd}	26.90^{ab}	2226^{c}
BLSB SO7 F12	15.92^{ab}	14.01^{ab}	26.53^{bc}	30.97^{a}	3505^{ab}
RAMPUR S03F02	15.03^{bcde}	14.04^{ab}	23.92^{d}	27.33^{ab}	2697^{bc}
Mean	14.8	14.0	26.3	28.0	2849
F-test	(0.0002)**	(0.0070)**	(0.0016)**	(0.0420)*	(0.0009)**
LSD (0.05)	0.9564	0.9564	2.143	5.052	732.1
SEM	0.3302	0.3302	0.7398	1.744	252.7
CV (%)	4.07	4.07	4.86	10.78	15.36

*(significant), **(highly significant) and ns (non-significant) at p=0.05, Treatments means bearing same letter (s) are not significantly different at (p=0.05) by DMRT. SEM= Standard error of mean, LSD = Least significant difference and CV = Coefficient of Variance, EL= Ear length, EG= Ear girth, NKPR= Number of kernel row^{-1}, HGW= Hundred kernel weights, GY/H= Grain yield ha^{-1}and g=gram

Data was recorded on randomly selected five plants from each plot for yield related traits viz; number of kernel row ear^{-1}, number of kernel row^{-1}, ear girth, ear length and hundred kernel weight were calculated for the entire plot, converted into yield ha^{-1} and quantitative traits viz. SPAD reading, days to 50% tasseling, days to 50% silking, plant height, ear height, days to physiological maturity. Data were statistically analyzed using analysis of variance appropriate for randomized complete block design. Means were compared using LSD test at 0.05 level of probability when the F values were significant (Steel and Torrie, 1984). Direct and indirect effects on different yield and yield related traits were observed by path coefficient analysis.

Simple correlation coefficients were calculated for each pairs of the parameters using the formula by Steel and Torrie (1980) and t-test was applied for testing significance of correlation coefficients.

RESULTS AND DISCUSSION

Means regarding different yield attributing traits and their comparison are given in Table 1. The mean data indicated that maize genotypes differ significantly in ear girth, ear length, number of kernel row^{-1}, hundred kernel weight and grain yield ha^{-1} (kg). Mean for number of kernel row^{-1}was found 26.34 and ranged from 23.92 to 29.33 shown by RAMPUR S03F02 and ACROSS 9331 RE respectively. Ear girth was ranged from 14.83 cm (RPOP-1) to 12.56 cm (S97TLYGH"AyB" (3). Hundred kernel weight ranged from 24.57 g (SIN-IBP-UTYF) to 31.37 g (RPOP-4) and among the tested genotypes RPOP-1 has been found high yielder (3589 kg ha^{-1}) and CEL-0HGYA/ CEL-0HGYB was low yielder (2849 kgha^{-1}) genotype. ANOVA showed highly significant result in ear girth, ear length, number of kernel row^{-1}, hundred kernel weight and grain yield ha^{-1} (kg) for genotypes. Correlation coefficient of ear girth and hundred kernel weight with grain yield ha^{-1} has been found significant and positive correlation which was shown in Table 2.

Table 2. Pearson's correlation coefficient among different yield and yield attributing traits of fifteen genotypes, Nepal, 2012/13

	SPAD	**DTT**	**DTS**	**EH**	**DM**	**EG**	**HKW**	**GY/H (kg)**
SPAD	1.00							
DTT	-0.43**	1.00						
DTS	-0.35**	0.61**	1.00					
EH	0.10 ^{ns}	-0.15 ^{ns}	0.32**	1.00				
DM	-0.14 ^{ns}	0.17 ^{ns}	0.65**	0.46**	1.00			
EG	0.20 ^{ns}	-0.38**	0.04 ^{ns}	0.39**	0.46**	1.00		
HKW	0.18 ^{ns}	-0.27 ^{ns}	-0.12 ^{ns}	0.35*	0.16 ^{ns}	0.47**	1.00	
GY/H (kg)	0.34**	-0.59**	-0.40**	0.13 ^{ns}	-0.07 ^{ns}	0.49**	0.46**	1.00

**= highly significant at the 0.05 level (two-tailed), *= significant at the 0.05 level (two-tailed) and ns = non-significant. SPAD= SPAD reading, DTT= days to 50% tasseling, DTS= days to 50% silking, EH= ear height, DM= days to physiological maturity, EG= ear girth, HKW= hundred kernel weight, and GY/H (kg ha^{-1})= grain yield per hectare

Mostly yield determinative traits were number of kernels row^{-1} followed by ear length, hundred kernel weight, number of kernel row ear^{-1} and ear girth and hence, simultaneous selection for these traits might bring an improvement in grain yield . Similar results were also reported by Sandeep Kumar *et al.,* (2011), Alvi *et al.,* (2003), Prakash *et al.,* (2006), Sreckov *et al.,* (2010), Manivannam (1998), Chinnadurai and Nagarajan (2011) and Satyanarayana *et al.,* (1990).

Table 3. Direct effects (bold) and indirect effects of yield components on grain yield of fifteen maize

Traits	SPAD	DTT	PH	EG	EL	NKPR	HKW
Via SPAD	0.070	-0.030	0.013	0.014	-0.001	0.015	0.013
Via DTT	0.093	-0.216	0.009	0.082	-0.009	0.039	0.058
Via PH	-0.045	0.009	-0.235	-0.087	-0.045	-0.028	-0.059
Via EG	0.094	-0.179	0.175	0.472	-0.080	0.094	0.222
Via EL	-0.005	0.009	0.044	-0.039	0.230	0.048	0.014
Via NKPR	0.020	-0.016	0.011	0.018	0.019	0.091	0.008
Via HKW	0.036	-0.054	0.050	0.093	0.012	0.018	0.199
Total	0.34	-0.59	0.05	0.49	0.1	0.28	0.46

SPAD= SPAD reading, DTT= days to 50% tasseling, PH= plant height, EG= ear girth, EL= ear length, NKPR= number of kernel row^{-1} and HKW=hundred kernel weight

Direct effect of ear girth on grain yield ha^{-1}had highest positive value (0.472) followed by ear length (0.230), hundred kernel weight (0.199),number of kernel row^{-1} (0.090) and SPAD reading (0.070) as an important yield attributing component based on positive direct effect in path coefficient analysis. This result is in agreement with Alvi *et al.,* (2003), Sreckov *et al.*, (2011), Sofi *et al.,* (2007) and Venugopal *et al.,* (2003). Hence, these traits except ear length, ear height and number of kernel row^{-1} could be relied upon for selection of genotypes to improve genetic yield potential of maize. Days to 50% tasseling (0.216) and plant height (0.235) showed negative direct effects on grain yield ha^{-1} (Table 3).

Among quantitative characters, high heritability (>0.60) has been observed for days to 50% silking (0.884) and days to physiological maturity (0.705) shown in Table 4. Wannows and his colleagues (2010) reported high heritability for days to physiological maturity and days to 50% silking which is agreed with our findings.

Table 4. Estimation of Heritability in broad sense of fifteen genotypes Nepal, 2012/13

	V_g	V_e	V_p	GCV (%)	PCV (%)	GAM	h_{bs}^2
SPAD	2.166	4.73	6.896	2.741	4.89	3.164	0.314
DTS	84.859	11.1	95.959	11.72	12.463	22.704	0.884
PH	116.012	128.212	244.224	6.438	9.341	9.141	0.475
EH	116.658	86.629	203.287	12.994	17.153	20.277	0.574
DM	20.333	8.508	28.841	2.838	3.38	4.909	0.705
EL	0.512	0.386	0.898	4.812	6.372	7.486	0.57
NKPR	1.468	1.642	3.11	4.599	6.695	6.509	0.472
GY/H	191931	191585	383516	15.373	21.732	22.404	0.5

V_g= genotypic variance, V_e= environmental variance, V_p= phenotypic variance, GAM = genetic advance as percentage of mean, PCV = phenotypic coefficient of variation GCV = genotypic coefficient of variation, h_{bs}^2= broad sense heritability, EL= ear length, NKPR= number of kernel row^{-1}, PH= plant height, EH= ear height, DM= days to physiological maturity, SPAD= soil and plant analyzer development, DTS= days to 50% silking, and GY/H= grain yield ha^{-1}

CONCLUSION

Thus, comparatively all the germplasm were highly different in their yield attributing traits and are directly and indirectly contributes on grain yield and can be improve by using their inter relationship so selection is effective. All the genotypes showed morpho-physiological diversity among genotypes and related traits. Selection of RPOP-1 is economically best variety for higher yield.

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ENERGY MANAGEMENT IN CONSERVATION AND CONVENTIONAL IN MAIZE

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ABSTRACT

Energy is the important aspect in any type of works. This study was conducted to determine the type and amount of energy required on the basis of type of agriculture i.e. conservation agriculture and conventional agriculture. The amount of input energy, output energy, energy use efficiency, net energy balance and type of energy used in conventional and conservation agriculture were compared. The input energy of conservation agriculture is lower in human labour, machinery, diesel fuel, fertilizer than the conventional agriculture. But input energy in chemical and residue use is much more in conservation agriculture as compared to conventional agriculture. Hence, the amount and type of energy used in conservation agriculture is better than the conventional agriculture.

INTRODUCTION

In all development process energy is the valuable aspect and in agriculture development process also energy has key role. The energy requirement for production, processing and distribution should be high to meet the demand of feeding of expanding population and social and economic growth (Khambalkar et al., 2010). The use of suitable energy is most necessary for the sustainable agriculture. Kalambalkar et al., 2010, reported that the traditional operational energy requirement increases in mechanized methods (3130.72 MJ/ha) then in traditional method (2680.78 MJ/ha) for green gram crop. While decrease in cost of operation in traditional method (Rs 8407.5/ha) was higher than in mechanized system (5147.0/ha).

To find the amount and type of energy, energy calculation was done from the field research of maize from February 2014 to March 2014 under conventional and conservation agriculture. In this aspect input energy, output energy, energy use efficiency and net energy balance were calculated.

MATERIAL AND METHODS

The energy management was calculated on the basis of factor of treatment. The research was conducted under maize rice cropping system with conservation vs conventional agriculture in fourth season of maize in strip-split plot design. The four factor with tillage, residue, fertilizer and weed management were managed under i) conventional tillage and ii) no tillage; i) 35 cm rice residue retained and ii) residue removal; i) farmer's practice level of fertilizer dose i.e. 10 ton ha^{-1} FYM +70:30:50 kg NPK ha^{-1} (Paudel and Matsuoka, 2008) and ii) Research-based recommendation dose i.e. 180:115:160 Kg NPK ha^{-1} under yield target of 8 t ha^{-1} for hybrid maize (ACIAR, 2009); i) herbicide use i.e. Atrazine, pre-emergence only @ 1.5 kg a. i. ha^{-1} within 48 hours of seeding and ii) manual weeding i.e. hand pulling i.e. at the interval of one month as not to disturb the soil under no tillage. No tillage, residue retention, farmer practice level of fertilizer dose and herbicide use for weed management are involved in conservation agriculture while conventional tillage, residue retained, research based fertilizer dose are involved in conservation agriculture. The energy was calculated on the basis of following method.

Energy input = All energy required during crop production till harvesting (MJ)
Energy output= Energy of seed (MJ) + Energy of stover (MJ)
Energy use efficiency = Output Energy (MJ/ha)/ Input Energy (MJ/ha)
Net Energy Balance = Output Energy (MJ/ha) – Input Energy (MJ/ha)

Table 1: Energy equivalents of input and output in maize production system

Equipment/inputs	Units	Equivalent energy (MJ)	References
A. Inputs			
Human labour			
a) Adult man	Man-hour	1.96	Bojaca and Schrevens, 2010
b) Adult woman	Woman-hour	1.57	Devasenapathy et al., 2009
Machinery	hour	64.80	Devasenapathy et al., 2009
Diesel fuel	Litre	56.31	Devasenapathy et al., 2009
Chemical Fertilizers			
a) N	Kg	64.40	Mobtaker et al., 2010; Mohammadi et al., 2010

b) P_2O_5	Kg	11.60	Devasenapathy et al., 2009
c) K_2O	Kg	6.7	Devasenapathy et al., 2009
Farm Yard Manure (FYM)	Kg (dry mass)	0.3	Devasenapathy et al., 2009
Chemicals (Herbicide)			
a) Glyphosate	Kg (a.i)	454	Audsley et al., 2009
b) Atrazine	Kg (a.i)	188.3	Audsley et al., 2009
Maize seed	Kg	15.2	Yadav et al.,2013
Rice straw (residue)	Kg	12.5	Yadav et al.,2013
B. Output			
Maize grain	Kg	15.2	Yadav et al.,2013
Maize stover	Kg	18	Yadav et al.,2013

Table 2: Input energy of equipment for irrigation

Particulars	Energy source	Energy calculation
	Equipment (Diesel motor 5 Hp)	= Wt. of the engine (kg)/ Life span (hrs) x MJ x hrs of operation = 150/10500 x 64.80 x 11.43 = 10.58 MJ
Sub-total (MJ/ha)		**10.58 MJ**

Table 3: General input energy (MJ/ha) for all treatment

S.N.	Particulars	Unit	Quantity	Equivalent energy (MJ)	Total Energy MJ/ ha
1.	Seed energy	Kg	20	15.2	304
2.	Preplant application of Glyphosate	Kg	2	454	908
3.	Spraying of Glyphosate	Man days	4	6 x1.96	47.04
4.	Diesel cost (for irrigation)	Liter	40	56.31	2252.4
5.	Labor for irrigation	Man days	8	6 x 1.96	94.08
6.	Equipment energy for irrigation		From Table 2		10.58
7.	Harvesting and shelling	Woman days	30	6 x 1.57	282.6
	Sub-total				**3898.7**

Table 4: Input energy (MJ/ha) for field preparation to sowing as influenced by factor of treatments

Particulars	**Energy source**	**Energy calculation**
For conventional tillage		
Tractor used for all operation from ploughing to sowing - (5 hrs/ha)	Mechanical Tractor	= Wt. of the tractor (kg)/Life span (hrs) x MJ × hours of operation = 2500/12000 × 64.80 × 5 = 67.5 MJ
Cultivator – (2hrs/ha)	Implement used – cultivator	= Wt. of the cultivator (kg)/Life span (hrs) × MJ x hours of operation = 400/6000 × 64.80 x 2 = 8.64 MJ
Pulverizing – (2hrs/ha)	Implement used - Rotavator	= Wt. of the rotavator (kg)/Life span (hrs) x MJ × hours of operation = 400/4000 × 64.80 × 2 = 12.96 MJ
Seeding – (1hr/ha)	Implement used - Seed drill	= Wt. of the seed drill (kg)/Life span (hrs) × MJ x hours of operation = 400/4000 κ 64.80 x 1= 6.48 MJ
	Diesel consumption (3.5 litre/hr)	= 3.5 × 5 × 56.31 MJ = 985.425 MJ
	Driver (Adult man)	= 5 × 1.96 MJ = 9.8 MJ
Sub-total (MJ/ha)		**1090.805 MJ**
For no tillage		
Seed sowing in no tillage – with Jab planter (9 x 6 hrs/ha)	Adult woman	= 9 x 6 x 1.57 MJ = 84.78 MJ
Sub-total (MJ/ha)		**84.78 MJ**

Table 5: Input energy (MJ/ha) for residue retention as influenced by factor of treatment

S.N	**Particulars**	**Unit**	**Quantity**	**Equivalent energy (MJ)**	**Total Energy MJ/ha**
1.	Residue kept				
a.	Residue	Kg	3000	12.5	37500
	Sub-total				**37500**

Table 6: Input energy (MJ/ha) for fertilizer management as influenced by factors of treatments

S.N	Particulars	Unit	Quantity	Equivalent energy (MJ)	Total Energy MJ/ha
1.	Farmer dose				
a.	FYM	kg	10000	0.3	3000
b.	N	Kg	70	64.40	4508
c.	P_2O_5	Kg	30	11.60	348
d.	K_2O	Kg	50	6.7	335
e.	Fertilizer application	Man days	12	6 x1.96	141.12
	Sub-total				**8332.12**
2.	Research dose				
a.	N	Kg	180	64.40	11592
b.	P_2O_5	Kg	115	11.60	1334
c.	K_2O	Kg	160	6.7	1072
e.	Fertilizer application	Man days	12	6 x1.96	141.12
	Sub-total				**14139.12**

Table 7: Input energy (MJ/ha) for weed management as influenced by factor of treatments

S.N	Particulars	Unit	Quantity	Equivalent energy (MJ)	Total Energy MJ/ha
1.	Herbicide				
a.	Atrazine	Kg	1.5	188.3	282.45
b.	Spraying of Atrazine	Man days	4	6 x 1.96	47.04
	Sub-total				**329.49**
2.	Manual	Woman days	75	6 x 1.57	706.5
	Sub-total				**706.5**

Table 8: Input energy (MJ/ha) for conservation and conventional agriculture

Input Energy	Conservation Agriculture (MJ/ha)	Conventional Agriculture (MJ/ha)
Human Labour	696.66	1281.14
Machinary	10.58	106.16
Diesel fuel	2252.4	3237.825
Fertilizer	8191	13998
Chemical	1190.45	282.45
Seed and residue incorporation	37804	304
Total	**50145.09**	**19209.58**

Table 6: Input energy, output energy, energy use efficiency, net energy balance, grain yield, stover yield as influenced by factors of treatments

Factors	Input Energy ($\times 10^3$ MJ ha^{-1})	Output Energy ($\times 10^3$ MJ ha^{-1})	Energy Use Efficiency	Net Energy Balance ($\times 10^3$ MJ ha^{-1})	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
Tillage methods						
CT	35.49	216.38^{b}	7.43^{b}	180.89^{b}	5.39^{b}	7.46^{b}
NT	34.49	268.42^{a}	9.45^{a}	233.94^{a}	6.64^{a}	9.30^{a}
LSD		23.08*	1.68*	23.08*	1.01*	1.78*
SEm±		3.79	0.28	3.79	0.17	0.29
Residue management						
RK	53.74	286.71^{a}	5.28^{b}	232.97	7.02^{a}	10.00^{a}
RR	16.24	198.10^{b}	11.60^{a}	181.86	5.02^{b}	6.76^{b}
LSD		65.42*	6.24**	NS	1.13*	2.72*
SEm±		10.75	0.44	10.75	0.19	0.45
Fertilizer doses						
FD	32.09	156.05^{b}	6.05^{b}	123.96^{b}	3.62^{b}	5.62^{b}
RD	37.89	328.76^{a}	10.83^{a}	290.86^{a}	8.42^{a}	11.15^{a}
LSD		30.41**	1.08**	30.41**	0.45**	1.48**
SEm±		6.41	0.23	6.41	0.09	0.31
Weed management						
Herbicide	34.80	245.59	8.51	210.79	6.07	8.52
Manual	35.18	239.21	8.37	204.03	5.97	8.25
LSD		NS	NS	NS	NS	NS
SEm±		7.25	0.34	7.25	0.18	0.29
CV%		14.66	19.80	17.13	14.28	17.06
Grand mean	**34.99**	**242.40**	**8.44**	**207.41**	**6.02**	**8.39**

CT = conventional tillage, NT = No. tillage, RK= residue kept, RR = residue removed, FD = farmer dose, RD = Research dose, * = Significantly different at $p \leq 0.05$, ** = Significantly different at $p \leq 0.01$ by DMRT, LSD value differs according to the level of significance

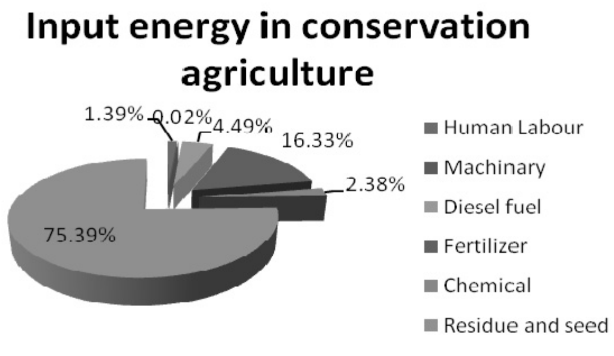

Fig 1: Percentage of input energy in conservation agriculture

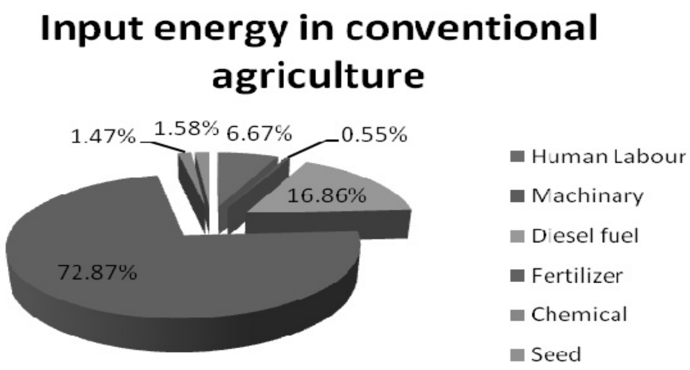

Fig 2: Percentage of input energy in conventional agriculture

RESULTS

The input energy of conventional tillage, residue kept, farmer dose of fertilizer and herbicide use has lower than no tillage, residue removed, research dose of fertilizer and manual weeding. Output energy is higher in no tillage, residue kept, research dose of fertilizer and herbicide use in comparison with conventional tillage, residue kept, farmer dose of fertilizer and manual weeding respectively. This output energy was depended upon only grain and stover yield. Similarly, energy use efficiency was higher in no tillage, residue removed, research dose of fertilizer and herbicide use in comparison with conventional tillage, residue kept, farmer dose of fertilizer and manual weeding respectively. Similarly net energy balance was higher in no tillage, residue kept, research dose of fertilizer and herbicide use in comparison with conventional tillage, residue removed, farmer dose of fertilizer and manual weeding (Table 6).

DISCUSSION

In conservation agriculture human labour input energy is nearly half than the conventional agriculture because manual weeding is very costly method than herbicide used. Dahal and Karki, 2014 also reported that there is requirement of high labour as compared herbicide use and there is low density and dry mass of weed as compared to manual weeding. Due to high machinery use in conventional agriculture the input energy in machinery and diesel fuel is more in conventional agriculture as compared to conservation agriculture. The input energy of chemical is more in conservation agriculture due to more use of herbicide instead of manual weeding. The input energy of fertilizer use is also more in research dose of fertilizer due to high amount of fertilizer and in conservation agriculture, residue incorporation has gained high amount of input energy. The energy used from residue incorporation is clean energy. Due to high yield of grain and stover in conservation agriculture (Dahal et al., 2014), the output energy is also high in conservation agriculture. Hence, even though more input energy is required in conservation agriculture, the type of energy is suitable in conservation agriculture as compared to conventional agriculture.

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RESPONSE OF BROCCOLI (BRASSICA OLERACEA L. VAR. ITALICA) VARIETIES TO DIFFERENT SOURCES OF NITROGEN AT GAINDAKOT, NAWALPARASI, NEPAL

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ABSTRACT

The study was conducted at farmer's field of Gaindakot, Nawalparasi during October 2012 to February 2013 to evaluate the influence of different sources of nitrogen (Vermicompost, farm yard manure and urea) and varieties on yield and yield attributing characteristic of broccoli. The experiment was laid out in factorial randomized complete block design (RCBD) with three replications. A total of fifteen treatments with the combination of five different sources of nitrogen ($N_{100\%Urea}$, $N_{100\%Vermi}$, $N_{100\%FYM}$, $N_{50\% Urea}$ + $N_{50\%Vermi}$ and $N_{50\%Urea}$ + $N_{50\%FYM}$) as the first factors and three varieties (Calabrese, Green Sprouting and Premium Crop) as the second were taken in each replication. Seedlings were transplanted at spacing of 45 x 40 cm in each plot. Among the various morphological and yield attributing curd parameters, Premium Crop showed better performance in $N_{50\%Urea}$ + $N_{50\%Vermi}$ except some of them. Premium crop produced the highest terminal curd yield (23.70 t/ha) in $N_{50\%Urea}$ + $N_{50\%Vermi}$ (20.30 t/ha) whereas Calabrese produced the highest auxiliary curd yield (9.34 t/ha) in $N_{50\%Urea}$ + $N_{50\%Vermi}$ (8.25 t/ha). Similarly, Green Sprouting produced the highest total yield (25.10 t/ha) in $N_{50\%Urea}$ + $N_{50\%Vermi}$ (28.55 t/ha). Although Premium Crop obtained the highest B: C ratio from $N_{100\%Urea}$ in the initial year, the B: C ratio of $N_{50\%Urea}$ + $N_{50\%Vermi}$ and $N_{50\%Urea}$ + $N_{50\%FYM}$ would be increased in the subsequent cropping season. It is due to the improvement in soil fertility and decrease in production cost of vermicompost in long run as residual nutrients from applied manure could be used in coming cropping seasons. Thus, Premium Crop can be suggested to grow with the combine use of $N_{50\%Urea}$ + $N_{50\%Vermi}$ followed by $N_{50\%Urea}$ + $N_{50\%FYM}$ for higher yield and soil fertility maintenance over a longer period of time.\

Key words: Vermicompost, FYM, combine use, broccoli varieties, yield etc.

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica*) is an important vitamin rich winter vegetable crop which belongs to family Brassicaceae. It is a rapidly developing compact floral vegetable that is harvested at compact head and immature bud stage (Gray, 1982). Nutritionally, broccoli is an excellent source of antioxidants, vitamin C, fibre and folate. It also contains good levels of iron, calcium, potassium and vitamin A and E (Gourley, 2003; Lister and Bradstock, 2003). The cancer fighting properties of broccoli related to the high levels of active plant chemicals called glucosinolates (Zhao *et al.*, 2007). Broccoli is comparatively a newer winter vegetable in Nepal (Ghimire *et al.*, 1993). MoAD (2013) reported that the total area under broccoli in Nepal in the year 2012/13 was 2138 ha with production 26769 mt and productivity 12.5 mt ha^{-1}. Though there are increasing trends of area, production and productivity of vegetables in Nepal still the increased demand of broccoli is not fulfilled by domestic production alone.

Plant nutrition is one of the prime considerations for getting higher yield of any crop. Being a heavy feeder, broccoli demands constant supply of large amount of both macro and micro nutrients for its luxuriant growth. Among the essential nutrients, nitrogen plays significant role in metabolism, growth, reproduction and hereditary characters of plant (Dutta, 1998). The indiscriminate use of chemical fertilizers increases soil acidification, impairs soil physical condition, reduces organic matter content, creates micro nutrient deficiencies and increases susceptibility to pests and diseases (Joshi and Singh, 2004). Farmers are using chemical fertilizer haphazardly in the name of achieving immediate higher benefit without considering their negative impact on long term soil fertility and sustainability. Thus, an alternative source of low cost plant nutrient is necessary to search for the maintenance of soil fertility and productivity over a longer period of time minimizing the adverse impact of chemical fertilizer on soil.

Organic manure is the traditional source of plant nutrient which is the most readily available to the farmers (Gaur *et al.*, 1995). The vermicompost affects the soil physics, chemical structure, and promotes biological properties of it (Suthar, 2008). It contains the plant hormone like substance which may be due to the presence of higher microbial population (Krishanamoorthy and Vajranabhaian, 1986). Application of vermicompost significantly increases the micronutrient in the field soil than with animal manure (Reddy and Reddy, 1999). It acts as better source of plant nutrient to substitute or complement the chemical fertilizer and may also reduce the need for synthetic pesticides as it also provide resistance to disease.

Farm yard manure plays an important role in maintaining and improving the soil as it contains all plant nutrients, humus and organic substances. Addition of it helps in solubilization of plant nutrients and increases the uptake of N, P, K, Ca and Mg during crop growth (Subbiah *et al.*, 1982). It is readily available in the most part of the country.

Neither the chemical fertilizers alone nor organic sources exclusively can achieve the production sustainability of soil as well as crops under high intensive cropping systems (Singh and Yadhav, 1992). Quality product along with higher economic return can be obtained without deteriorating the soil condition for subsequent cropping through the judicious application of organic and inorganic fertilizer (Devi *et al.*, 2003; Wang and Li, 2004).

Broccoli posses comparatively wider adoptability to environment, higher nutritive value, better taste and less risk to crop failure due to various biotic and abiotic factors than that of cauliflower. Moreover, awareness of the consumers towards organic product as well as broccoli is increasing day by day in different parts of the country. This indicates the enough scope for its promotional efforts. Only a very few research work have been carried on broccoli varieties and their response to different sources of nitrogen (organic, inorganic and their combination). Every variety does not respond equally to the available nutrients at all places of different climatic condition. So, an appropriate variety selection is necessary for higher yield of the crop. Therefore, the suitable variety and appropriate source of nutrient to the plant most be identified for crop cultivation practices to obtain optimum yield.

MATERIALS AND METHOD

The study was conducted at farmer's field of Gaindakot, Nawalparasi from October 2012 to February 2013. The experiment was laid out in a factorial randomized complete block design (RCBD) with three replications. A total of 15 treatments with the combinations of five different sources of nitrogen ($N_{100\ \%Urea}$, $N_{100\%Vermi}$, $N_{100\%FYM}$, $N_{50\%\ Urea}$ + $N_{50\%Vermi}$ and $N_{50\%\ Urea}$ + $N_{50\%\ FYM}$) and three varieties (Calabrese, Green Sprouting and Premium Crop) were taken in each replication. Source of nitrogen was the first factor of experiment while the variety of broccoli was the second under the experiment. There were a total of 45 plots with 4.5 m^2 of each. The laboratory analysis of vermicompost, FYM and soil before transplanting of seedlings was done in the regional soil laboratory, Pokhara, Nepal. The recommended dose of nitrogen, phosphorous, potash was supplied by using urea, single super phosphate (SSP), and murate of potash (MOP) at the rate of 100:60:50 kg NPK $ha^{-1.}$ The data recording was done on various growth attributing characters (plant height, leaf length, leaf width, leaf number, stem diameter and rosette diameter), maturity characters (days to 50% heading, days to first harvest and days to last harvest), yield and yield attributing parameters (length and diameter of terminal curd, terminal curd stem diameter, no. of side shoots, yield of terminal and auxiliary curd, total yield, total biomass and harvest index). All the collected data were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT) for mean separation using MSTAT-C.

Table 1 : Labouratory analysis of vermicompost, FYM and soil before transplanting of seedlings

Manure	Nutrient content percentage			Organic matter	pH	Soil texture
	Nitrogen (%)	Phosphorous	Potash (%)			
Vermicompost	1.4	0.71 %	1.98 (%)	-	-	-
FYM	0.67	0.38 %	1.14 (%)	-	-	-
Soil	0.23 (high)	967kg/ha (high)	648kg/ha (high)	4.6 % (medium)	5.4 (acidic)	Sandy loam

RESULTS AND DISCUSSION

Plant height, leaf length, leaf width, leaf number, stem diameter and rosette diameter

Effects of different sources of nitrogen and varieties on plant height, leaf length, leaf width, leaf number, stem diameter and rosette diameter were significant (Table 2) at harvest. The nitrogen source, $N_{50\%Urea}$ + $N_{50\%Vermi}$ showed the highest on plant height (54.68 cm), leaf length (56.49 cm), leaf width (20.83 cm), leaf number (13.58), stem diameter (3.50 cm) and rosette diameter (71.92 cm) whereas $N_{100\%FYM}$ showed the lowest values on them at harvest. Similarly, Calabrese recorded the highest plant height (60.38 cm) and leaves number (13.32) whereas Green Sprouting and Premium Crop recorded the lowest plant height (45.38 cm) and leaves number (11.55), respectively at harvest. Likewise, Premium Crop recorded the highest leaf length (55.84 cm), leaf width (20.31 cm), stem diameter (3.87 cm) and rosette diameter (69.83 cm). However, Green Sprouting recorded the lowest leaf length (50.92 cm), leaf width (18.25 cm), stem diameter (2.60 cm) and rosette diameter (59.78 cm) at harvest.

Rafi *et al.* (2002) revealed that the plant height recorded at 90 days after sowing was maximum from treatment 50% RDF + 50% vermicompost and the shortest was from control. Maurya *et al.* (2008) also reported longer leaf length, leaf width and leaf number from the combined application of 2.5 t/ha vermicompost + ½ RDF as compare to organic (vermicompost and FYM) and inorganic fertilizer (RDF) alone in broccoli. The result was in harmony with the findings of Giri (2007) and Bhattrai (2013) who also reported that greater plant height and number of leaves were observed from Calabrese as compare to Green Sprouting and Premium Crop, respectively.

Table 2. Effects of different sources of nitrogen and varieties on plant height, leaf length, leaf width, leaf no., stem diameter and rosette diameter of broccoli at Gaindakot, Nawalparasi, Nepal during 2012/13

Treatments	**Plant height at harvest (cm)**	**Leaf length at harvest (cm)**	**Leaf width at harvest (cm)**	**Leaf no. per plant at harvest**	**Stem diameter at harvest (cm)**	**Rosette diameter at harvest (cm)**
Source of nitrogen (N)						
$N_{100\%Urea}$	53.20^{a}	54.81^{ab}	19.66^{ab}	12.47^{ab}	3.25^{b}	64.65^{b}
$N_{100\%Vermi}$	51.22^{ab}	52.36^{b}	18.42^{bc}	11.64^{b}	3.19^{b}	62.11^{b}
$N_{100\% FYM}$	47.71^{b}	47.77^{c}	17.05^{c}	11.40^{b}	3.13^{b}	56.70^{c}
$N_{50\% Urea}$ + $N_{50\%Vermi}$	54.68^{a}	56.49^{a}	20.83^{a}	13.58^{a}	3.50^{a}	71.92^{a}
$N_{50\% Urea}$+ $N_{50\%FYM}$	54.47^{a}	55.09^{ab}	20.36^{a}	13.11^{a}	3.27^{b}	69.69^{a}
SEM±	1.65	1.12	0.49	0.43	0.078	1.34
$LSD_{0.05}$	4.79*	3.24**	1.43**	1.25**	0.22*	3.87**
Varieties						
Calabrese	60.38^{a}	53.15^{b}	19.24^{ab}	13.32^{a}	3.34^{b}	65.44^{b}
Green Sprouting	45.38^{c}	50.92^{b}	18.25^{b}	12.45^{ab}	2.60^{c}	59.78^{c}
Premium Crop	51.01^{b}	55.84^{a}	20.31^{a}	11.55^{b}	3.87^{a}	69.83^{a}
SEM±	1.28	0.87	0.38	0.33	0.06	1.04
$LSD_{0.05}$	3.71**	2.51**	1.11**	0.97**	0.17**	3.00**
Grand mean	52.26	53.30	19.27	12.44	3.27	65.01
CV (%)	9.49	6.30	7.70	10.39	7.04	6.17

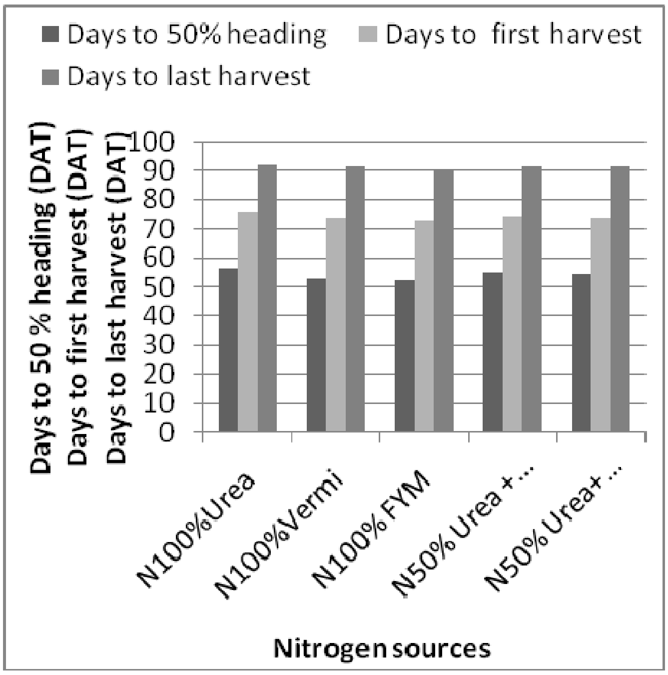
Means followed by the same letter (s) within a column are not significant at 5% level of significance as determined by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance.

Days to 50% heading, days to first harvest, and days to last harvest of broccoli

Effects of different sources of nitrogen and varieties on days to 50% heading in broccoli were significant (Figure. 1). Nitrogen source, $N_{100\%Urea}$ had the longest period to 50 %

heading (56.00 DAT) followed by $N_{50\%Urea}$ + $N_{50\%Vermi}$ (54.44DAT) and $N_{50\%Urea}$+ $N_{50\%FYM}$ (53.89DAT), all of them were similar whereas $N_{100\%FYM}$ had the shortest (51.89 DAT) period. However, effects of different sources of nitrogen on days to first harvest and days to last harvest in broccoli were non-significant although effect of varieties on them were significant. Premium Crop showed the longest period to 50% heading (57.27 DAT) and first harvest (79.93DAT) whereas Green Sprouting showed the longest period to last harvest (93.13DAT). However, Calabrese showed the shortest period to 50 % heading (51.47 DAT) and first harvest (64.60 DAT). Likewise, Premium Crop showed the shortest period to last harvest (87.27 DAT).

The earliness in heading had been attributed to the faster enhancement of vegetative growth through mineral nitrogen and storing sufficient reserved food material through slow release nutrient from FYM for heading. Since total amount of nitrogen become available to the crop with the use of urea alone and its higher dose in the integrated nutrient management permits luxurious growth. This might have delayed transformation of vegetative phase to curd formation phase. Consequently, it might have delayed curd initiation and time of harvest. The shortest period to harvest from Calabrese might be due to the faster growth rate of Calabrese than others.



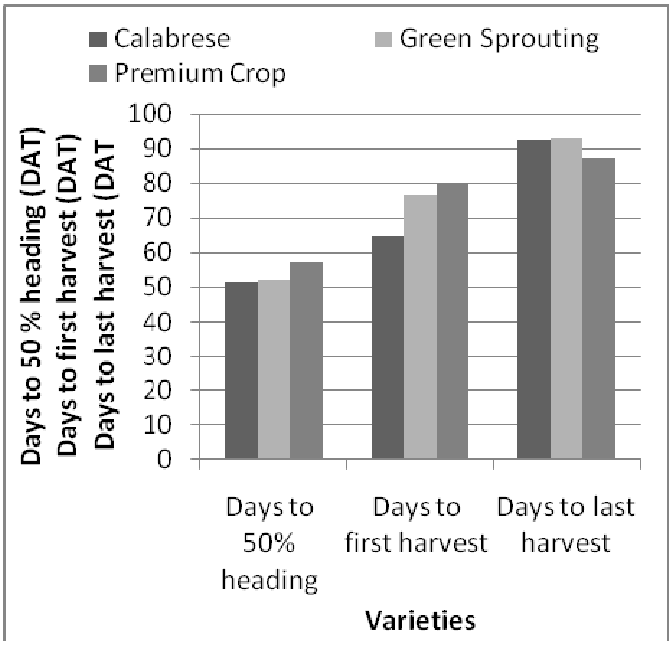


Figure 1: Effects of (a) nitrogen sources, and (b) Varieties on days to 50% heading, days to first harvest, and days to last harvest of broccoli at Gaindakot, Nawalparasi, Nepal during 2012/13

Terminal curd and number of side shoots

Effects of different sources of nitrogen and varieties on terminal curd length, terminal curd diameter, terminal curd stem diameter and number of side shoots of broccoli were significant (Table 3). Nitrogen source, $N_{50\%Urea}$ + $N_{50\%Vermi}$ produced the highest terminal curd length (23.37 cm), terminal curd diameter (16.55 cm), terminal curd stem diameter (3.24 cm) and number of side shoots (6.42) whereas $N_{100\%FYM}$ produced the lowest values on them. Premium Crop produced the highest terminal curd length (23.37 cm), terminal curd diameter (19.09 cm) and terminal curd stem diameter (3.44 cm) whereas Calabrese produced the highest no. of side shoots per plant (8.12) than Green Sprouting. No. auxiliary curds were harvested from Premium Crop. This finding was in harmony with the findings of Bhattrai (2013). Green Sprouting produced the lowest terminal curd length (18.45 cm) while Calabrese produced the lowest terminal curd diameter (17.09 cm) and terminal curd stem diameter (2.42 cm). Bhattrai (2013) also reported that the longest terminal curd length, largest terminal curd diameter and terminal curd stem diameter was obtained from Premium Crop as compare to Calabrese with the combine application of organic and inorganic fertilizer in broccoli.

Table 3: Effects of nitrogen sources and varieties on terminal curd length, terminal curd diameter, terminal curd stem diameter and number of side shoots of broccoli at Gaindakot, Nawalparasi, Nepal during 2012/13

Treatments	Terminal curd length (cm)	Terminal curd Diameter (cm)	Terminal curd stem Diameter (cm)	No. of side shoots
Source of nitrogen (N)				
$N_{100\%Urea}$	20.84^{b}	15.44^{ab}	3.15^{a}	2.11^{b} (4.93^{b})
$N_{100\%Vermi}$	20.75^{b}	15.10^{bc}	3.06^{a}	2.002^{bc} (4.38^{bc})
$N_{100\% FYM}$	17.82^{c}	13.91^{c}	2.69^{b}	1.90^{c} (3.86^{c})
$N_{50\% Urea}$ + $N_{50\%Vermi}$	23.37^{a}	16.55^{a}	3.24^{a}	2.35^{a} (6.42^{a})
$N_{50\% Urea}$+ $N_{50\%FYM}$	23.28^{a}	15.47^{ab}	3.18^{a}	2.11^{b} (4.95^{b})
SEM±	0.62	0.42	0.11	0.05(0.34)
$LSD_{0.05}$	1.79**	1.22**	0.31**	0.16(0.99)**
Varieties				
Calabrese	21.81^{b}	9.70^{c}	2.42^{b}	2.93^{a} (8.12^{a})
Green Sprouting	18.45^{c}	17.09^{b}	3.33^{a}	2.64^{b} (6.60^{b})
Premium Crop	23.37^{a}	19.09^{a}	3.44^{a}	0.71^{c} (0.00^{c})
SEM±	0.48	0.33	0.08	0.04(0.26)
$LSD_{0.05}$	1.38**	0.95**	0.24**	0.12(0.76)**
Grand mean	21.21	15.30	3.07	2.09(2.09)
CV (%)	8.72	8.28	10.50	7.69(7.69)

Means followed by the same letter (s) within a column are not significant at 5% level of significance as determined by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance.

Note: Values on auxiliary curd yield were square root transformed at 0.5

Curd yield

Nitrogen source, $N_{50\%Urea}$ + $N_{50\%Vermi}$ recorded the significantly ($p< 0.01$) higher terminal curd yield (20.30 t ha^{-1}), auxiliary curd yield (8.25 t ha^{-1}) and total curd yield (28.55 t ha^{-1}) (Table 4). The highest terminal curd yield from $N_{50\%Urea}$ + $N_{50\%Vermi}$ was similar to $N_{50\%Urea}$ + $N_{50\%FYM.}$ However, nitrogen source $N_{100\%FYM}$ recorded significantly lower terminal curd yield (13.28 t ha^{-1}), auxiliary curd yield (2.81 t ha^{-1}) and total curd yield (16.09 t ha^{-1}). There were significant ($p<0.01$) effects of different varieties on curd yield of broccoli. No auxiliary curd was harvested from variety Premium Crop. Premium Crop produced the highest (23.70 t ha^{-1}) terminal curd yield whereas Calabrese produced the lowest (10.53 t ha^{-1}) terminal curd yield. Calabrese produced significantly higher (9.34 t ha^{-1}) auxiliary curd yield than Green Sprouting (7.09 t ha^{-1}). Likewise, Green Sprouting produced the highest (25.10 t ha^{-1}) total curd yield which was similar to Premium Crop (23.70 t ha^{-1}) whereas Calabrese produced the lowest (19.88 t ha^{-1}) total curd yield. Although the highest terminal curd yield was recorded from Premium Crop, the highest total curd yield was from Green Sprouting. It may be attributed to the multiple harvesting in Green Sprouting over a longer period of time but no auxiliary curd harvesting was held from Premium Crop. These results were in agreement with the findings of Bhattrai and Mishra (2012) that the maximum yield was recorded by the application of 1/2NPK+ 2t ha^{-1} vermicompost whereas the minimum yield was from control in broccoli. Bhattrai (2013) also reported higher terminal curd yield from Premium Crop as compare to Calabrese. Likewise, Giri (2007) found that Green Sprouting produced higher total yield than Calabrese.

Dry matter of curd, total biological yield and harvest index

Nitrogen source $N_{100\%FYM}$ showed significantly higher (13.27%) dry matter percentage of curd whereas $N_{100\%Urea}$ showed lower (10.47%) dry matter percentage of curd (Table 4). $N_{50\%Urea}$ + $N_{50\%Vermi}$ exhibited significantly higher (52.70 t/ha) total biological yield whereas $N_{100\%FYM}$ exhibited lower (35.17 t/ha) total biological yield. $N_{50\%Urea}$ + $N_{50\%Vermi}$ recorded the highest (54.73 %) harvest index followed by $N_{50\%Urea}$ + $N_{50\%FYM}$ whereas $N_{100\%FYM}$ recorded the lowest (44.78%) harvest index. Calabrese recorded significantly higher (13.32%) dry matter percentage of curd whereas Premium Crop recorded lower (11.00%) dry matter percentage of curd. Premium Crop exhibited the highest (47.81 t ha^{-1}) total biological yield which was identical with Green Sprouting whereas Calabrese exhibited the lowest (41.36 t ha^{-1}). Similarly, Green Sprouting recorded the highest (54.56%) harvest index while, Calabrese recorded the lowest (47.04 %) harvest index.

Table 4: Effects of nitrogen sources and varieties on curd yield, dry matter of curd, total biological yield and harvest index of broccoli at Gaindakot, Nawalparasi, Nepal during 2012/13

Treatments	Curd yield (t ha^{-1})			Dry matter of curd (%)	Total biological yield (t ha^{-1})	Harvest index (%)
	Terminal	Auxiliary	Total			
Source of nitrogen (N)						
$N_{100\%Urea}$	17.83^{bc}	2.20^{c} (5.54^{c})	23.36^{c}	10.47^{c}	47.13^{b}	49.76^{bc}
$N_{100\%Vermi}$	16.06^{c}	1.94^{d} (4.15^{d})	20.21^{d}	11.84^{abc}	41.82^{c}	48.50^{cd}
$N_{100\%\ FYM}$	13.28^{d}	1.68^{e} (2.81^{c})	16.09^{e}	13.27^{a}	35.25^{d}	44.78^{d}
$N_{50\%\ Urea}$ + $N_{50\%Vermi}$	20.30^{a}	2.61^{a} (8.25^{a})	28.55^{a}	11.18^{bc}	52.70^{a}	54.73^{a}
$N_{50\%\ Urea}$+ $N_{50\%FY\ M}$	19.60^{ab}	2.38^{b} (6.64^{b})	26.23^{b}	12.71^{ab}	48.89^{b}	53.86^{ab}
SEM±	0.77	0.04 (0.23)	0.57	0.61	1.07	1.46
$LSD_{0.05}$	2.22**	0.12 (0.65)**	1.64**	1.77*	3.10**	4.23**
Varieties						
Calabrese	10.53^{c}	3.05^{a} (9.34^{a})	19.88^{b}	13.32^{a}	41.36^{b}	47.04^{b}
Green Sprouting	18.01^{b}	2.73^{b} (7.09^{b})	25.10^{a}	11.36^{b}	46.03^{a}	54.56^{a}
Premium Crop	23.70^{a}	0.71^{c} (0.00^{c})	23.70^{a}	11.00^{b}	47.81^{a}	49.43^{b}
SEM±	0.595	0.03 (0.18)	0.59	0.47	0.83	1.13
$LSD_{0.05}$	1.72**	0.10 (0.51)**	1.70**	1.37**	2.40**	3.28**
Grand mean	17.41	2.16 (5.48)	22.76	11.89	45.16	50.34
CV (%)	12.88	5.86 (12.38)	7.45	15.41	7.11	8.71

Means followed by the same letter (s) within a column are not significant at 5% level of significance as determined by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance.

Note: Values on auxiliary curd yield were square root transformed at 0.5

ECONOMIC ANALYSIS

The selling price of the broccoli was variable depending up on the nutrient sources and varieties.

Net benefit and B: C ratio

The effects of different sources of nitrogen on gross income, net benefit and B: C ratio of broccoli production was significant (Table 5). $N_{50\%Urea}$ +$N_{50\%Vermi}$ obtained the highest (NRs.424,800 ha^{-1}) net benefit which was similar to $N_{50\%Urea}$+ $N_{50\%FYM}$ (NRs.417,600 ha^{-1}) and $N_{100\%Urea}$ (NRs.415,700 ha^{-1}) whereas $N_{100\%FYM}$ obtained the lowest (NRs.92,110 ha^{-1}). $N_{100\%Urea}$ obtained the highest (3.37) B: C ratio while, $N_{100\%Vermi}$ obtained lowest (1.17) B:C ratio. The higher B: C ratio from $N_{100\%Urea}$ might be due to lower cost production from chemical fertilizer than other organic manures whereas lower B: C ratio from $N_{100\%Vermi}$ might be due to the higher production cost from vermicompost during the initial year of production than others. But in the subsequent years the cost of production would be decreased due to residual nutrients from applied manure could be used in coming cropping seasons. Premium Crop had higher net benefit (NRs.420,100 ha^{-1}) and B: C ratio (2.56). The higher B: C ratio from Premium Crop was due to higher gross income and net benefit than others.

Table 5: Effects of nitrogen sources and varieties on gross income, net benefit and B: C ratio of broccoli at Gaindakot, Nawalparasi, Nepal during 2012/13

Treatments	**Gross income (NRs. ,000)/ha**	**Net benefit (NRs. ,000)/ha**	**B:C ratio**
Source of nitrogen (N)			
$N_{100\%Urea}$	589.20^{c}	415.70^{a}	3.37^{a}
$N_{100\%Vermi}$	617.40b^{c}	92.11^{b}	1.17^{e}
$N_{100\%FYM}$	455.80^{d}	138.40^{b}	1.44^{d}
$N_{50\% Urea}$ + $N_{50\%Vermi}$	774.20^{a}	424.80^{a}	2.21^{c}
$N_{50\% Urea}$+ $N_{50\%FYM}$	663.10^{b}	417.60^{a}	2.69^{b}
SEM±	20.87	20.87	0.07
$LSD_{0.05}$	60.45**	60.45**	0.20**
Varieties			
Calabrese	413.30^{c}	115.60^{c}	1.58^{c}
Green Sprouting	674.70^{b}	357.50^{b}	2.40^{b}
Premium Crop	753.80^{a}	420.10^{a}	2.56^{a}
SEM±	16.16	16.16	2.18
$LSD_{0.05}$	46.82**	46.82**	9.76**
Grand mean	619.90	297.72	2.18
CV (%)	10.10	21.03	9.76

Means followed by the same letter (s) within a column are not significant at 5% level of significance as determined by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance.

SUMMARY AND CONCLUSION

Among the various morphological and yield attributing curd parameters, Premium Crop showed better performance in $N_{50\%Urea}$ + $N_{50\%Vermi}$ except some of them. Premium crop produced the highest terminal curd yield, Calabrese produced the highest auxiliary curd yield and Green Sprouting produced the highest total yield with nitrogen source $N_{50\%Urea}$ + $N_{50\%Vermi}$. Although Premium Crop obtained the highest B: C ratio from $N_{100\%Urea}$ in the initial year, the B: C ratio of $N_{50\%Urea}$ + $N_{50\%Vermi}$ and $N_{50\%Urea}$ + $N_{50\%FYM}$ would be increased in the subsequent cropping season. It is due to the improvement in soil fertility and decrease in production cost of vermicompost in long run as residual nutrients from applied manure could be used in coming cropping seasons. Premium Crop was best for higher terminal curd yield, net benefit and B: C ratio with uniform harvest although Green Sprouting produced higher total curd yield statistically similar to Premium Crop due to multiple harvest over a longer period of time from it and no auxiliary curd harvesting was held from variety Premium Crop. Thus, Green Sprouting along with the application of $N_{50\%Urea}$ + $N_{50\%Vermi}$ followed by $N_{50\%Urea}$ + $N_{50\%FYM}$ can be suggested to grow by the small gardener for their home consumption whereas Premium Crop along with the application of $N_{50\%Urea}$ + $N_{50\%Vermi}$ followed by $N_{50\%Urea}$ + $N_{50\%FYM}$ can be suggested to grow by large scale commercial grower for sustainable broccoli production.

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ASSESSMENT OF OPTIMUM FEEDING RATE ON GROWTH AND PRODUCTION OF CARP POLYCULTURE IN NEPAL

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ABSTRACT

Polyculture of carp was done in fertilized earthen ponds to identify appropriate feeding rates. The present work was conducted at Central Fisheries Building, Balaju, Kathmandu, Nepal to assess the growth performance and production of common carp, silver carp, bighead carp and grass carp polyculture during 28 August, 2013 to 5 January 2014 for 128 days. The experiment was carried out in 3 earthen ponds which are partitioned into 12 experimental units by nylon net with size of 129-138.7m^2. The experiment consisted of four treatments with three replications in Completely Randomized Design (CRD). Treatments were: feed @ 2% of fish body weight (T1), feed @ 3% of fish body weight (T2), feed @ 4% of fish body weight (T3) and No feeding (control) (T4). Common carp, silver carp, bighead carp and grass carp were stocked at the ratio of 40:30:15:15 with combined stocking density of 1.5fish/m^2. Ponds were fertilized by urea and diammonium phosphate to provide 0.15g N/m2/day and 0.05 g P/m2/day (3:1 N: P ratio) in fortnightly interval. Fish were fed daily between 9-10 am, with a locally made pelleted feed (22% crude protein) six days a week. Feed rations were adjusted monthly based on sampling weights. Water temperature, dissolved oxygen, pH and Secchi disc visibility ranged from 15.1-27.6 °c, 2.2-5.9 mg/L, 6.8-7.6 and 17.3-25 cm respectively. The overall mean survival rate for all species ranged from 87% to 92.6 %. Total fish production ton/ha/year was 2.66, 3.69, 3.61 and 1.98 in T1, T2, T3 and T4 respectively. The rate of return was 342.1 % in T1, 368.2 % in T2, 198.1 % in T3 and 3045.2 %. Total net yield (ton/ha/year) was significantly higher ($p<0.05$) in T2 (3.69) than T1 (2.66) and T4 (1.98) where as T2 (3.69) and T3 (3.61) are statistically similar ($p>0.05$). Feed conversion ratio was 1.18, 1.16 and 1.85 in T1, T2 and T3 respectively. Overall growth and production performance of all carps were very encouraging in total production. Thus, among the four different feeding levels, T2 (3% feeding rate) treatment showed optimum rate for better growth and production of Carps.

Key words: Feeding rate, polyculture, common carp, silver carp, bighead carp, grass carp

INTRODUCTION

Aquaculture development began in Nepal in the mid 1940s on a small scale in ponds with indigenous Indian major carp seed from India. Further development began in 1950s with the introduction of the exotic species common carp (*Cyprinus carpio L*) and Chinese carp species silver carp (*Hypophthalmichthys molitrix Val.*), bighead carp (*Aristichthys nobilis*) and grass carp (*Ctenopharyngodon idella*) (FAO, 2006). Fisheries are an important sector with fastest growth rate, production reached to 57,520 mt. in 2012/13, in which aquaculture contributed nearly 63% (DoFD, 2012). The combination of the four species may ensure maximum utilization of available natural food in ponds because of their different feeding habits: common carp, silver carp, bighead carp and grass carp could be considered as bottom and surface feeders respectively (Cremer & Smitherman, 1980). Pond fertilization (applications of organic and/or inorganic fertilizers) increases production (Boyd, 1981; Olah, 1986). Additionally, artificial feed may be provided to increase fish growth and production above that possible in fertilized ponds. Although supplemental feeding in fertilized ponds resulted in significantly higher growth rates and greater yields than fertilization alone (Green, 1992).Feeding costs contributes up to 60% of the variable costs of culture systems. Therefore, it is essential to provide a proper and applicable feeding management program. In fact, an inadequate food supply directly affects production costs and water quality (Silva *et al.,* 2007; Mihelakakis *et al.,* 2002; Ng *et al*., 2000). Overfeeding mostly causes feed spillage, decreasing in feed efficiency, and polluting the environment. Similarly, underfeeding results in decreased feed efficiency as well as degraded growth (Dediu *et al.,* 2011). Therefore, it is essential, in terms of both economy and biology, to determine the optimum feeding rate for growth (Aydin *et al.,* 2011). It should be noted that optimal feeding rate is essential not only because of promoting best growth and minimizing feed conversion rate (FCR), but also for economic and environmental aspects, preventing water quality degradation (Yuan *et al*., 2010). There are no quantitative data available on optimum feeding rates for polyculture in fertilized earthen ponds. Also, to our knowledge, no work-feeding rate of polycultured fish has ever been done. When optimum feeding rate is not known or has not been adequately determined, increased inputs of supplementary food might occur. In fact, commercial fish farmers frequently use higher feeding rates than necessary, resulting in a lower economic return and water quality problems. Supplemental feeding is expensive and constitutes an appreciable portion of the total production cost, and fish farmers cannot afford any misuse of feed. Therefore, the availability of reliable data for the appropriate feeding level of fish in a polyculture system is important for rapid growth of fish and cost control of feed. Determination of feeding levels based on reliable data may help to save feed while promoting fish growth and production, thus increasing profitability. A study of this sort contributes towards a better understanding of the feed requirements of a combination of fish species that has access to natural food items. It may also contribute to improving aquaculture management practices and increasing fish farm profitability. The objective of the study was to assess the optimum feeding rates on growth and production of Carps polyculture in Nepal. Therefore, a study on better understanding of the optimum feeding rate of Carps polyculture has been tried.

MATERIALS AND METHODS

The experiment was conducted in 3 outdoor earthen ponds which are partitioned by nylon net into 12 experimental units of nearly about 135.2 m^2 (129-138.7m^2) at Central Fisheries Building, Balaju, Kathmandu, starting from 28 August, 2013 to 5 Jan, 2014 for 128 days. The earthen ponds were completely drained out about 1 week before the stocking of the fishes. The ponds were kept sun dried for one week, liming at the rate of 500 kg/ha and filled with boring water. The ponds were fertilized with inorganic fertilizer (Urea and DAP) at the rate of 100 kg/ha/month.

The experiment was conducted in a Complete Randomized Design (CRD) consisting of 4 treatments (T1- Feed @ 2% of fish body weight, T2- Feed @ 3% of fish body weight, T3- Feed @ 4% of fish body weight and T4- Control (no feeding) with 3 replications. Common Carp was used for main species in all treatments where stocking ratio of Common Carp, Silver Carp, Bighead Carp and Grass Carp was 40%, 30%, 15% and 15% in T1, T2, T3 and T4 treatments respectively. Stocking density was same in all 4 treatments. The stocking density of all fish species was 1.5fish/m^2 in all treatments. Fish seeds were procured from Central Fisheries Lab, Kathmandu. Large size of fingerlings of Common Carp (80-85) having average weight (41.6-46.24 g) were stocked in each pond. Similarly, Silver carp (60-65) having average size (108-115.8 g) were stocked in each pond. Bighead carp (30-35) having average size (89.7-106.9 g) was stocked in each pond. Grass carp (30-35) having average size (44.2-48.5 g) was stocked in each pond. Batch weight of each species was taken to determine the average stocking weight by using electronic balance.

Feed and feeding

Fish were fed on locally factory made pellets contained of 22% crude protein. Feed was given at the rate of 2%, 3% and 4% of total fish body weight. The ingredients used were Rice-bran, Mustard oil cake and Wheat flour to prepare pellet feed. The feed was given once a day i.e. at 10 am in the morning. Feeding tray was used for feeding the fish. The quantity of feed was adjusted at monthly i.e. 30 days intervals based on fish growth measurements.

Final harvesting of all carps, including common carp, silver carp, bighead carp and grass carp were done after 128 days with complete draining of pond. During harvest, all fishes were counted and weighed separately to assess survival rate and production.

Water quality

Weekly water quality parameters were measured at 6am from August 30, 2013. Transparency, dissolved oxygen, pH and temperature were measured in situ.

Fish growth and production

Initial mean weight of fingerlings was recorded and stocked in respective earthen ponds. Monthly fish growth was determined by taking sampling at 30 days of interval. Fish of each species (10-20%) was sampled periodically and feed adjustment was done accordingly. Fishes were harvested after 128 days and final weight of each species was measured with the help of weighing balance. Growth and production parameters such as daily growth rate, Net fish yield (t/ha/yr), FCR and Survival rate were calculated.

Economic analysis

Gross margin and rate of return were analyzed from total variable cost (operational cost) and total value of all products. The variable cost item included was pellet feed required for the production based on current market price. Labor, fertilizer and seed is not accounted in production cost analysis. Gross margin and rate of return was calculated based on produce sold at farm gate prices.

Statistical analysis

Statistical analysis of data was performed by using one-way analysis of variance (ANOVA) using M-Stat Microsoft computer programs for windows. The results with statistical differences at the level of 5% significance were further analyzed with LSD to determine where these differences were occurred. All means were given at ± 1 standard error (S.E.).

RESULTS AND DISCUSSION

The mean growth of carps is highest in T2 (88g) followed by T3 (82.3g), T1 (75.6g) and T4 (52.1g). The mean growth (g) was found highest in common carp followed by grass, silver and bighead carp in decreasing order in polyculture in different feeding rates. Growth rate of common carp was lower in T4 (48.9g) and highest in T3 (104g) treatment. Similar trend found by Pandey (2002) reported mean growth (g) of common carp was found highest in four species polyculture of the common carp, followed by silver carp, grass carp and bighead carp. The present study showed that growth rates of common and grass carp was found better than silver carp and bighead carp. Common carp is omnivorous, bottom-dwelling fish that can be raised on supplementary feed (MOAAF, 1988) and prefers more artificial feed than other carps (Schroeder, 1983). The growth rate of grass carp found better though with application of grasses in the pond. Woynarovich (1975) reported that grass carp eats the artificial feed supplied specially for common carp, but extent of such utilization is comparatively little. The growth rate of common carp and grass carp was also found better in all polyculture with feeding system. Abdelghany and Ahmad (2002) stated that supplemental feed caused increases in yields by 14.1%, 22.4%, 39.7% and 34.4% in the treatments in which fish were fed at 0.5%, 1%, 3% and 5% of their body weight per day respectively. These results suggest the efficacy of supplemental feed for promoting better growth and production. The growth of fish is temperature dependent as a cold- blooded animal (Wonarovich, 1975). Fish growth is faster in higher temperature under suitable range. In the present study, fish growth is higher in the initial month and lower after the October where as water temperature dropped below 20^{o}c. Water temperature below 20^{o}c observed from the middle of November to December.

Table 1. Mean Stoking weight; mean harvesting weight and mean survival rate of different carp species in different treatments (Mean ± SE.) during experimental period of 128 days

Fish species	Treatments	Mean stocking weight (g)	Mean harvesting weight (g)	Mean survival rate (%)
Common carp	T1(Feed @ 2% of fish body weight)	45.3±1.46 (44.1-48.2)	106.6±3.93c (105.3-107.0)	90.6±9.51a (83.7-100)
	T2(Feed @ 3% of fish body weight)	41.6±1.46 (40-42.3)	119.7±3.93b (114.9-123.6)	91.6±9.55a (71.7-100)
	T3(Feed @ 4% of fish body weight)	41.6±1.46 (37.6-44.7)	145.6±3.93a (134.5-158.6)	95.9±9.79a (88.2-100)
	T4(Control)	46.2±1.46 (44-48.2)	95.1±3.93c (90.9-99)	96.3±9.81a (96.2-96.4)
Silver carp	T1 Feed @ 2% of fish body weight)	115.8±2.13 (110.7-118.4)	195.8±3.59b (186.8-203.7)	88.9±9.41a (76.9-100)
	T2(Feed @ 3% of fish body weight)	112±2.13 (107.2-115)	212.3±3.59a (204.6-217.2)	96.8±9.84a (95.3-100)
	T3(Feed @ 4% of fish body weight)	108±2.13 (104.6-110)	187.2±3.59b (182.9-189.3)	98.4±9.92a (96.9-100)
	T4(Control)	112.1±2.13 (109.2-115)	169.9±3.59c (165-170.1)	95.2±9.75a (90.7-100)
Bighead carp	T1(Feed @ 2% of fish body weight)	94.6±4.39 (91.4-103.3)	184.4±5.59b (176.4-195.8)	92.3±9.60a (80-100)
	T2(Feed @ 3% of fish body weight)	106.9±4.39 (88.5-126.6)	209.2±5.59a (199.4-216)	100±10a
	T3(Feed @ 4% of fish body weight)	89.7±4.39 (88.3-91.7)	172.7±5.59b (162.2-170.6)	91.9±9.58a (85.7-100)
	T4(Control)	92.7±4.39 (88.5-98.3)	147.1±5.59c (138.5-154.1)	90.4±9.50a (80-100)
Grass carp	T1(Feed @ 2% of fish body weight)	45.7±3.11 (37.3-51.4)	117±3.34ab (105-123.4)	76.5±8.73a (66.6-88.5)
	T2(Feed @ 3% of fish body weight)	47.8±3.11 (46-50.2)	119±3.34a (116.8-120.4)	82±9.02a (62.8-100)
	T3(Feed @ 4% of fish body weight)	44.2±3.11 (42.8-46.5)	106.9±3.34b (104.1-109.4)	71.1±8.37a (51.4-93.3)
	T4(Control)	48.5±3.11 (41.3-55.7)	95.5±3.34c (93.2-100)	70.7±8.34a (46.6-85.7)
Total	T1(Feed @ 2% of fish body weight)	75.3±3.20	150.9±4.11	88.2±3.60
	T2(Feed @3% of fish body weight)	77±3.20	165±4.11	92.9±3.92
	T3(Feed @ 4% of fish body weight)	70.8±3.20	153.1±4.11	92.1±3.90
	T4(Control)	74.8±3.20	126.9±4.11	91.2±3.88

Note: Figure in parenthesis is range values. Means with different superscripts within treatments within each groups differ significantly at $p<0.05$.

Extrapolated total net fish yield (NFY) of T2 (3.69 ton/ha/yr) was significantly ($p<0.05$) higher than the T1 (2.66 ton/ha/yr) and T4 (1.98 ton/ha/yr). However, the NFY of T2 (3.69 ton/ha/yr) and T3 (3.61 ton/ha/yr) was not significantly different to each other. NFY of four species polyculture was little low with the government estimated yield 4-5 ton/ha/year (Pradhan and Shrestha, 1997). But, in the present study production was low which might be to the low temperature and low dissolved oxygen.

Table 2. Net fish yield and FCR of different carp species in different treatments (Mean ± SE)

Treatments	Net Fish Yield (ton/ha/year)	FCR
T1	2.664±0.14b	1.18±0.07
T2	3.694±0.25a	1.16±0.10
T3	3.617±0.22a	1.85±0.08
T4	1.981±0.09c	0

Note: Mean values with same superscript letters in the same row were not significantly different at $p< 0.05$.

During experimental period the food conversion ratio (FCR) of fish is 1.18, 1.16 and 1.85 in T1, T2 and T3 respectively. These results are in complete agreement with results of Wu_Goangyum (1992), Abdel_Hakim *et al*., (2000) and Yasser (2005) who studied the high yield of polyculture of mullet and carps. It was stated that feed conversion decreases as the amount of feed fed decreases and increases with an increase in the amount of feed fed (Halver, 1989). Food conversion ratio depends on the oxygen concentration and temperature of the pond water, the size of the fish and its feeding habit and health condition.

Mean fish production, net income, rate of return and variable costs involved in fish production in different treatments are shown in Table 3. The total variable costs involved in fish production were statistically similar in all treatments, though T3 demands comparatively higher expenditure. The net income was higher in T2 (725.4±68) than T1 (515.2±37.7), T3 (601.1±49.6) and T4 (479.4±24.8). Rate of return is significantly higher in T4 (3045.2%) than T3 (198.1±13). T1 (342.1±25.8) and T2 (368.2±41.6) are statistically similar ($p>0.05$).

Table 3. Economic analysis of Carps with different feeding rates computed in thousand NRs/ha/year

Particulars	Treatments (Mean±SE)			
	T1	T2	T3	T4
Variable cost				
Pellet Feed (Nrs/ha)	135.5±0.7	182.3±5.7	287.2±7.7	—
Fish seed (Nrs/ha)	15.7±0.1	15.7±0.1	15.7±0.1	15.7±0.1
Total variable cost	151.2	198	302.9	15.7
Revenue				
Fish production (kg/ha)*	2612±149.5	3693.7±256.3	3616.3±222.2	1980.7±99.6
Income	665.8±37.3	923.4±64.1	904±55.5	495.2±24.9
Net income	515.2±37.7	725.4±68	601.1±49.6	479.4±24.8
Rate of return (%)	342.1±25.8	368.2±41.6	198.1±13	3045.2

* Fish production in thousand

Pellet feed @NRs 43/kg, Fish seed@1Nrs/no. and Fish Farm gate price @ NRs 250/kg.

Most of the water quality parameters were within a suitable range for fish production. Water quality parameters such as Transparancy, pH, dissolved oxygen concentration and Pond water temperature were fluctuated during the experimental period without any particular trend. Pond water temperature was higher in stocking period, decreased continuously and reached upto 13^{o}c at last of experiment. Pond water temperature start to decrease from November Ist week to December last week as a result of all carps growth significantly retarded.

All carps showed better growth performance at water temperature above 20^{o}c and slower growth was observed below this temperature with very minimal growth at temperature at 13^{o}c during this study. Azad (1996) observed the growth of all carps was better in above 20^{o}c to 30^{o}c but not eat well below 13^{0}c. Bakos (2001) reported 2% body weight daily feeding and fortnightly application of manure seems to be safe in term of water quality. In the present study the highest dissolved oxygen (DO) (4.4 mg/ L) was obtained in control ponds of (T4), with natural feed, while the lowest (DO) was recorded in ponds of (T1, T2 and T3), supplemented with feed. Swingle (1969) considered concentration of dissolved oxygen below 5mg/L as undesirable in ponds. Boyd (1992) postulated that excess feeding can result in an increase in organic material with increases in oxidation through metabolic processes by bacteria producing a decrease in DO. pH values were almost in suitable range (6.8 – 7.6) which are in the tolerable range for fish and for primary productivity to flourish (Boyd, 1992).

Table 4. Mean and range values of water quality parameters in different treatments during experimental period of 128 days

Parameter	T1	T2	T3	T4
Dissolved Oxygen (mg/L)	4.3 ± 0.16 (2.9 - 5.3)	4.2 ± 0.22 (2.4 - 5.4)	3.9 ± 0.23 (2.2 - 5.2)	4.4 ± 0.25 (2.7 - 5.9)
Temperature (^{o}c)	23 ± 0.0 (15.1 - 27.6)	22.7 ± 0.1 (15.1 - 27.8)	22.7 ± 0.0 (15.3 - 27.4)	22.7 ± 0.1 (15.6 - 27.6)
pH	7 ± 0.0 (7.1 - 7.6)	7.3 ± 0.1 (6.8 - 7.6)	7.3 ± 0.0 (7 - 7.6)	7.3 ± 0 (6.9 - 7.6)
Secchi disc visibility (cm)	21 ± 0.6 (19 - 21)	20.8 ± 1.1 (19.3 - 22.3)	20.5 ± 0.5 (17.3 - 21.7)	22.4 ± 0.4 (21 - 25)

CONCLUSION

Fish growth retarded after mid of November to December last week while water temperature was below 20^{o}c. So, active growth period of fish was short. The time of active growth was April to October. Although, feed based fish species showed higher performance in growth and production, common carp played major role to increase production and grass carp has economic production. Silver carp and bighead carp has little role besides maintaining the aquatic environment. So, the fish species can be used as a bonus fish for ecological point of view for suitable pond environment management. The growth rate of common carp was higher than the silver carp and bighead carp. Grass carp was second in position for growth performance. Small size fish seed of grass carp had high mortality which decreases the production. Due to short time of fish production multiple stocking and multiple harvesting systems will be suitable to increase production. Fish production can be increased by early stocking, high density of large size of fingerling of grass carp and common carp with adequate feeding in polyculture. Supplemental feed not only provided necessary nutritional components and energy for better fish growth but also improved survivability. Most of the water quality parameters were found to be within the limits.

In the present study, it appears that the daily feed application rate of 3% body weight was near to optimum when the fish grows. The results suggest that, although a feeding rate of 4% gave the highest growth performance, Carps should be fed at the rate of 3% body weight per day, considering feed conversion efficiency, survival rate, economic efficiency and growth response. This level of feeding minimized feed wastage as optimal utilization was achieved. It is therefore recommended that Carps should be raised at this level of feeding rate to ensure effective usage of high cost of feed and feeding.

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EFFECT OF PHOSPHORUS MANAGEMENT ON YIELD OF DIFFERENT VARIETIES OF BLACK GRAM (VIGNA MUNGO L.) UNDER CHITWAN CONDITION OF NEPAL

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ABSTRACT

The field experiment entitled effect of phosphorus management on yield of different varieties of black gram (Vigna mungo L.) was carried out in the farmer's field of Bharatpur Municipality-13 Rambag, Chitwan during August to November 2013. The experiment was laid out in factorial randomized complete block design (RCBD) with three factors namely black gram varieties (BLG-0067-1 and Pant U 31), phosphorus levels (40 kg ha^{-1} and 60 kg ha^{-1}) and phosphorus application methods (solid form, liquid form and liquid form two times) with altogether twelve treatment combinations and three replication. The study revealed that the growth, yield attributing characters and yield were significantly influenced by black gram varieties, phosphorus levels and phosphorus application methods. The dry matter recorded was significantly higher (31.75 gm) in BLG-0067-1 variety with 40 kg P_2O_5 ha^{-1} at 75 days after sowing. Significantly higher number of seeds per pod (6.98) was recorded in BLG-0067-1 variety and liquid form phosphorus application method. Significantly maximum number of filled pods (34.8) per plant were recorded under the treatment BLG-0067-1 variety of black gram with 40 kg ha^{-1} P_2O_5 with liquid form two times phosphorus application method. Significantly maximum grain yield (1710.42 kg ha^{-1}) was recorded under the treatment variety BLG-0067-1, although grain yield was not affected significantly because of two levels of phosphorus 40 kg ha^{-1} and 60 kg/ha indicating the lower dose 40 kg ha^{-1} as best from economic point of view. Further, among three method of application grain yield although did not differ significantly but higher yield (1580.47 kg ha^{-1}) was obtained under liquid form two times application. The maximum net income (Rs. 1, 24,649.30 ha^{-1}) and B:C ratio (2.80) were recorded in the BLG-0067-1 variety at 40 kg ha^{-1} phosphorus level with liquid form two times application method. Thus, the variety BLG-0067-1, 40 kg ha^{-1} phosphorus level and liquid form two times phosphorus application method can be concluded as the best package for black gram cultivation in Chitwan and Chitwan like terai condition of Nepal.

Key words: Black gram, phosphorus management, yield

INTRODUCTION

Black gram is an important and popular pulse crop in Nepal. It is an important summer grain legume in mid hills. Black gram has 3rd position in area (25227 ha) and 4th in production (21364 Mt.) with the productivity (847 kg /ha) and is the major pulse of hilly peoples of Nepal (MoAD, 2013). The black gram is used for various purposes i.e., green pods as vegetables, seeds as dhal and green plants as fodders. Seeds of black gram contain about 9.7% water, 32.4% protein, 1 % fates, 57% carbohydrates, 3.8% fibers and 4.8% ash, and also rich in minerals and vitamin-B (Purseglove, 1968). The caloric value of black gram is same us that of rice (Anonymous, 1966). Like other leguminous crop, black gram play a vital role in maintaining the nitrogen balance in the soil. It possesses nodules on its roots, containing nitrogen fixing bacteria Rhizobium sp. which fixes nitrogen in symbiotic association with the plant and release a significant amount for plant growth and development (Sharoar *et al.,* 2006). The crop normally grows and develops only under higher temperature regimes, thrives well and gives normal yield only under irrigation. It is grown in different types of light and heavy soils. However, it thrives well only in well drained soils with neutral pH. The crop plants may tolerate lower level of soil salinity (Rajbhandari and Bhatta, 2008). Although many local and improved varieties are cultivated throughout the country but the government has released only one variety, Kalu, so far (MoAC, 2011). Many of black gram growing regions in the tropics and semi-arid tropics have soil with low phosphorus availability and intensive phosphorus fertilization is not affordable by many farmers. Hence, yield loss due to phosphorus deficiency can be significant. The grain legumes are predominantly grown as associated and relay crops with cereals and oilseeds. The summer legumes are grown mixed with maize and finger millet in the hills. The black gram is also grown along with rice on the bunds of paddy fields. Soil acidity poses a serious constraint to legumes in Nepal, where surface soil pH falls below 5.0. Acidity problems are due to leaching of bases because of higher rainfall. Consequently, legumes face phosphorus deficiency and nodulation problems. As compared to other legumes, very fewer achievements have been made in this crop (NGLRP, 2005).

Nitrogen increases vegetative growth while phosphorus favors root development, reproductive growth and fastens maturity. Moreover, it over comes the effect of excessive nitrogen. Application of N along with adequate amount of P_2O_5 improves the grain yield (Maqsood *et al*., 2001). Phosphorus play significant role in the growth and development of the plant and occupy an important position in plant nutrition. Some of the nutrients constitute an integral part of several biologically important micro-nutrients including amino acids, nucleosides, co-enzymes, purines, pyrimidines, nucleotides, intermediate metabolites and growth hormones (Develin and Witham, 1986; Salisbury and Ross, 1986) which directly regulate plant metabolism. The supply of different level of phosphorus in black gram has enhanced the nodule formation. This might be attributed to the fact that phosphorus is an important constituent of energy rich compound for energy transfer during certain metabolic process of plant. The nodule bacteria might have received energy for fixing atmospheric nitrogen in root nodule in the presence of phosphorus (Beg *et al.,* 2013). Whyte *et al.* (1953) held the view that presence of adequate phosphorus is essential to retain the mobility and flagellation of bacterial cells, which helps their migration and thereby favors early infection of legume roots.

Many of black gram growing regions in the tropics and semi-arid tropics have soil with low phosphorus availability and intensive phosphorus fertilization is not affordable by many farmers. Hence yield loss due to phosphorus deficiency can be significant (Jakkeral *et al.,* 2009). In Nepal, black gram is cultivated as a low yielding rain-fed *kharif* crop with poor field management condition. On this ground, it is need to increase the yield of black gram by means of adopting improved agronomic management practices. Among all practices, fertilization is an important one, because the soils of Nepal are very much deficient in important nutrient element like phosphorus in pulse crop production. Therefore, the study on effect of phosphorus management on yield of different varieties of black gram was carried out.

MATERIALS AND METHODS

A field experiment was carried at Bharatpur-13, Rambag, Chitwan condition during rainy season of 2013. The experiment site was located at inner terai region of central Nepal having subtropical humid climate and its elevation about 256 masl. the soil was neutral in reaction with medium organic matter and nitrogen content, K_2O and P_2O_5 content. The soil was sandy loam type. The experimental site had mean maximum temperature ranged from 19.74 °C to 36.98 °C. Similarly, the mean minimum temperature ranged from 11 °C to 29.35 °C. About 2014.30 mm of total rainfall was received during the entire growing season. It was maximum (667.50 mm) in June and minimum rainfall (1.60 mm) in the month of November.

The experiment was laid out in factorial randomized complete block design (RCBD) with three factors namely black gram varieties (BLG-0067-1 and Pant U 31), phosphorus levels (40 kg ha^{-1} and 60 kg ha^{-1}) and phosphorus application methods (solid form, liquid form and liquid form two times) with altogether twelve treatment combinations and three replication. Spacing and individual plot size was 40×10 cm^2 and 3.2×2.0 m^2 respectively. Individual plot contained eight rows having twenty plants within row and 160 plants per plot. The total plant population in the experimental plot was 5760 plants. The total area of the experiment was 367.35 m^2. Vegetative characters were recorded after 30 DAS at 15 days interval up to harvest. Yield attributing characters were recorded during the growth period and at harvest.

RESULTS AND DISCUSSION

Yield attributing characters of black gram

Pod cluster per plant

The variety Pant U 31 was recorded with higher number of pod clusters per plant 35.19 which was significantly higher than the variety BLG-0067-1 (26.11). The maximum pod clusters per plant was 30.67 at 40 kg ha^{-1} phosphorus at the time of harvesting of black gram. 30.64 clusters per plant was found at 60 kg ha^{-1} phosphorus level. In case of three phosphorus application methods, there was no significant effect on number of pod clusters per plant. Liquid form basal application of phosphorus had maximum pod clusters (31.29) per plant. 31.08 pod clusters $plant^{-1}$ was observed in solid form application and 29.58 pod clusters were found in liquid form two times (basal and 30 DAS) (Table 1).

No of pod per plant

The variety Pant U 31 was recorded with higher number of pod per plant 45.14 which was significantly higher than the variety BLG-0067-1 (37.46). The maximum pod per plant was 42.64 at 40 kg ha^{-1} phosphorus at the time of harvesting of black gram. 39.96 pods per plant was found at 60 kg ha^{-1} phosphorus level. In case of three phosphorus application methods, there was no significant effect on number of pod per plant. Liquid form two times application of phosphorus had maximum pod number of 41.93 per plant. 40.62 pods $plant^{-1}$ were observed in solid form application and 41.35 pods were found in liquid form phosphorus application method (Table 1).

Effective pod number per plant

There was significant response of two varieties on filled pod number per plant. The variety BLG-0067-1 was recorded with significant effects on filled pod number per plant (33.36 pods) than the variety Pant U 31 (28.72 pods). Filled pods per plant was significantly higher (34.80) in BLG-0067-1 with liquid form two times application interaction than Pant U 31 with liquid form two times application of phosphorus interaction (Table 1).

Pod length (cm)

The variety Pant U 31 was recorded with maximum pod length (4.43 cm) which was higher than the variety BLG-0067-1 (4.37 cm). The average pod length was 4.41 at 60 kg ha^{-1} phosphorus at the time of harvesting of black gram. 4.39 cm pod length was found at 40 kg ha^{-1} phosphorus level. In case of three phosphorus application methods, there was no significant effect on pod length. Liquid form basal application of phosphorus had higher average pod length of 4.42 per plant. 4.40 cm was observed in solid form application and 4.38 cm were found in liquid form two times phosphorus application method (Table 1).

Number of seeds per pod

Among three phosphorus application methods, there was significant effect on number of seeds per pod. Liquid form basal application of phosphorus had significant effects on number of seeds per pod (6.98) than solid form (6.73) basal application method of phosphorus. However, the variety BLG-0067-1 was recorded with maximum number of seeds per pod (6.89 seeds) which was higher than the variety Pant U 31 (6.84). Seeds number was recorded significantly higher (6.98) in BLG-0067-1 with liquid form application interaction than in interaction of Pant U 31 with solid form phosphorus application (6.67 seeds pod^{-1}) (Table 1).

Table 1. Effects of phosphorus level and application methods on Pod cluster per plant, No of pod per plant, pod length (cm), number of seeds per pod and effective pod per plant of black gram varieties at Bharatpur-13, Rambag, Chitwan, 2013

Treatments	**Pod cluster per plant**	**No of pod per plant**	**Pod length (cm)**	**No of seeds per pod**	**Effective pod number**
Variety (A)					
BLG-0067-1	26.11^{b}	37.46^{b}	4.37	6.89	33.36^{a}
Pant U 31	35.19^{a}	45.14^{a}	4.43	6.84	28.72^{b}
SEm±	1.65	1.64	0.03	0.05	1.31
LSD (p=0.05)	4.826	4.813	ns	ns	3.848
P_2O_5 level (Kg ha^{-1}) (B)					
40	30.67	42.64	4.39	6.80	31.54
60	30.64	39.96	4.41	6.93	30.53
SEm±	1.65	1.64	0.03	0.05	1.31
LSD (p=0.05)	ns	ns	ns	ns	ns
P_2O_5 application methods (C)					
Solid form	31.08	40.62	4.40	6.73^{b}	30.87
Liquid form	31.29	41.35	4.42	6.98^{a}	30.82
Liquid form (2 times)	29.58	41.93	4.38	6.88^{ab}	31.43
SEm±	2.02	2.01	0.04	0.06	1.61
LSD (p=0.05)	ns	ns	ns	0.187	ns
CV %	22.77	16.86	3.12	3.24	17.93
Mean	30.65	41.30	4.40	6.86	31.04

In column, figures bearing same letter do not differ significantly at 5% DMRT

YIELD CHARACTERS OF BLACK GRAM

Harvest index

Significant effect was not obtained on harvest index of black gram varieties, phosphorus level and phosphorus application methods. However, maximum harvest index (0.291) was recorded in 40 kg ha^{-1} phosphorus level as compared to 60 kg ha^{-1} phosphorus level (0.265). Similarly, harvest index was maximum (0.290) in liquid form two times application method of phosphorus than other methods of application. There was not significant effects on harvest index of treatment combinations interactions (Table 2).

Shelling recovery (%)

Variety BLG-0067-1 as compared to Pant U variety (64.99%). There was not significant effect on shelling recovery percentage due to the effect of phosphorus levels and phosphorus application methods (Table 2).

Test weight

The variety BLG-0067-1 was recorded maximum test weight of 41.33 gm than the variety Pant U 31 having test weight of 41.13 gm (Table 2).

Grain yield (kg ha^{-1})

There was significant response of black gram varieties on grain yield. The variety BLG-0067-1 was recorded with significantly higher grain yield of 1710.42 kg ha^{-1} than the variety Pant U 31 having yield (1383.51 kg ha^{-1}). Maximum yield (1547.57 kg ha^{-1}) was found higher in 40 kg ha^{-1} phosphorus than in 60 kg ha^{-1} phosphorus (1546.36 kg ha^{-1} grain yield). Maximum grain yield was higher (1580.47 kg ha^{-1}) in liquid form two times (half at basal and at 30 DAS) application method of phosphorus.

There was significant effect on grain yield in variety and levels of phosphorus interaction. Grain yield was recorded significantly higher (1707.47 kg ha^{-1}) in interaction of BLG-0067-1 with 40 kg ha^{-1} phosphorus level than the grain yield recorded in Pant U 31 with 40 kg ha^{-1} (1387.68 kg ha^{-1}) and 60 kg ha^{-1} (1379.34 kg ha^{-1}) phosphorus level. There was significant effect on grain yield in varieties and application methods of phosphorus interaction. Grain yield was recorded significantly higher (1753.91 kg ha^{-1}) in BLG-0067-1 with liquid form two times application interaction than Pant U 31 with solid form (1225.26 kg ha^{-1} grain yield), Pant U 31 with liquid form two times application (1407.03 kg ha^{-1}) and Pant U 31 with liquid form application (1518.23 kg ha^{-1}) interaction (Table 2).

Straw yield (kg ha^{-1})

The variety BLG-0067-1 was recorded with maximum straw yield of 2184.67 kg ha^{-1} than the variety Pant U 31 having yield (1947.82 kg ha^{-1}). Maximum straw yield (2105.57 kg

ha^{-1}) was recorded in 40 kg ha^{-1} phosphorus in liquid form application method of phosphorus (2158.93 kg ha^{-1}) (Table 2).

Table 2. Effects of phosphorus level and application methods on harvest index, shelling recovery (%) and test weight (1000 grain weight) of black gram varieties at Bharatpur-13, Rambag, Chitwan, 2013

Treatments	**Harvest index**	**Shelling recovery (%)**	**Test Weight (gm)**	**Grain yield (kg ha^{-1})**	**Straw yield (kg ha^{-1})**
Variety (A)					
BLG-0067-1	0.278	71.72[a]	41.33	1710.42[a]	2184.67
Pant U 31	0.278	64.99[b]	41.13	1383.51[b]	1947.82
SEm±	0.0102	0.3622	0.30	65.60	98.72
LSD (p=0.05)	ns	1.062	ns	192.4	ns
P_2O_5 level (Kg ha^{-1}) (B)					
40	0.291	68.08	41.54	1547.57	2105.57
60	0.265	68.63	40.92	1546.36	2026.93
SEm±	0.0102	0.3622	0.30	65.60	98.72
LSD (p=0.05)	ns	ns	ns	ns	ns
P_2O_5 application methods (C)					
Solid form	0.262	68.49	40.72	1482.16	1891.44
Liquid form	0.282	68.47	41.35	1578.26	2158.93
Liquid form (2 times)	0.290	68.10	41.63	1580.47	2148.38
SEm±	0.0126	0.4435	0.37	80.34	120.91
LSD (p=0.05)	ns	ns	ns	ns	ns
CV %	15.64	2.25	3.11	17.99	20.27
Mean	0.278	68.35	41.23	1546.96	2066.25

In column, figures bearing same letter do not differ significantly at 5% DMRT

ECONOMIC EVALUATION

Total return varied with the grain yield of black gram. Higher production turned out the higher income. Total return of BLG-0067-1 at 40 kg ha^{-1} phosphorus with half liquid basal and half liquid 30 days after sowing (30 DAS) was higher (Rs.1,93,589.00) than the return (Rs. 178119.70) of BLG-0067-1 at 40 kg ha^{-1} with liquid basal application methods of phosphorus. In the similar way, the total return of Pant U 31 was higher (Rs. 1,73,192.8.00) at 60 kg ha^{-1} with half liquid basal and half liquid 30 days after sowing (30 DAS) than the return attained (Rs.1,18,250.00) at 60 kg ha^{-1} with solid application method of phosphorus. The highest B:C ratio (2.80) was found in BLG-0067-1 at 40 kg ha^{-1} phosphorus with half liquid basal and half liquid 30 DAS phosphorus application methods. Whereas lowest B:C ratio (1.61) was found in Pant U 31 at 60 kg ha^{-1} with solid basal application method of phosphorus.

CONCLUSION

In conclusion, black gram variety, BLG-0067-1 with 40 kg ha^{-1} P_2O_5 level and liquid form two times (half at basal and half at 30 DAS) phosphorus application method recorded significantly higher grain yield (1710.42 kg ha^{-1}), maximum net income (Rs. 1,24,649.30 ha^{-1}) and B:C ratio (2.8) over other treatment combinations. Thus it has been recommended from the experiment that for black gram production in the areas like in Chitwan terai condition, BLG-0067-1 variety of black gram at 40 kg ha^{-1} phosphorus with two times liquid form application (half liquid at basal and half liquid at 30 days after sowing) can be applied to obtain maximum grain yield of black gram as economical return.

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IMPACT OF CLIMATE CHANGE ON CROP PRODUCTION OF RUPANDEHI DISTRICT OF NEPAL

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ABSTRACT

Climate change is posturing a warning on present and future food security in low income countries. But, the actual effect of the climate change on food security is still unknown. Using primary and secondary data collected by household survey and reported by the government, the paper examines the effects of climate change on yield of major food crops in Nepal. Statistical analysis is used for exploring the effects of global warming on domestic production of major cereals. The results are discussed at district level empirically. The results suggest that very few significant relationships between yield and climate variables, such coefficient can be used to assess real effect of climate variables in change of yield of food-crops increasing threat of food insecurity. The paper suggests relationship between crop yields and weather factors and some policy measures for improving food security situation in the country and open up some areas for further research.

Key words: Cereals, Climate change, Crop yield, Food security

INTRODUCTION

The relationship between climate change (CC) and agriculture is two-way; agriculture contributes to it in several ways and climate change in general adversely affects agriculture. Agricultural production and productivity are primarily dependent on climatic factors, and the favorable climatic conditions are to be crucial in generating optimal yield. So, economy of the country is more sensitive to agriculture and climate change (Alam and Regmi, 2004). The agricultural sector with low productivity growth is facing high rate of population growth coupled with the effects of climate change leading to serious consequences for sustainability. In the recent years, intensity, amount and distribution of rainfall are changing in unpredictable manner. So, the changes in the rainfall pattern may be fatal for them. Once the climate is disturbed, the whole agriculture system is affected. Climate change affects food, feed, fiber and fuel (4"F") causing food insecurity. According to MOPE (2004), Nepal's temp is rising by 0.41^{o}C per decade with pronounced warming, which is rising in higher rate as compared to the global increase of 0.74^{0}C. Climate change affects green sectors more than other sectors of the economy. Agricultural production is

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the outcome of the freshwater irrigation supplies from rivers and spring and rainfall, fertile soil terraced and maintained by the farmers for generations. Agriculture production depends on nature and gets affected by the change in the climatic parameters such as expected changes in frequency, duration, intensity and geographic distribution of rainfall and increased frequency, duration and intensity of droughts (FAO, 2010). Effects of climate change on agriculture are particularly high as the agriculture produces food and provides the primary source of livelihood for large chunks of weaker sections of the society (Pant, 2012). Climate change is expected to influence on crop production, hydrological balances, input supplies and other components of agricultural systems (Ludi, 2009 and IFPRI, 2009). If agricultural production in Nepal is adversely affected by climate change, the livelihoods of 2/3rd of the labor force, particularly of the rural poor will be at threat. The study analyzes the effect of climate variables on yield of major food-crops in Nepal based on historical data. The scope of the paper is limited to the impacts of climate change on crop yield and farmers.

MATERIALS AND METHODS

The study was based on household survey, literature review and analysis of primary and secondary data. Literatures relating to the climate change and food security were reviewed in addition to the national policies relating to the food security directly and indirectly. In Rupandehi district–Hatti Bangai and Manmateria VDCs were chosen on the basis of previous literatures and in consultation with District Agriculture Development Office as a study area for the research. Average annual rainfall, maximum and minimum temperature of the district is 1391 mm, 42.4^{o}C and 8.75^{o}C respectively. The population of the district is 0.88 million with the growth rate of 3.05% (CBS, 2011). Simple random sampling technique was used to select sample households from the area where individual household represented one sampling unit. Fifty three households from Hatti Bangai and Ninety one households from Manmateria VDCs were selected as sample from Rupandehi district with the help of formula cited by Gautam and Shivakoti, (2001). The analyses were done using statistical and econometric techniques. Regression analysis was done for estimating the effects of temperature and Rainfall on food production in Rupandehi district using Multivariate Regression Analysis**.** $\Delta\text{Yield} = m + r_y\Delta\text{Climate} + \varepsilon$…………(1)

ΔYield is the observed trend in yield, *m* is the average yield change due to management and other non-climatic factors or intercept, ΔClimate is the observed trend in temperature and rainfall, r_y is the yield response to this trend, and $\boldsymbol{\varepsilon}$ is the residual error. Paddy, maize, millet, wheat, barley, and potato are the major food-crops of Nepal as these crops are used to meet the basic food requirement of its population (Subedi, 2003).

RESULTS AND DISCUSSION

Rainfall Pattern (1973-2011) of Rupandehi District

Average annual rainfall of the Rupandehi district was 1808.33mm from 1973-2011. The lowest rainfall was1081.6 mm recorded in 2005-06 while the highest was 2797.4 mm recorded in 1998. The trend of rainfall (1973-2011) also shows fluctuation over 38 years in Rupandehi district.

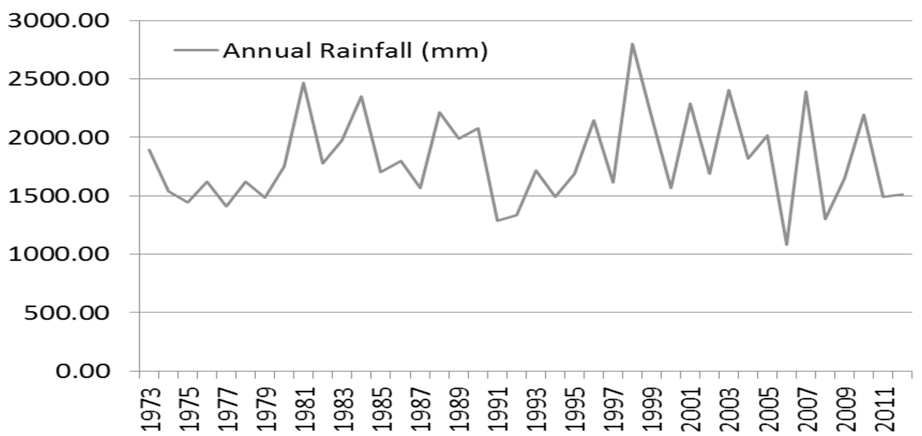

Fig 1 : Trend of average annual rainfall in Rupandehi district from 1973-2011

SOURCES OF LIVELIHOOD

Agriculture (above 75%) was found the main occupation for livelihood in Rupandehi district followed by employment, Remittance and business (Fig 2).

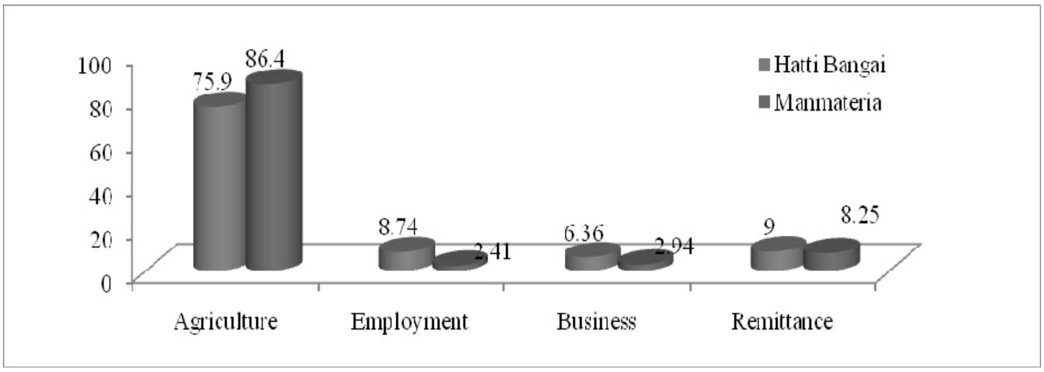

Figure 2: Livelihood sources of Rupandehi district, 2014

FARMER'S PERCEPTION ABOUT CLIMATE CHANGE

More than 80% of the population of Rupandehi district perceived the changes in temperature and rainfall over the years (Table 1). Majority of the households perceived visible changes in summer and winter temperature and intensity of rainfall.

Table 1 : Farmer's perception about climate change, 2014

Perceive CC	Do not perceive	Temp change		Noticed changes					
		Yes	No	Summer Temp			Winter Temp		
				I	D	NC	I	D	NC
82.6	17.4	85	15	78.2	17.6	4.2	56.4	36.3	7.3

I=Increased, D = Decreased, NC = No change, X^2 value = 4.1 df = 1, P-value = 0.024, Sig at 0.05 level

Yield of summer crops in response to climate variables in 2014

Table 2 : Results from multiple regression model (Summer crops in response to climate variables), 2014

Variable	Paddy		Maize		Potato		Millet	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Sumrain	.021(0.006)	0.01***	-.003(0.004)	0.34	0.0031(0.013)	0.68	-.001(0.001)	0.53
Summintemp	-0.11(0.14)	0.25	0.07(0.003)	0.37	0.24(0.38)	0.45	0.02(0.02)	0.61
Summaxtemp	0.09(0.13)	0.61	-0.11(0.05)	0.04**	-0.023(0.35)	0.73	-0.04(0.01)	0.21
R^2	0.31		0.15		0.09		0.07	

*** Significant at 0.01, ** Significant at 0.05 level, Sumrain-Summer Rainfall, Summintemp-Summer Minimum Temperature, Summaxtemp-Summer Maximum Temperature, Figures in parentheses indicates standard error

Table 3 : Results from multiple regression model (Winter crops in response to climate variables), 2014

Variable	Wheat		Barley	
	Coefficient	P-Value	Coefficient	P-value
Winrain	0.003(0.004)	0.54	0.001(0.002)	0.61
Winmintemp	0.04(0.03)	0.11	-0.002(0.02)	0.83
Winmaxtemp	0.008(0.03)	0.62	0.01(0.02)	0.45
R^2	0.21		0.01	

The model is able to describe a variation in food-crops yield ranging from 31% in the case of paddy to only 1% in the case of barley (Table 2 and 3). In addition, sign of coefficients give direction of movement of yield against change in climate variable. Climate variables show significant relations with paddy and maize. The coefficient estimated indicates that paddy yield increase significantly with increase in summer rainfall. Maize yield shows negative relation with summer maximum temperature, i.e., if summer maximum temperature increases yield of maize will decline sharply. The yield trend of the paddy, maize, millet, potato, wheat and barley based on the regression coefficient against time shows that time has significant (P-value < 0.00) effect on yield of all the food-crops.

FOOD SUFFICIENCY (PERCENTAGE) OF RUPANDEHI DISTRICT, 2014

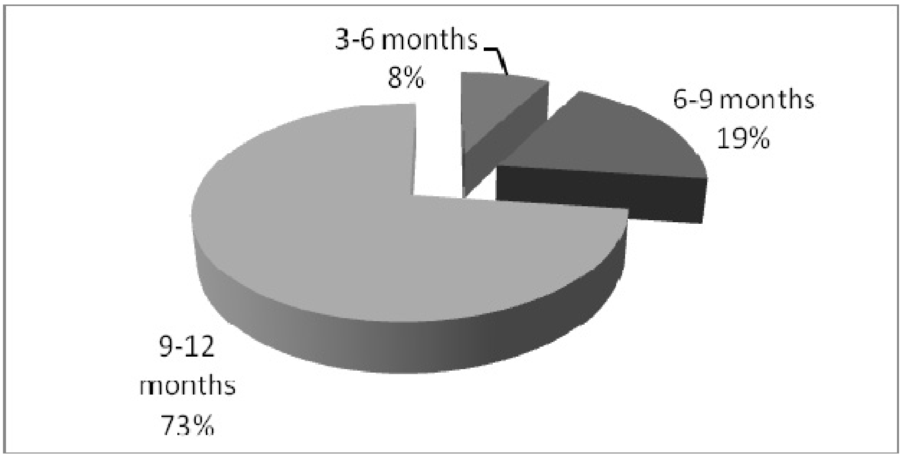

Figure 3 : Food surplus/ deficit situation of Rupandehi district, 2014

About 73% of the population is in food surplus condition in 2014 (Fig 3). Eight percent of the population has enough production for 6 months only. Those populations are in deficit condition. Food balance sheet of Rupandehi district also shows that the district is in food surplus condition.

IMPACT ON FOOD PRICE

The price trend of rice and wheat was found rapidly increasing from 2062 to onwards (fig 4). Warming of more than 2.5^{o}C could reduce global food supplies and contribute to higher food prices (UNEP and UNFCCC, 2002). Simulation studies on the effects of CC report price rise of major staples from 10 to 60% by 2030 (Hertel et at. 2010).

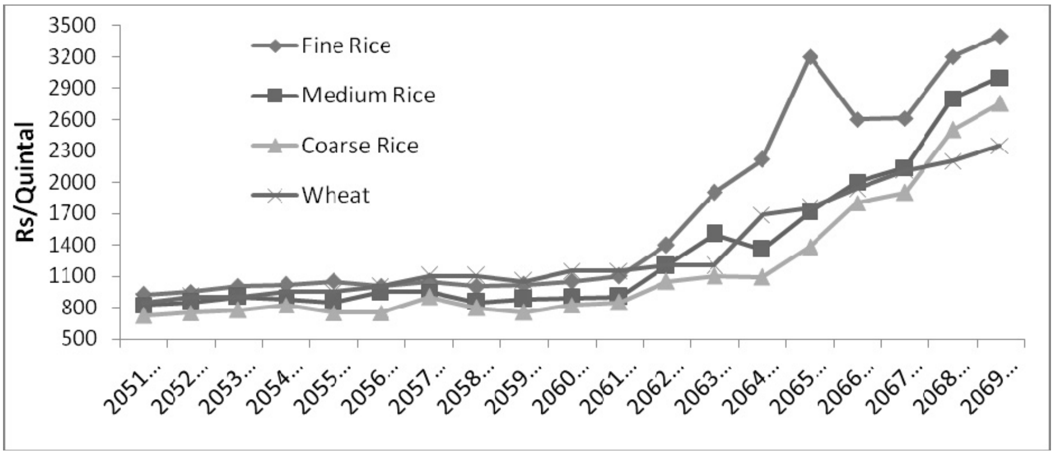

Figure 4 : Trend of wholesale price of Rice and Wheat

DISCUSSIONS

Though, the regression results show very few significant relationships between yield and climate variables, such coefficient can be used to assess real effect of climate variables in change of yield of food-crops considered for this study (Nicholls, 1997). Potato has the highest regression coefficient against time variable. Yield of potato is growing by 0.2 ton/ha every year. Thus, yield of potato has increased from 5.5 ton/ha in 1978 to 13.64 ton/ha in 2013 contributing the yield growth rate of 2.32 percent. The yield growth rate of paddy was found lower than the population growth rate (3.05%) of the Rupandehi district.

Wheat also shows better performance in terms of yield growth. With the regression coefficient of 0.003 against time variable, yield growth rate of wheat is 0.69 percent. Sharp decline in the yield of paddy and maize in 1982 can be linked to sharp decline in summer rain in the same year. Yield decline in paddy and maize is directly associated with summer rain. The current trend in climate variables has contributed positively to yield of both winter crops namely wheat and barley. In the case of wheat, there is 634 kg increase of yield during the study period, out of which 15.1 kg is contributed by the current climate trend. Here, decreasing winter rain and winter minimum temperature offset the positive effect of increased winter maximum temperature. In the case of summer crops, only paddy is favored by the current climate trend. It has contributed 28 kg increase in yield in case of paddy. An increase in summer rain and increase in summer maximum temperature have contributed highly in such increase in paddy yield. Other crops especially maize are adversely affected by the current climate trend in Nepal.

Food insecurity at the global level increases food price increasing the challenge of affording for food security by the people of low income net food importing countries. Government of Nepal has a policy of increasing food production to meet the domestic food need. But, the food production is getting threatened by climate change. The socioeconomic shocks include rise in international food price, rise in input prices like that of seed, fertilizers and fuel and decrease in public sector investment in food production. The changes in crop productivity affects food price affecting the consumption pattern. Most youths are getting detracted from agriculture with the opportunities of foreign employment. Land fallowing are already observed in some hilly regions due to limitation on labor force. Under such precarious condition of agriculture, the climate change is adding challenge in food production. Thus, Nepalese agriculture is at the cross road posing challenge on the food security particularly among the poor.

CONCLUSIONS

Majority of the population of Rupandehi district perceive the climate is changing. Population growth is the primary factor causing climate change. Regression model shows very few significant relationships between yield and climate variables. The climate change affects the entire food system from production, processing, distribution, consumption and utilization. Food security in Nepal is particularly vulnerable to climate change due to low level of human control over the water and temperature and fragile ecosystems that get easily affected from the climate change. Government needs to implement social security measures to deal with high food price for empowering poor in accessing food. In addition to agricultural development to increase domestic food production and application of reasonably high tariff for protecting domestic producers from cheap imports, it is necessary to integrate food supply into global trade rules. Some studies are necessary for revising the coefficients used in preparing food balance sheet, such as use of food grains for feed and opportunities and enhancing food security of small farmers through diversification of income and livelihood opportunities by growing non-food crops, cash crops and other environmental services.

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COMPARATIVE EFFICACY OF DIFFERENT ANTICOCCIDIAL FEED ADDITIVES AND TREATMENT PRODUCTS AGAINST CAECAL COCCIDIOSIS IN BROILERS

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ABSTRACT

To compare the effectiveness of salinomycin, maduramicin, and diclauzuril as feed additive anticoccidials and toltrazuril, sulfaquinoxaline, and sulfaclozine as treatment product anticoccidials, a research was conducted on 240 broiler chickens divided equally among eight groups (Treatments) employing Completely Randomized Design. Among feed anticoccidials, highest weight gain was observed in salinomycin (1825 ± 0.97gm) group than maduramicin (1795 ± 1.03gm) and diclazuril groups (1744 ± 1.23). Similarly toltrazuril group (1722 ± 1.20gm) was found with highest weight gain as compared to the sulfaclozine (1706±1.26gm) and sulfaquinoxaline group (1691 ± 1.23gm). Among feed anticoccidials, statistically lowest ($P < 0.05$) FCR value was found in salinomycin group (2.253 ± 0.001), than maduramicin (2.281 ± 0.001) and diclazuril group (2.308 ± 0.002) and significantly lowest ($P < 0.05$) FCR was found in toltrazuril group (2.315 ± 0.002) than sulfaclozine (2.320 ± 0.002) and sulfaquinoxaline group (2.337 ± 0.002). In the comparision of the mean feed intake/group, highest feed intake was found in salinomycin group (4112 gm) than maduramicin (4095gm) and diclazuril group (4025gm). Among feed anticoccidials, salinomycin group was found significantly ($P < 0.05$) lowest OPG count followed by maduramicin and diclazuril on 5th, 6th and 7th days of post infection but non-significant differences occurred on 8th days of post infection. Similarly, among water medicated treatment product anticoccidials, oocyst count was lowest in toltrazuril group. The average lesion score of the positive control group was 2.40 ± 0.51 which was significantly highest ($P < 0.05$) as compared to the negative control (0 ± 0), salinomycin (0.80 ± 0.37) and toltrazuril groups (0.60 ± 0.24) while non-significant difference occurs as compared to the rest of the groups. Among feed anticoccidials, average lesion score of salinomycin group was lowest but was not statistically significant. Similarly among water medicated anticoccidials, highest average lesion score was observed in sulfaquinoxaline group (1.60 ± 0.51) and lowest in toltrazuril group. There was no mortality due to coccidiosis in negative control group however the highest mortality was recorded in dicalzuril group. Salinomycin (T_3) showed better results as feed anticoccidials in term of weight gain, FCR, feed intake, mortality, reduced oocyst count, as compared with maduramicin and dicalzuril. Similarly among treatments, Toltrazuril (T_6) was found with better results than other anticoccidials.

INTRODUCTION

The increase in the efficiency and productivity in the poultry enterprise has greatly been affected by health and management hazards in poultry production. Among the managemental diseases, coccidiosis is most important which causes heavy losses to the poultry industry. In Nepal, economic losses due to this malady are still unknown due to lack of indices. However, in the world, the annual losses directly attributed to coccidiosis amount to hundreds of million dollars (McDougald, 1985). Coccidiosis may strike in any type of poultry in any type of facility. Most infections are relatively mild, but because of the potential for the disastrous outbreak and the resulting financial loss, almost all young poultry are given continuous medication with low levels of anticoccidial drugs in the feed, which prevent the infection or reduce chances of outbreak. There are many anticoccidials available in the market and feed manufactures find it difficult to choose the best one for addition in the ration. The present study was therefore planned to investigate the prophylactic effect of different commercially available feed additive anticoccidials and treatment products.

Poultry diseases continue to represent a serious loss to poultry producers in all areas of the world. Both industrialized and subsistence production is impacted, involving broilers, layers, turkeys, water fowl, as well as minor species. Diseases in poultry vary from being infectious like viral, bacterial, fungal, protozoal to non-infectious like management, stress, predation, etc. As the poultry industry is expanding globally and risk for outbreak of diseases is also looming largely. The raising of chickens under intensive farming practices predisposes birds to poor health and management scenarios finally resulting in economic losses.

Coccidia are almost universally found wherever chickens are raised. The widespread occurrence of coccidial infections in chickens even under modern conditions of production reflects both the adaptability of the parasite and the way birds are raised (Conway and McKenzie, 2007). Surveys in North and South America revealed coccidia present in almost all broiler farms. Also, very high percentages of positive flocks were also reported from Europe (Saif, 2003). The ubiquitous nature of poultry coccidia precludes the possibility of elimination or prevention of coccidia by quarantine, disinfection, and sanitation. Once a poultry shed becomes contaminated, it is virtually impossible to totally decontaminate the environment (Reid, 1989).

Coccidiosis is an enteric disease of poultry caused by intracellular protozoan parasite of genus *Eimeria*. Coccidiosis is a disease of almost universal importance in poultry production (Saif, 2003). It is one of the most detrimental and lethal managemental disease of poultry. Coccidiosis is rapidly developing intestinal disease presenting with bloody diarrhea and listlessness. It causes heavy mortality in affected flock. The losses due to coccidian outbreak are primarily by impaired feed conversion, depressed growth, lost pigmentation and downgrading at processing and mortality (McDougald and Roberson, 1988). Nine species of *Eimeria* infect chickens (Jordan and Pattison, 1996). The species important in broiler production include *Eimeria tenella* (90%), *E. maxima, E. acervulina*, and *E. mivati*; the species important in breeder and egg- layers are *E. burnetti* and *E. necatrix*. The most common species are *Eimeria tenella*, which causes the cecal or bloody type of coccidiosis, *E. necatrix*, which causes bloody intestinal coccidiosis and *E. acervulina* and *E. maxima,* which cause chronic intestinal coccidiosis. Field experience indicates that a severe *E. tennela* infection, due to bad litter, is in many cases followed by intestinal *E. coli* infection (Stroom and Sluis, 1999). The induced tissue damage and change in intestinal function may allow colonization by various harmful bacteria, such as *Clostridium perfringens*, leading to necrotic enteritis (Helmboldt and Bryant, 1971; Maxey and Page, 1977).

Coccidiosis is controlled in flocks by using either chemicals like amprolium, sulfa drugs or polyether ionophores like monensin, salinomycin etc. Resistance to chemical anticoccidials is common while that to polyether ionophores is slow and gradual. Fully one-third of the 90 isolates of mixed species of coccidia collected from 15 broiler growing areas of Brazil and Argentina were found to be either resistant or had seriously reduced sensitivity to monensin, salinomycin, and narasin (McDougald,1982).

The feed manufacturers are using synthetic feed additive anticoccidials in the feed to combat the coccidiosis similarly farmers are using commercially available anticoccidials to treat the infection. The prolong use of synthetic anticoccidials often develop resistant in birds to these drugs. On the other hand, commercial coccidiostats lead to increase cost of poultry rations (Hayat *et al*., 1996) and increases cost of production for farmers. The present study was, therefore planned to investigate the most appropriate drug to be used in feed as feed additive and best suitable anticoccidial for treatment against coccidiosis in broilers.

MATERIALS AND METHODS

Isolation, Sporulation and Counting of oocyst

Infected guts were collected from Ratna Poultry Farm, Mukundapur-1, Nawalparasi during clinical outbreak of caecal coccidiosis. Those collected caecal contents and mucosal scrapings were subjected to microscopic examination to identify the positive cases. The isolation and sporulation of the oocyst was done by the technique given by MAFF (1987). The average no of oocyst per 0.1 ml of the suspension was calculated to obtain the total count of oocysts in 1 ml of the undiluted stock mixture.

Experimental Design:

Two hundred and forty cobb-500 broiler birds with 43.25 ± 0.15gm average body weight were randomly divided into eight groups (Treatments: T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8) of 30 chicks each. The experimental design used is Completely Randomized Design (CRD). The birds were divided into treatments such as T_1- non-infected and non-medicated (Negative control), T_2- infected and non-medicated (Positive control), T_3- infected and with salinomycin in feed, T_4- infected and maduramicin in feed T_5- infected and with diclazuril in feed, T_6 infected + Toltrazurl in water, T_7 infected + Sulfaclozine in water and T_8 infected + Sulfaquinoxaline in water. Chicks were reared under standard management practices. All the chicks were kept on broiler starter ration up to 14 days of age and later on fed with broiler grower ration up to 28 days and broiler finisher ration from 29 days. The birds were reared on the rice husk as litter and the moisture level of the litter was kept 20-30%. The litter was replaced with clean litter after two weeks of age. The feed and water were provided ad libitum to all the birds. The temperature in the shed was kept at 95^0F during the first week and reduced by 5^0F on weekly basis. Lighting was provided for 24 hours throughout the experimental period. All the birds were vaccinated for Newcastle disease on 5^{th} day of age, for Infectious bursal disease on 14^{th} day of age and for Hydropericardium syndrome on 7^{th} day of age. Well-cleaned, hygienic environmental conditions were maintained in experimental shed. The chicks were fed with an isocaloric and isoproteinous experimental feed. Anticoccidials were added in the starter, grower and finisher ration.

The birds in all the groups except those of T_1 were infected with 30,000 sporulated oocysts at the age of 21^{st} day. Water medicated treatment drugs were used in 24^{th} days after clinical signs were seen. During the experimental period of six weeks, the parameter of feed consumption, weight gain, FCR, oocyst count, mortality percentage and lesion scorings were studied. The data thus collected was subjected to statistical analysis by using one way Aanlysis of Variance (ANOVA) and means were compared with Duncans Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Growth performances

The impact of oral administration of sporulated coccidial oocysts on body weight gain of different treatment groups of chicken are presented in table below.

Table 1. Mean weight gain of broilers in different groups

Treatments	Body wt (gm) (1st wk)	Body wt (gm) (2nd wk)	Body wt (gm) (3rd wk)	Body wt (gm) (4th wk)	Body wt (gm) (5th wk)	Body wt (gm) (6th wk)
T_1(Negative control)	146±0.85^c	405±0.98^c	674±1.16^d	1121±1.26^h	1655±1.38^h	2050±1.38^h
T_2(Positive control)	148±0.77^d	403±0.69^c	678±0.86^e	945±0.90^a	1265±1.23^a	1628±1.23^a
T_3(Salinomycin)	143±0.74^b	399±0.97^b	656±1.15^c	1088±1.30^g	1462±1.16^g	1825±0.97^g
T_4(Maduramicin)	140±0.76^a	393±1.10^a	645±1.35^b	1025±1.14^f	1402±1.16^f	1795±1.03^f
T_5(Diclazuril)	140±0.54^a	392±0.96^a	638±1.13^a	1012±1.06^e	1386±1.20^e	1744±1.23^e
T_6(Toltrazuril)	149±0.53^d	408±1.03^d	682±0.89^f	979±1.05^d	1378±1.23^d	1722±1.20^d
T_7(Sulfaclozine)	145±0.87^{bc}	414±0.93^e	690±1.31^g	974±0.82^c	1364±1.17^c	1706±1.26^c
T_8(Sulfaquinoxaline)	151±0.61^e	416±0.84^e	688±1.39^g	968±0.96^b	1349±0.99^b	1691±1.23^b
LSD (=0.05)	2.01	2.64	3.28	3.03	3.37	3.36
CV, %	2.7	1.3	1.0	0.6	0.5	0.4

Different superscripts within a column indicate significant difference between the means, abcd: p<0.05

At the 42 days of the experimental period, significantly ($P < 0.05$) highest body weight was seen in negative control group (2050 ± 1.375 gm) as compared to other treatment groups like T_2 (1628 ± 1.233gm), T_3 (1825 ± 0.973gm), T_4 (1795 ± 1.033gm), T_5 (1744 ± 1.22gm), T_6 (1722 ± 1.200gm), T_7 (1706 ± 1.255gm) and T_8 (1691 ± 1.225gm) groups. While significantly ($P < 0.05$) lowest body weight was seen in positive control group (1628 ± 1.233gm). Among feed anticoccidials, highest weight gain was observed in salinomycin group than maduramicin and diclazuril groups. Similarly among water medicated anticoccidial groups, significantly ($P < 0.05$) highest body weight was observed in toltrazuril group as compared to sulfaclozine and sulfaquinoxaline group.

Feed intake analysis

Mean values for feed consumption have been presented in table below:

Table 2. Mean feed intake/week/birds in different groups

Treatments	1st wk (gm)	2nd wk (gm)	3rd wk (gm)	4th wk (gm)	5th wk (gm)	6th wk (gm)
T_1(Negative control)	136	550	1250	2200	3420	4421
T_2(Positive control)	139	548	1252	1980	2945	3930
T_3(Salinomycin)	132	545	1252	2134	3232	4112
T_4(Maduramicin)	130	541	1235	2096	3195	4095
T_5(Diclazuril)	132	545	1231	2084	3179	4025
T_6(Toltrazuril)	140	562	1252	2005	3155	3986
T_7(Sulfaclozine)	134	568	1263	2002	3141	3958
T_8 (Sulfaquinoxaline)	139	565	1260	1992	3136	3952

Mean values of average feed consumption at 42 days of age are 4421, 3930, 4112, 4095, 4025, 3986, 3958 and 3952 grams for the T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8 groups respectively. The study revealed that the groups of birds that were not infected with coccidial infection consumed more feed; while in infected groups the lower feed intake was due to coccidial stress. Among feed anticoccidials, highest average feed consumption was seen in the T_3 (Salinomicin) and lowest was seen in T_5 (Diclazuril) group. Among treatment produt anticoccdials, highest feed consumption was seen in T_6 (Toltrazuril) group and lowest feed consumption was seen in T_8 (Sulfaquinoxaline) group.

FCR analysis

The FCR analysis was done by dividing individual weight with the average feed intake of that group. The table below summarizes the mean FCR values found in different treatment groups.

Table 3. Feed Conversion ratio of different treatment groups

Treatments	FCR (6^{th} wks)
T_1 (Negative control)	2.157 ± 0.001^{a}
T_2 (Positive control)	2.414 ± 0.002^{h}
T_3 (Salinomycin)	2.253 ± 0.001^{b}
T_4 (Maduramicin)	2.281 ± 0.001^{c}
T_5 (Diclazuril)	2.308 ± 0.002^{d}
T_6 (Toltrazuril)	2.315 ± 0.002^{e}
T_7 (Sulfaclozine)	2.320 ± 0.002^{f}
T_8 (Sulfaquinoxaline)	2.337 ± 0.002^{g}
LSD (=0.05)	0.004349
CV, %	0.4

Different superscripts within a column indicate significant difference between the means, abcdefgh: $p<0.05$

At the end of the experimental period, significantly highest ($P < 0.05$) FCR value (2.414 ± 0.002) was found in positive control group and significantly lowest ($P < 0.05$) FCR value (2.157 ± 0.001) was found in negative control group. The average FCR values of other groups lie between them. Salinomycin in feed was found with significantly lowest FCR (2.253 ± 0.001) as compared to the maduramicin (2.281 ± 0.001) and diclazuril (2.308 ± 0.002). Among treatment product anticoccidials, toltrazuril was with significantly lowest FCR value (2.315 ± 0.002) as compared to the sulfaclozine (2.320 ± 0.002), and sulfaquinoxaline (2.337 ± 0.002).

Mortality percentage analysis

Table 4. Mortality percentage/week in different groups

Treatments	1st wk	2nd wk	3rd wk	4th wk	5th wk	6th wk	Total mortality	Total mortality due to coccidiosis	Mortality %
T_1 (Negativecontrol)	0	0	1	0	0	0	1	0	3.33
T_2 (Positive control)	0	1	0	7	2	0	10	6	33.33
T_3 (Salinomycin)	1	0	0	2	1	0	4	3	13.33
T_4 (Maduramicin)	0	2	0	3	1	0	6	4	20
T_5 (Diclazuril)	1	0	0	4	1	1	7	5	23.33
T_6 (Toltrazuril)	0	1	0	2	1	0	4	3	13.33
T_7 (Sulfaclozine)	0	1	0	4	1	0	6	5	20
T_8(Sulfaquinoxaline)	0	0	1	5	2	1	9	6	30

There was highest mortality in positive control group (33.33%) and lowest mortality in negative control group (3.33%). Among feed anticoccidials, lowest mortality was seen in salinomycin group (13.33%) followed by maduramicin group (20%) and diclazuril group (23.33%). Lowest mortality among water medicated group was seen in toltrazuril group (13.33%) followed by sulfaclozine group (20%) and sulfaquinoxaline group (30%).

Oocyst per gram (OPG) counts

Oocyst counting was done for each treatment group by collecting the fecal samples after the 5th, 6th, 7th, and 8th days of post inoculation of oocyst (PI). There was no any oocyst found in T_1 (Negative control) group as it was not infected with the coccidia. Significantly ($P<0.05$) highest OPG count was observed in T_2 (Positive control) group in all four days. Among feed anticoccidials, T_3 (Salinomycin) group was found significantly ($P<0.05$) lowest OPG count followed by T_4 (Maduramicin) and T_5 (Diclazuril) on 5th, 6th and 7th days of PI but non-significant differences occurred on 8th days of PI. Similarly, among treatment product anticoccidials, oocyst count was lowest in T_6 (Toltrazuril) group compared to that of T_7 (Sulfaclozine) and T_8 (Sulfaquinoxaline) group.

Table 5. Oocyst output of broilers treated in different groups

Treatments	Day5 PI	Day6 PI	Day7 PI	Day 8 PI
T_1(Negative control)	$0.00±0.00^{a}$	$0.00±0.00^{a}$	$0.00±0.00^{a}$	$0.00±0.00^{a}$
T_2(Positive control)	$20422.33±407.92^{g}$	$26222.33±924.84^{e}$	$27689.00±3563.16^{d}$	$19133.33±2036.85^{c}$
T_3(Salinomycin)	$1267.00 ±115.47^{b}$	$1422.33±135.27^{ab}$	$1778.00±212.17^{a}$	$1133.33±231.23^{a}$
T_4(Maduramicin)	$4311.00±218.76^{e}$	$6311.00±475.03^{c}$	$6111.33±464.00^{b}$	$4778.00±404.29^{ab}$
T_5(Diclazuril)	$10755.67±648.89^{f}$	$13511.004±1944.44^{d}$	$10622.33±484.11^{c}$	$9266.67±604.99^{b}$
T_6(Toltrazuril)	$1722.33±174.73^{bc}$	$1444.33±173.58^{ab}$	$889.00±134.97^{a}$	$444.67±173.28^{a}$
T_7(Sulfaclozine)	$2355.67±123.69^{cd}$	$2377.33±346.83^{ab}$	$2422.33±256.43^{ab}$	$1111.33±96.74^{a}$
T_8(Sulfaquinoxaline)	$3110.33±173.51^{d}$	$3711.33±181.93^{b}$	$2444.67±211.89^{ab}$	$1378.00±124.02^{a}$
LSD (=0.05)	902.30	2385.2	3868.4	4972.7
CV, %	9.50	20.0	34.4	61.7

Different superscripts within a column indicate significant difference between the means, abcd: $p<0.05$. PI: Post-infection

Lesions score analysis

The evaluation of the severity of gross lesions is usually the easiest method of assessment of the status of the infection in experimental birds. Lesion score is considered as the visible effect of the drug on coccidiosis.

Table 6. Result of the lesion score data

Treatments	No. of birds in each lesion score					Total lesion score	Mean Lesion score
	LS 0	LS 1	LS 2	LS 3	LS 4		
T_1 (Negative control)	5	0	0	0	0	0	$0±0^{a}$ (0.71±0.00)
T_2 (Positive control)	0	1	2	1	1	12	$2.40±0.51^{c}$ (1.68±0.15)
T_3 (Salinomycin)	2	2	1	0	0	4	$0.80±0.37^{ab}$(1.09±0.17)
T_4 (Maduramicin)	1	2	2	0	0	6	$1.20±0.37^{bc}$(1.26±0.16)
T_5 (Diclazuril)	1	2	1	1	0	7	$1.40±0.51^{bc}$(1.32±0.20)
T_6 (Toltrazuril)	2	3	0	0	0	3	$0.60±0.24^{ab}$(1.02±0.13)
T_7 (Sulfaclozine)	1	2	2	0	0	6	$1.20±0.37^{bc}$(1.26±0.16)
T_8 (Sulfaquinoxaline)	1	1	2	1	0	8	$1.60±0.51^{bc}$(1.39±0.20)
LSD(=0.05)						0.4522	
CV, %						28.90	

a,b,c means with the different indices between groups are significantly different for $p<0.05$. Note that parentheses indicates square root transformed value of original value ($\sqrt{(x+0.5)}$)
Note: LS: Lesion score

The average lesion score of the positive control group (T_2) was 2.40 ± 0.51 which was significantly highest ($P<0.05$) as compared to the T1, T3 and T6 groups while non-significant difference occurred as compared to the rest of the groups. More caecal lesions were seen in this group. While the average lesion score of the negative control group was 0 ie lowest. No any coccidial lesions were seen in this group. Among feed anticoccidials, average lesion score of T_3 (Salinomycin) group 0.80 ± 0.37 was non-significantly ($P<0.05$) lowest in comparison to others likeT_4 (Maduramicin) 1.20 ± 0.37 andT_5 (Diclazuril) 1.40 ± 0.51. Similarly Among water medicated anticoccidials, Non-significantly ($P<0.05$) highest average lesion score was observed in T_8 (Sulfaquinoxaline) group 1.60 ± 0.51 followed by T_7 (sulfaclozine) group 1.20 ± 0.37 and T_6 (Toltrazuril) 0.60 ± 0.24.

CONCLUSION

In this study, the efficiency of three different feed anticoccidials and three different treatment product anticoccidials as a method of controlling avian coccidiosis was compared and studied the differences in number of oocysts recovered from feces, the lower macroscopic lesion score and the improved performance of chickens. The result form the study gives some tentative susceptibility patterns of the *Eimeria* parasite to the drugs available in the market. Salinomycin, being found higher efficacy, should be given higher emphasis as feed anticoccidial and similarly the toltrazuril as treatment product anticoccidials. This pattern of the efficacy may not be same in all cases but the literature and based on the present study, use of salinomycin is preferred in feed and toltrazuril in water for treatment.

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RESPONSE OF ONION (ALLIUM CEPA L.) VARIETIES AND NPK LEVELS TO OFF-SEASON BULB PRODUCTION IN CHITWAN TERAI, NEPAL

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ABSTRACT

The field experiment entitled response of onion (Allium cepa L.) varieties and NPK levels to off season bulb production was carried out in the farmer's field at Bharatpur-13, Rambag, Chitwan, Nepal during June 2013 to February 2014. The field experiment was laid out in factorial Randomized Complete Block Design (RCBD) with three varieties (Nasik Red 53, Agrifound Dark Red and Bemausami-1) of onion and four levels of NPK (60:40:20, 80:60:40, 100:80:60 and 120:100:80 kg ha^{-1}) replicated thrice. Agrifound Dark Red had significant effect on plant height (48.32 cm) and number of leaves per plant (9.68) at 60 DAT than Bemausami-1 and Nasik Red 53. The highest plant height (46.61 cm) and number of leaves per plant (9.13) were recorded at 120:100:80 kg NPK ha^{-1} which was significantly higher than 60:40:20 NPK kg ha^{-1} at 60 DAT. Marketable bulb yield of Agrifound Dark Red was significantly higher (36.97 ton ha^{-1}) than Bemausami-1 (31.61 ton ha^{-1}) and Nasik Red 53 (31.30 ton ha^{-1}). The nutrient level of 120:100:80 NPK kg ha^{-1} gave higher marketable bulb yield (36.48 ton ha^{-1}) as compared to the yield recorded under other nutrient levels. The effect of NPK levels on marketable bulb yield at 120:100:80 kg ha^{-1}, 100:80:60 kg ha^{-1} and 80:60:40 kg ha^{-1} were similar. The bulb weight retained in variety Agrifound Dark Red during ordinary room storage was 669.58gm/10bulbs and 573.25gm/10bulbs at 15 and 30days after harvesting respectively than Nasik Red 53 and Bemausami-1. The highest B:C ratio of 6.08 was found in Agrifound Dark Red at nutrient level of 120:100:80 NPK kg ha^{-1} with highest total return of Nrs.14,52,022.00 ha^{-1} as compared to Nasik Red 53 and Bemausami-1. Keeping in view the higher yield and better post harvest keeping quality, Agrifound Dark Red variety was found to be superior for off season onion bulb and green production during rainy-autumn season because of higher plant height, greater number of leaves and maximum biological yield. Regarding NPK levels, 120:100:80 kg ha^{-1} responded higher marketable bulb yield and biological yield of onion than other NPK levels.

Key words: Onion, Off-season onion bulb production, NPK levels, Marketable bulb yield.

INTRODUCTION

Agriculture is the predominant occupation involving 65.6 % population of the country and accounts for 35.65 % share in the total GDP (MoAC, 2011). Agricultural Perspective Plan (APP) has prioritized the enhanced production of fresh vegetables as one of the seven high value enterprises (APPROSC, 1995). Onion is the most important bulb crop grown on commercial scale both for local consumption and for export. Government of Nepal has set a strategy "Onion Mission" which aims to replace imports by increasing the land devoted to onion production areas (MoAC, 2011). Onion (*Allium cepa*) is normally a cool-season vegetable crop but it can be grown successfully throughout most of the warm temperate hill as well as in the terai areas of Nepal. The biophysical conditions of the warm-temperate hilly regions of Nepal are congenial for the overall growth and development of onion. In Nepal, onion production is concentrated during the period of November to May (main season) because onion requires cool climate during vegetative growth and comparatively higher temperature during bulbing. There is sufficient availability of onion bulb during May to June and after this period, the availability of quality bulb declines because of the post harvest losses during storage (mainly sprouting and rotting). There is the opportunity to produce the onion in off season through set and seedling transplantation during rainy-autumn season in mid hills and terai to supply for lean availability in local market and to reduce the high import of onion from India and other country. Efforts have been made for off season onion production to substitute the import. Traditionally, off-season onion bulb is produced through the set obtained from previous year's sowing of seed. Alternatively, off season onion can be produced through transplanting of onion seedlings produced by sowing the seed during June to July. Nepal fulfills higher demand of onion during June to December importing from India (Budathoki, 2006). The storage loss goes as high as 88 % (Srivastava and Sharma, 1993) during June to December, which hinders the supply of domestic produce in the market. In addition to bulbs, farmers can get immediate income from selling of green top from off-season onion (Rokaya and Bhandari, 2004, Gautam, 2006). This profitable business gives benefit cost ratio of 7.1: 3 (Singh *et al*., 1995).

Onion is grown in more or less in all the districts of the country, however, the average yield is 13.1 ton ha^{-1}, which is very low as compared to many other onion producing countries of the world (MoAC, 2010/2011). To increase yield of onion, it is possible through adoption of high yielding varieties and appropriate nutrient management. Varieties and soil nutrients determine the off-season onion yield. Although many local and imported onion varieties are popular among the farmers in Nepal. But, government has released only one variety, Red Creole so far (AICC, 2069 BS). However, the farmers prefer Indian variety Nasik 53 and Agrifound Dark Red as these varieties perform better. But there are limited reports on the suitability of onion variety and appropriate nutrient management for off season (Rainy-Autumn season) bulb production under different ecological zones of Nepal. Onion responded to N, P_2O_5 K_2O and S positively in terms of yield and quality of bulbs (Patel and Patel, 1990). Onions are more susceptible to nutrient deficiencies than most crops plants because of their shallow and un-branched root system; hence they require and often respond well to addition of fertilizers (Brewster, 1994).

Among the constraints associated with low productivity and the availability of onion throughout the season in Nepal, the suitability of varieties and appropriate nutrient levels primarily nitrogen, phosphorus and potash are of paramount importance for maximizing off season onion bulb yield in the hills and terai condition. Therefore, the study on response of onion (*Allium cepa* L.) varieties and NPK levels to off season bulb production was carried out.

MATERIALS AND METHODS

A field experiment was carried out in the farmer's field at Bharatpur-13, Rambag, Chitwan, Nepal during June 2013 to February 2014. The experiment site was located at inner terai region of central Nepal having subtropical humid climate and its elevation about 256 masl. The soil was neutral in reaction with medium organic matter and nitrogen content, K_2O and P_2O_5 content. The soil was sandy loam type. The experimental site had mean maximum temperature ranged from 19.74 °C to 36.98 °C. Similarly, the mean minimum temperature ranged from 11 °C to 29.35 °C. About 2014.30 mm of total rainfall was received during the entire growing season. It was maximum (667.50 mm) in June and minimum rainfall (1.60 mm) in the month of November.

The field experiment was laid out in factorial Randomized Complete Block Design (RCBD) with three varieties (Nasik Red 53, Agrifound Dark Red and Bemausami-1) of onion and four levels of NPK (60:40:20, 80:60:40, 100:80:60 and 120:100:80 kg ha^{-1}) replicated thrice. There were a total of 36 plots. Individual net plot area comprised of 1.35 m x 1.5 m (2.025 m^2) with 90 plants at spacing 15 cm row to row and 15 cm plant to plant. Total 52 plants excluding the boarder plants were used for data recording. The 10 plants for each treatment in each replication were used for data recording. The total experimental area was 157.5 m^2. Vegetative, quality and yield attributing parameters were recorded and data were analyzed by using MSTAT-C. Means were separated using Duncan's Multiple Range Test (DMRT) at 5 % levels of significance.

RESULTS AND DISCUSSION

Yield and yield attributing components

Plant stands

The plant stand (%) recorded in Agrifound Dark Red was 90.09 % at 45 DAT and 86.38% at 60 DAT. Similarly, the plant stand (%) of Bemausami-1 was 90.92% at 45 DAT and 86.2 % at 60 DAT. The plant stand percentage of both the varieties Agrifound Dark Red and Bemausami-1 were significantly higher than Nasik Red 53 at 45DAT and 60 DAT. Highest plant stand percentage in Agrifound Dark Red and Bemausami-1 might be due to its tolerance to heat stress during off-season cultivation (Table 1).

Fresh bulb yield, Fresh leaf yield and Biological yield at harvest

The highest biological yield was recorded at 120:100:80 NPK kg ha^{-1} (54.58 ton ha^{-1}) which was found to be significantly different as compared to 60:40:20 NPK kg ha^{-1} (38.21 ton ha^{-1}) and at 80:60:40 NPK kg ha^{-1} (43.45 ton ha^{-1}). Higher fresh bulb yield of Agrifound Dark Red (37.07 ton ha^{-1}) at harvest was recorded significant than Bemausami-1(31.74 ton ha^{-1}) and Nasik Red 53 (28.82ton ha^{-1}). There was the relationship of fresh leaf yield and biological yield of onion at harvest. Higher fresh leaf yield had higher total biological yield at harvest (Table 1).

Average bulb yield and Marketable bulb yield

The marketable bulb yield of Agrifound Dark Red (36.97 ton ha^{-1}) was significantly higher than that of Nasik Red 53 (31.30 ton ha^{-1}) and Bemausami-1 (31.61 ton ha^{-1}). Similarly, the marketable bulb yield recorded at 120:100:80 NPK kg ha^{-1} (36.48 ton ha^{-1}) was significantly higher than the yield recorded at 60:40:20 NPK kg ha^{-1} (28.42 ton ha^{-1}). The effects on marketable bulb yield at nutrient levels 120:100:80, 100:80:60 and 80:60:40 kg ha^{-1} were at par. Bulb diameter and polar length have highly significant association with biological yield, bulb yield and marketable bulb yield. Neck thickness and doubled bulb have highly significant but negative association with biological yield, bulb yield and marketable yield (Table 1).

Table 1. Response of onion varieties and NPK levels on biological yield, fresh bulb yield, fresh leaf yield, average bulb yield and marketable yield at Bharatpur-13 Rambag, Chitwan, Nepal, 2013/14

Treatments	Plant stand (%) at harvest	Biological yield at harvest (ton ha^{-1})	Fresh bulb yield at harvest (ton ha^{-1})	Fresh leaf yield at Harvest (ton ha^{-1})	Average bulb yield (gm)	Marketable bulb yield (ton ha^{-1})
Variety						
Nasik Red 53	70.92	43.66	28.82^{b}	14.83	70.42^{b}	31.30^{b}
Agrifound Dark Red	76.29	50.31	37.07^{a}	13.23	83.19^{a}	36.97^{a}
Bemausami-1	74.35	45.43	31.74^{b}	13.68	71.13^{b}	31.61^{b}
SEm	1.7541	1.9003	1.3665	1.302	2.8372	1.261
LSD (p=0.05)	ns	ns	4.008**	ns	8.321**	3.698**
N:P:K level (kg ha-^{1})						
60:40:20	70.49	38.21^{c}	28.30^{c}	9.91^{c}	63.95^{b}	28.42^{b}
80:60:40	73.7	43.45^{bc}	30.95^{bc}	12.49^{bc}	75.76^{a}	33.67^{a}
100:80:60	74.19	49.63^{ab}	34.81^{ab}	14.82^{ab}	77.87^{a}	34.61^{a}
120:100:80	77.03	54.58^{a}	36.13^{a}	18.45^{a}	82.09^{a}	36.48^{a}
SEm±	2.0255	2.1943	1.5779	1.5034	3.2761	1.456
LSD (p=0.05)	ns	6.436**	4.628**	4.409**	9.609**	4.27**
CV %	8.23	14.16	14.54	32.4	13.12	13.12
Mean	73.85	46.473	32.551	13.921	74.918	33.297

In column, figures bearing same letter(s) do not differ significantly at 5% DMRT. * and ** denotes significance at 5% and 1% level of significance respectively

QUALITY PARAMETERS

Bulb diameter, polar length and neck thickness

Agrifound Dark Red produced significantly larger bulb diameter (5.63cm) than Nasik Red 53 (4.93cm). However bulb diameter of Bemausami-1 was at par with the diameter of Agrifound Dark Red and Nasik Red 53. The larger bulb diameter of Bemausami-1 and Agrifound Dark Red was due to varietal differences and favorable response of plant to short day photo period and higher temperature. The polar length of Agrifound Dark Red (7.91cm) was significantly greater than that of Nasik Red 53 (7.21cm). Increasing levels of NPK from 60:40:20 to 120:100:80 kg ha^{-1} had no significant effects on the bulb diameter and polar length. Maximum neck thickness was recorded in Bemausami-1(1.47cm) as compared to Agrifound Dark Red (1.41 cm) and Nasik Red 53 (1.39 cm). However all the three varieties were at par with each other with respect to neck thickness (Table 2).

Bulb splitting and bolting

Bulb splitting was significantly higher in Nasik Red 53 (6.57%) as compared to Agrifound Dark Red (3.51%). However bulb splitting in Bemausami-1 was similar to Nasik Red 53 and Agrifound Dark Red. Nutrient levels had no significant effect on bulb splitting percentage. There is no significance difference on bolting percentage in variety and levels of NPK. However, maximum bolting was observed in Bemausami-1(2.01%) and minimum bolting was observed in Agrifound Dark Red (1.47%). There was also no significant difference on bolting between the variety and level of NPK interactions (Table 2).

Table 2. ***Response of onion varieties and NPK levels on bulb splitting, bolting, bulb diameter, polar length, neck thickness at Bharatpur-13 Rambag, Chitwan, Nepal, 2013/14***

Treatments	Bulb splitting (%)	Bolting (%)	Bulb diameter (cm)	Polar length (cm)	Neck thickness (cm)
Variety					
Nasik Red 53	6.57^{a}	1.73	4.934^{b}	7.217^{b}	1.395
Agrifound Dark Red	3.51^{b}	1.47	5.633^{a}	7.912^{a}	1.414
Bemausami-1	4.07^{ab}	2.01	5.269^{ab}	7.558^{ab}	1.478
SEm±	0.87	0.2499	0.4199	0.163	0.055
LSD (p=0.05)	2.55^{*}	ns	0.1432^{**}	0.4782^{*}	ns
NPK level (kg ha^{-1})					
60:40:20	3.58	1.97	5.319	7.596	1.333
80:60:40	5.06	2.02	5.299	7.604	1.446
100:80:60	5.06	1.50	5.299	7.634	1.476
120:100:80	5.18	1.45	5.199	7.416	1.462
SEm±	1.737	0.2885	0.1654	0.1888	0.0635
LSD (p=0.05)	ns	ns	ns	ns	ns
CV %	63.75	49.86	9.4	7.46	13.32
Mean	4.72	1.736	5.279	7.563	1.429

In column, figures bearing same letter(s) do not differ significantly at 5% DMRT. * and ** denotes significance at 5% and 1% level of significance respectively

Post harvest quality attributes

Bulb sprouting, weight retained and marketable bulb percentage in ordinary room storage condition

Sprouting, weight loss and retained bulb quality are the major quality attributes for post harvest shelf life of onion bulb. There was no significant difference between the varieties on sprouting when kept at ordinary room condition. However, minimum sprouting percentage was observed in Agrifound Dark Red which was 28.33% at 30DAH, 34.17% at 45DAH and 44.16% at 60 DAH. The bulb weight retained in Agrifound Dark Red after 15 and 30 days after harvesting was 669.58gm/10bulbs and 573.25gm/10bulbs respectively which was significantly higher than the weight retained by Nasik Red 53 and Bemausami^{-1}. Similarly, the bulb weight retained at nutrient levels 120:100:80 kg ha^{-1} (621.66gm/10bulbs) and at 100:80:60 NPK kg ha^{-1} (622.61gm/10bulbs) was significantly higher than 60:40:20 NPK kg ha^{-1} (523.39gm/10bulbs) after 15 days of harvesting. The marketable bulb retained percentage in Agrifound Dark Red was significantly higher at 30 days after harvesting (96.66%) and at 45 days after harvesting (90%) when kept at ordinary room condition as compared to Nasik Red 53 at 30 days (85.83%) and bulb retained at 45 days after harvesting (81.66%) (Table 3).

Table. 3 Response of onion varieties and NPK levels on sprouting of bulbs% and weight retained at different days after harvesting (DAH) in ordinary room condition at Bharatpur-13 Rambag, Chitwan, Nepal, 2013/14

Treatments	% of bulb sprouting in ordinary room condition				Weight retained of 10 bulbs (gm) in ordinary room condition			
Variety	15 DAH	30 DAH	45 DAH	60 DAH	15 DAH	30 DAH	60 DAH	At harvest
Nasik Red 53	21.66	30.00	35.00	51.66	541.16^{b}	447.92^{b}	283.50	704.29
Agrifound Dark Red	20.83	28.33	34.17	44.16	669.58^{a}	573.25^{a}	384.41	831.91
Bemausami-1	20.00	28.33	37.50	44.16	562.45^{b}	482.25^{b}	291.25	711.33
SEm±	2.71	3.23	3.58	3.52	21.67	22.31	31.87	28.37
LSD (p=0.05)	ns	ns	ns	ns	63.56*	65.46**	ns	ns
NPK level (kg ha^{-1})								
60:40:20	21.11	24.44	32.22	43.33	523.39^{b}	447.55	271.00	639.50
80:60:40	24.44	33.33	41.11	50.00	596.61^{ab}	518.11	316.11	757.61
100:80:60	20.00	28.88	33.33	43.33	622.61^{a}	535.66	372.88	758.72
120:100:80	17.77	28.88	35.55	50.00	621.66^{a}	503.22	318.88	820.88
SEm±	3.13	3.73	4.14	4.07	25.02	25.77	36.80	32.76
LSD (p=0.05)	ns	ns	ns	ns	73.39*	ns	ns	ns
CV %	45.19	38.78	34.94	26.18	12.7	15.43	34.54	13.12
Mean	20.83	28.88	35.55	46.66	591.07	501.14	319.72	749.18

In column, figures bearing same letter(s) do not differ significantly at 5% DMRT. * and ** denotes significance at 5% and 1% level of significance respectively

ECONOMIC EVALUATION

The cost of production of onion bulb varied with the nutrient levels. The highest B:C ratio was observed in Agrifound Dark Red (6.08) at NPK level of 120:100:80 kg ha^{-1} with highest total return of Rs.14, 20,022.00 ha^{-1} than Nasik Red 53 and Bemausami-1.

CONCLUSION

In conclusion, keeping in view the higher yield and better post harvest keeping quality, Agrifound Dark Red variety was found to be superior for off season onion bulb and green production during rainy-autumn season because of higher plant height, greater number of leaves and maximum biological yield. Regarding NPK levels, 120:100:80 kg ha^{-1} responded higher marketable bulb yield and biological yield of onion than other NPK combinations. Thus, onion variety Agrifound Dark Red and nutrient level 120:100:80 NPK kg ha^{-1} has been suggested for off season onion bulb production during rainy-autumn season in Chitwan terai and other similar terai condition of Nepal.

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