Agriculture Development Journal

Volume 15 ISSN:2091-0738(Print)2091-0746(Online) July 2021

Government of Nepal
Ministry of Agriculture and Livestock Development
Agriculture Information and Training Centre
Hariharbhawan, Lalitpur, Nepal
Email: info@aitc.gov.np, website: www.aitc.gov.np

Agriculture Development Journal

EVALUATION OF FULL SEASON MAIZE GENOTYPES ACROSS THE MID-HILLS OF NEPAL

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ABSTRACT

Maize is one of the important cereal crops of Nepal. Mostly maize is grown in rainfed conditions in the mid-hills. In order to identify appropriate high yielding full season maize genotypes, different genotypes were evaluated in Intermediate Yield Trial, Coordinated Varietal Trial and Coordinated Farmers' Field Trial at six hilly research stations of NARC such as ARS, Pakhribas; HCRP, Dolakha; ABD, Khumaltar; RARS, Lumle; GRP, Salyan and HRS, Dailekh. Experiments were done in randomized complete block (RCB) design with three replications at each location in 2015 and 2016. In IYT, Manakamana-3 produced the highest yield (5841 kg/ha) followed by RAMPUR S0F08 (5836 kg/ha) and RAMPUR S13F28 (5680 kg/ha). Similarly, in CVT, 05SADVI produced the highest yield (5125 kg/ha) followed by KSYN10 (5035 kg/ha) and Manakamana-3 (4948 kg/ha). Similarly, in CFFT, TLBRS07F16 produced the highest yield (5277 kg/ha) followed by BGBYPOP (5090 kg/ha) and 07SADVI (5081 kg/ha). RAMPUR S0F08 and RAMPUR S13F28 of IYT could be promoted in CVT. Similarly, 05SADVI and KSYN10 of CVT could be promoted in CFFT. Genotypes, TLBRS07F16 and BGBYPOP could be proposed for the release process for the mid-hills of Nepal.

Keywords: CFFT, CVT, Full season maize, grain yield and IYT

INTRODUCTION

Maize (*Zea mays* L.) is the second most important food crop in Nepal. Area, production and productivity of maize are 9,54,158 ha, 2,555,847 kg and 2,679 kg/ha respectively. Out of total maize area, mountain, hill and terai occupy about 10%, 74% and 16% respectively (MOALD 2018). Most maize growing areas of hill belongs to medium to low input situations where only open pollinated maize varieties can perform well. Farmers have very few varietal selection options in maize. Farmers have to grow the same variety for many years despite their interest to change. In addition to this, the yield potential of the available varieties is very low (SQCC 2019). Due to these reasons, maize cultivation is unable to become a profitable choice of farmer in mid-

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hills. The broad objective of this project was to identify the suitable high yielding open pollinated maize varieties for hill farmers of Nepal. The specific objectives of the project were (i) to find best genotypes in Intermediate Yield Trial (IYT), (ii) to find best genotypes in Coordinated Varietal Trial (CVT) and (iii) to find best genotypes in Coordinated Farmers Field Trial (CFFT) of full season maize. This paper highlights the result of IYT, CVT and CFFT of full season maize genotypes which were tested across the mid-hill environments of Nepal during 2015 and 2016 summer.

MATERIALS AND METHODS

Different experimental trials i,e Initial Yield Trial (IYT), Coordinated Varietal Trial (CVT) and Coordinated Farmer Field Trial (CFFT) of full season maize genotypes were carried out at Agriculture Research Station (ARS), Pakhribas; Hill Crop Research Program (HCRP), Kabre; Agriculture Botany Division (ABD), Khumaltar; Regional Agriculture Research Station (RARS), Lumle; Ginger Research Program (GRP), Salyan and Horticultural Research Station (HRS), Dailekh and their respective outreach sites. The experiments were conducted in the summer seasons of 2015 and 2016 AD. IYT and CVT were conducted inside the stations and CFFT were conducted in the outreach sites of the respective stations and programs. There were 14, 10 and 6 genotypes in IYT, CVT and CFFT respectively. RCB design was used with three replications in IYT and CVT and with farmer as a replication in CFFT. In all the experiments, row length was 3 m. Number of rows in each plot was 2, 4 and 6 in IYT, CVT and CFFT respectively. Plot size was 4.5 meter square in IYT, 9 meter square in CVT and 13.5 meter square in CFFT. Two seeds were planted per hill and one plant per hill was maintained after weeding by thinning extra plants. FYM was applied at the rate of 10-15 tons per ha. NPK was applied at the rate of 120:60:40 kg/ha. Full dose of DAP and potash was applied at planting time as basal application. Urea was applied in three split such as at knee high, flowering and milking stage. Liming was done before 15 days of maize planting according to the acidic nature of the soil. Data collection was done manually in most of the stations. Field Log application (mobile application used for data recording) was used only in few stations. Data was arranged in excel and analyzed in Gen Stat software (VSN International 2004).

RESULTS AND DISCUSSION

The combined analysis of IYT full season set tested across six hill research stations (Table 1) showed that Manakamana-3 produced the highest grain yield (5841 kg/ha) followed by RAMPUR S03F08 (5836 kg/ha) and RAMPUR S13F28 (5680 kg/ha). The grain yield was highly significant for genotypes, years and locations. All the interaction effects were highly significant except Genotypes × Years. Days to anthesis were highly significant for years, locations and genotypes. All the interaction effects were highly significant except Years × Locations which was only significant. Days to silking were highly significant for years and genotypes but only significant for locations. All the interaction effects were highly significant except Genotypes × Years. Plant Height was highly significant for genotypes, years and locations. All the interaction effects were also highly significant. Ear height was highly significant for years and genotypes and only significant for locations. All the interaction effects were highly significant except Genotypes × Years.

05SADVI was found to be the highest yielder (5125 kg/ha) followed by KSYN10 (5035 kg/ha) and Manakamana-3 (4948 kg/ha) in the combined analysis of CVT full season set evaluated across the six hilly research stations. All the interaction effects were highly significant except Genotypes × Years × Locations. Days to anthesis were highly significant for years, locations and genotypes. All the interaction effects were highly significant except Locations × Genotypes. Days to silking were highly significant for years and genotypes but only significant for locations. All the interaction effects were highly significant except Years × Locations × Genotypes. Plant height was highly significant for genotypes, years and locations. All the interaction effects were highly significant except Years × Locations which was only significant. Ear height was highly significant for years, genotypes and locations. All the interaction effects were highly significant except Years × Locations and Genotypes × Years. Years × Locations was non-significant and Genotypes × Years was only significant.

The result of combined analysis of CFFT full season set assessed across six hilly research command areas revealed that TLBRS07F16 produced the highest yield (5277 kg/ha) followed by BGBYPOP (5090 kg/ha) and 07SADVI(5081 kg/ha) respectively. The grain yield was significant for genotypes but non-significant for years and locations. All the interaction effects were non-significant. Days to anthesis were significant for years and genotypes but non-significant for locations. All the interaction effects were non-significant except Years × Locations × Genotypes which was significant. Days to silking were significant for years and genotypes but non-significant for locations. All the interaction effects were non-significant. Plant height was highly significant for years but non-significant for locations and genotypes. All the interaction effects were non-significant except Genotypes × Years which was significant. Ear height was significant for genotypes but non-significant for Years × Locations. All the interaction effects were non-significant except Years × Locations × Genotypes which was significant.

Table 1. Combined analysis of grain yield and other traits of maize genotypes in IYT Over locations in 2015 and 2016 summer (NMRP 2015 and NMRP 2016).

S.N.	Genotypes	Grain Yield(kg/ha)	50% flowering days		Height (cm)	
			Male	Female	Plant	Ear
1	MANAKAMANA-3	5841[a]	64	69	200	104
2	RAMPUR S03F08	5836[a]	67	70	197	101
3	RAMPUR S13F28	5680[ab]	67	69	237	133
4	FARMERS' check	5189[bc]	66	69	201	106
5	RAMPUR S10F18	4869[cd]	67	71	233	129
6	HGA/HG-AB	4848[cd]	72	75	237	122
7	ZM627	4762[cde]	69	72	220	114
8	KLYPOP	4730[cde]	67	70	197	100
9	RAMPUR S10F20	4642[cde]	66	68	200	98
10	BLBSRS07F10	4456[de]	67	70	212	99
11	BLSBRS07F12	4343[def]	71	74	225	121
12	R-POP-2	4192[ef]	66	69	203	104
13	RAMPUR S13F01	3768[f]	66	68	207	113
14	RAMPUR S13F30	3004[g]	69	72	205	98
	Year (Y)	**	**	**	**	**
	Location (L)	**	**	*	**	*
	Genotype (G)	**	**	**	**	**
	Year (Y) × Location (L)	**	*	**	**	**
	Location (L) × Genotype (G)	**	**	**	**	**
	Genotype (G) × Year (Y)	ns	**	ns	**	ns
	(Y) × (L) × (G)	**	**	**	**	**
	LSD (0.05) (G)	553	2.44	2.64	22.13	18.99
	CV, %	17.7	2.19	2.26	5.95	11.1

Table 2. Combined analysis of grain yield and other traits of maize genotypes in CVT over the locations in 2015 and 2016 summer

S.N.	Genotypes	Grain Yield (kg/ha)	50% flowering days		Height (cm)	
			Male	Female	Plant	Ear
1	05SADVI	5125[a]	72	75	216	114
2	KSYN10	5035[a]	65	71	239	136
3	MANAKAMANA-3	4948[a]	71	74	211	113
4	KSYNF10	4929[a]	69	72	192	102
5	ZM401	4914[a]	73	76	243	132
6	RAMPUR S03F04	4544[b]	70	73	198	94
7	RAMPUR S10F22	4436[b]	71	74	193	102
8	FARMER'S check	4390[bc]	70	72	211	110
9	RAMPUR S03F06	4309[bc]	68	71	212	113
10	P501SRCO/P502SRCO	4045[c]	68	72	205	100
	Year (Y)	**	**	**	**	**
	Location (L)	**	**	*	**	**
	Genotype (G)	**	**	**	**	**
	Year (Y) × Location (L)	**	**	**	*	ns
	Location (L) × Genotype (G)	**	ns	**	**	**
	Genotype (G) × Year (Y)	**	**	**	**	*
	(Y) × (L) × (G)	ns	**	ns	**	**
	LSD (0.05) (G)	358	2.98	3.04	24.27	18.06
	CV, %	20.6	4.52	2.35	6.56	10.38

Table 3. Combined analysis of grain yield and other traits of maize genotypes in CFFT over the locations in 2015 and 2016 summer (NMRP 2015 and NMRP 2016).

S.N.	Genotypes	Grain Yield (kg/ha)	50% flowering days		Height (cm)	
			Male	Female	Plant	Ear
1	TLBRS07F16	5277[a]	66	73	249	125
2	BGBYPOP	5090[a]	67	72	258	137
3	07SADVI	5081[a]	71	77	244	131
4	Across 9942/Across 9944	4976[a]	71	78	272	149
5	Manakamana-3	4928[a]	71	78	252	137
6	Farmer's check	3714[b]	68	72	241	135
	Year (Y)	ns	*	*	**	ns
	Location (L)	ns	ns	ns	ns	ns
	Genotype (G)	*	*	*	ns	*
	Year (Y) × Location (L)	ns	ns	ns	ns	ns
	Location (L) × Genotype (G)	ns	ns	ns	ns	ns
	Genotype (G) × Year (Y)	ns	ns	ns	*	ns
	(Y) × (L) × (G)	ns	*	ns	ns	*
	LSD (0.05) (G)	759	3.99	4.27	12.72	15.7
	CV, %	16.8	6.84	3.38	16.63	17.4

RAMPUR S03F08 and RAMPUR S13F28 was the best performer of IYT trials across the locations. These genotypes could be upgraded to the CVT trials in the next year. The paramount genotypes of CVT were 05SADVI and KSYN10 across the locations. These genotypes could be advanced to the CFFT trials in the next year. CFFT trials showed that TLBRS07F16 and BGBYPOP were the preeminent genotypes when tested in different locations. BGBYPOP, Manakamana-3 and Across 9942/Across 9944 were the preeminent genotypes in 2014 (Rijal et al 2014). Similarly, Pop45C10 and Across 9942/Across 9944 were found top genotypes in 2010 (Upadhyay et al 2010). In the same way, Across 9942/Across 9944 was found best in 2007 (Sharma et al 2007). Across 9942/Across 9944 was already released as Manakamana-7 for the mid hills of Nepal in 2018 (MOALD/AITC 2018).

CONCLUSION

TLBRS07F16 and BGBYPOP were best genotypes in the CFFT of 2015 and 2016. These genotypes were also best in CVT and IYT of previous years. These genotypes will be further tested in Participatory Varietal Selection (PVS), Farmers Acceptance Test (FAT) and Informal Research and Development (IRD) in the coming years. If they showed better performance in PVS, FAT and IRD, they could be proposed for release process for Mid-hills of Nepal.

ACKNOWLEDGEMENTS

The authors are indebted to the chiefs of related divisions, programs and stations of NARC for collaboration in conducting the trials. Our sincere thanks go to all other helping hands who directly or indirectly contributed in carrying out these experiments.

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RESPONSE OF PROMISING RICE GENOTYPES TO DIFFERENT NITROGEN LEVELS IN CENTRAL TERAI REGION OF NEPAL

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ABSTRACT

Field experiments were conducted at National Rice Research Program, Hardinath with the objective of studying the response of promising rice genotypes on different levels of nitrogen in 2018 and 2019. Split plot design with five rice varieties; WAS 122-IDSA-1-WAS-B, IR 10L 185, CT 19021-3-5-2V1-1, BP 9474C-1-1-B and NR 2157-122 as main plot and five nitrogen levels; 0, 60, 80, 100 and 120 N kg ha^{-1} as sub plot with three replications was applied in the study. Nitrogen levels had significant effect on grain yield and straw yield of rice in both years. NR 2157-122 and BP 9474C-1-1-B performed better in terms of grain yield as compared to other genotypes in both the years. Combined analysis of two mean year data showed that application of 100 N kg ha^{-1} produced the highest grain yield of 3.74 tha^{-1}. The interaction effect of rice genotypes and nitrogen levels was not found significant in both the years. Promising rice genotypes can be grown successfully with the application of 100 N kg ha^{-1} and NR 2157-122 was confirmed the most promising genotype among the tested genotypes.

Keywords: Genotypes, Nitrogen, Rice

INTRODUCTION

Rice is the first staple food crop in Nepal followed by maize and wheat which contributes significantly to Nepalese agriculture. Rice is grown from high hills (Jumla), mid hills and terai regions of Nepal and is cultivated in around 1.48 million hectares of land with average productivity of 3.8 tha^{-1} producing 5.50 million tons of rice (Krishi Diary, 2078). Rice occupies vital share in Gross Domestic Products (7%) and in Agricultural Domestic Products (20%) (Dhungel and Acharya, 2017). Moreover, rice contributes nearly 53% of total cereal production and provides 33% of the total calorie requirement of the Nepalese people (Tripathi et al, 2019).

Rice is grown in various ecosystems throughout the world and nearly 78% of the world's rice is grown under irrigated or rainfed lowland conditions (IRRI, 1997). However, the scenario is different in case of Nepal and only 56% of total rice area is

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grown under irrigated condition. Nearly, 44% of the total rice area is under rainfed condition, out of which 39% rice area is under rainfed lowland and 5% is under rainfed upland (Tripathi et al, 2019). The production status of rice in large area under irrigated condition resembles that of rainfed environment as supply of water is not that much reliable. Such condition is reflected by low yield in irrigated rice (3.5 t ha^{-1}) while scenario is worst in case of rainfed rice (2.45 t ha^{-1}) upland (Tripathi et al, 2019).

Though nitrogen is one of the most expensive inputs, nitrogen is usually a key factor for rice growth and metabolic processes which ultimately helps in attaining optimum rice yield (Fageria et al, 1997). If nitrogen is applied at adequate rate and appropriate time, it provides maximum economic return to farmer and helps to reduce environmental pollution. However, excessive nitrogen application results in accumulation of large amount of post harvest residual soil nitrogen which would be subsequently available to next season crop (Fagaria and Baligar, 2003). The major constraints to increase rice yield in south Asia is low fertility status of rice growing soils and a limited or excessive supply of inorganic fertilizers. Application of appropriate level of nitrogenous fertilizer is a major discussion with regards to profitable rice crop production. So, there should be evaluation of rice for optimum rate of different application levels to obtain better growth and maximum yield of each promising rice genotypes before making recommendations of the nitrogen fertilizer doses in rice. The objective of this study was to find out promising rice genotypes to different nitrogen levels in order to identify the actual requirement of nitrogen for each rice genotype in central terai region of Nepal.

MATERIALS AND METHODS

Field experiments were conducted during rainy seasons of 2018 and 2019 at National Rice Research Program (NRRP), Hardinath, Dhanusha. The experimental site was located in 26° 48’ E latitude and 85° 59’ N longitude with an elevation of 75 meter above sea level and has a sub-tropical climate. The average temperature during rice growing season, 2018, at NRRP was 27.9 °C and total rainfall during this period was 893 mm. Similarly, during 2019, total rainfall during rice growing season was 1319 mm and average temperature was 28.4 °C. In general, the site receives ample of rainfall during the monsoon, which starts from June and continues up to September. Experiment was laid out in split plot design with three replications. Two factors namely genotypes and nitrogen levels were included in main plot and sub plot respectively. The plot size of experiment was 5 X 3 m^2.

Main plot (Genotypes)	Sub plot (Nitrogen levels kg ha^{-1})
WAS 122-IDSA-1-WAS-B	0
IR 10L 185	60
CT 19021-3-5-2V1-1	80
BP 9474C-1-1-B	100
NR 2157-122	120

Half dose of nitrogen, full dose of phosphorus (30 kg P_2O_5 ha^{-1}) and murate of potash (30 kg K_2O ha^{-1}) were applied as basal dose in rice. Remaining half dose of nitrogen fertilizer was applied as top dress in two-split doses i.e., 1/4th at active tillering stage and 1/4th at panicle initiation stage. Fertilizers were applied through Urea, DAP and Muriate of Potash. Thirty days old seedlings were transplanted both the year in well puddled soil with the spacing of 20 cm x 20 cm and seed rate of 40 kg ha^{-1} for all genotypes in continuous stagnant water. agronomic practices were followed as per recommendations. Statistical analysis was done to evaluate different parameters using R studio program.

RESULTS AND DISCUSSION

Days to heading

The result of 2018 showed that days to heading was not significantly affected by the genotypes while that of 2019 were affected by the genotypes significantly (Table 1). NR 2157-122 was early in heading (94 days) compared to other varieties, meanwhile, BP 9474C-1-1-B recorded the maximum number of days to complete heading (104 days) during 2019. The significant differences in number of days to heading among genotypes may be attributed to nature of varieties, which is mainly affected by genetic and partially by the environmental factors such as fertilizers, soil condition and weather (Seedak et al, 2009). During 2019, average temperature was higher than 2018 which may be one of the factors for genotype to be early in days to heading as compared to 2018. Moreover, days to heading were also found to be non-significant due to genotypes and nitrogen levels for combined analysis of two-year experiment. Similarly, there was not any statistical significance to rice genotypes for days to heading due to various level of nitrogen both the years. Likewise, the interaction between nitrogen levels and genotypes were found to be non-significant for both seasons.

Days to maturity

Rice genotypes differed significantly in their days to complete maturity during 2019 while days to complete maturity for various genotypes were statistically non-significant during 2018 and for combined analysis of two-year experiment (Table 1). During 2019, NR 2157-122 was early maturing (121 days) while BP 9474C-1-1-B took maximum days to mature (131 days). Differences in days to maturity may be attributed either to varietal characteristics or by various environmental factors such as weather, soil status and nutrient sources. Early maturity in genotype, NR 2157-122, may be due to high average temperature during 2019 (28.4°C) as compared to that of 2018 (27.9°C). Days to maturity for promising rice genotypes were found to be non-significant with respect to nitrogen levels in both years. Similar findings were obtained by Paneru et al (2020). Nitrogen level and genotypes interaction was non-significant for both season while combined mean analysis of two-year experiment showed nitrogen level and genotypes interaction to be significant.

Table 1. Days to heading, Days to maturity and Plant height of promising rice genotypes as affected by levels of nitrogen during rainy seasons of 2018 and 2019.

Treatments	Days to heading			Days to maturity			Plant height (cm)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Genotypes									
WAS 122-IDSA-1-WAS-B	99	100	99	125	126	125	102	110	105
IR 10L 185	96	100	97	123	127	124	96	106	101
CT 19021-3-5-2V1-1	98	96	99	124	126	126	95	102	99
BP 9474C-1-1-B	100	104	101	125	131	127	93	93	94
NR 2157-122	99	94	98	125	121	125	96	107	101
CV(%)	8.13	2.03	6.25	4.05	1.82	4.29	14.27	4.82	7.82
P value	0.68	<0.01	0.44	0.8	<0.01	0.66	0.49	<0.01	0.04
LSD(0.05)		1.7			1.94			4.2	6.6
Nitrogen levels (kg ha^{-1})									
0	99	98	99	124	126	126	96	99	98
60	98	99	97	123	127	126	97	103	101
80	99	98	100	124	126	125	96	104	101
100	99	99	101	124	126	126	95	104	100
120	99	99	98	124	127	126	98	106	102
CV %	1.31	1.15	0.94	0.89	0.68	0.6	3.14	2.42	1.83
p-value	0.86	0.12	0.67	0.99	0.22	0.76	0.11	<0.01	<0.01
LSD $_{0.05}$								1.85	1.4
Genotype X Nitrogen level									
p-value	0.27	0.13	0.24	0.16	0.07	0.02	0.28	0.23	0.14
LSD $_{0.05}$						1.24			

Plant height

Plant height was found to be insignificant with respect to genotypes and nitrogen levels during rainy season of 2018 while it was found to be significantly affected by genotypes and nitrogen levels both during 2019 and combined analysis of two-year experiment (Table 1). BP 9474C-1-1-B (94 cm) recorded the shortest height and was statistically similar with other genotypes while, WAS 122-IDSA-1-WAS-B (105 cm) gave the tallest plant in both the seasons. This variation may be due to genetic makeup of studied lines. Application of various levels of nitrogen significantly increased the plant height for rice varieties. By applying nitrogen at the rate of 120 N kg ha^{-1} resulted in tallest plant (98 and 106 cm) in both seasons. Such increment in plant height with increasing nitrogen levels may be attributed to improved plant growth, internode elongation, photosynthesis due to important role of nitrogen. The interaction between genotypes and nitrogen levels for plant height was non- significant in both seasons. The results are similar with those of Metwally et al (2011) and Paneru et al (2020).

Tillers

The result revealed that number of tillers per meter square was not affected due to genotypes and nitrogen levels (Table 2). Among the promising genotypes, highest number of tillers per meter square was found on CT 19021-3-5-2V1-1 (288) and IR 10 L 185 (390) during 2018 and 2019, respectively. Moreover, combined analysis of two-year experiment showed that CT 19021-3-5-2V1-1 (294) produced highest number of tillers. Likewise, highest number of tillers was obtained at nitrogen level of 120 kg N ha^{-1} (296) followed by 60 kg N ha^{-1} (287) while lowest number was observed at control in combined analysis of two-year experiment. The interaction effect between genotypes and nitrogen levels for number of tillers per square meter was non-significant for both seasons. Similar findings were observed by Khatri et al (2015).

Grain yield

Grain yield was not significantly influenced by genotypes and highest yield was obtained from genotype NR 2157-122 (3.35 t ha^{-1}) and lowest was obtained with genotype WAS 122-IDSA-1-WAS-B (2.9 t ha^{-1}) during 2018 (Table 2). Similarly, during rice growing season of 2019, there was statistically significance in grain yield. Highest grain yield was obtained with genotype NR 2157-122 (4.04 t ha^{-1}) followed by 3.91 t ha^{-1} from genotype CT 19021-3-5-2V1-1 (Table 2). The statistical significance in grain yield during second year may be attributed to higher rainfall of around 956.2 mm from June to August (vegetative phase) in comparison with 767.5 mm of rainfall during same period of 2018. Similarly, higher grain yield in most of the genotypes were observed which may be attributed to lower maximum temperature of 31.5 °C during flowering time in 2019 as compared to maximum temperature of 33 °C during same period in 2018. Similar results were obtained by Abbas and Mayo, 2020 indicating that there is negative impact of maximum temperature at flowering stage during reproductive phase. Combined analysis of two-year result indicated that statistically there in no significance in grain yield with respect to genotypes and highest grain yield was obtained with genotype NR 2157-122 (3.37 t ha^{-1}) and BP 9474C-1-1-B (3.37 t ha^{-1}) (Table 2). Moreover, NR 2157-122 was taken into consideration for variety as BP 9474C-1-1-B showed the problem of neck blast in the experimental field. Though it was high yielding, it was not promoted for variety release.

Table 2. Effect of different levels of nitrogen on Tillers/m^2, Grain yield and Straw yield of promising rice genotypes during rainy seasons of 2018 and 2019

Treatments	Tillers/m^2			Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Genotypes									
WAS 122-IDSA-1-WAS-B	266	338	290	2.9	3.4	2.94	5.96	4.26	5.49
IR 10L 185	240	390	272	3.17	3.08	3.17	5.51	3.86	5.03
CT 19021-3-5-2V1-1	288	370	294	3	3.91	3.16	5.77	3.73	5.18
BP 9474C-1-1-B	286	353	285	3.21	3.6	3.37	5.59	3.58	5.16
NR 2157-122	284	295	284	3.35	4.04	3.37	6.25	3.39	5.56
CV %	20.31	23.21	24.66	21.18	22.7	19.11	38.09	17.74	24.15
P value	0.19	0.09	0.93	0.43	<0.01	0.36	0.89	0.05	0.75
LSD (0.05)					0.5				
Nitrogen levels (kg ha^{-1})									
0	271	319	277	2.86	3.24	2.84	5.52	3.06	4.69
60	279	340	287	3.05	3.5	3.1	5.49	3.67	5.07
80	270	352	282	3.24	3.64	3.08	5.87	3.95	5.42
100	274	366	284	3.85	3.89	3.74	6.63	3.2	5.96
120	271	369	296	3.02	3.76	3.25	5.56	3.94	5.28
CV %	14.28	15.59	13.41	13.54	15.3	10.71	10.22	17.34	8
P value	0.97	0.09	0.81	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$LSD_{0.05}$				0.31	0.3	0.25	0.44	0.5	1.19
Genotype X Nitrogen level									
p-value	0.11	0.75	0.05	0.38	0.44	0.402	0.07	0.63	<0.01
$LSD_{0.05}$									0.7

Increased nitrogen levels from 0 to 100 N kg ha^{-1} significantly increased grain yield for all promising rice genotypes and after 100 N kg ha^{-1} there was decline in grain yield during both seasons (Table 2). Similar results were obtained from Adhikari et. al (2018) and Gyawali et.al (2020). Highest grain yield was obtained with 100 N kg ha^{-1} while minimum grain yield was obtained with treatment without Nitrogen application (Figure 1). The increase in grain yield might be due to application of nitrogen which helped in enhancing dry matter production, improving rice growth rate by increasing activity of growth hormones like gibberellins and promoting elongation of internodes. Likewise, nitrogen application also helped in increasing yield components such as tillers per square meter, 1000 grain weight, number of grains per panicle and panicle length which ultimately improved grain yield. Moreover, increased grain yield might be attributed to nitrogen application as it contributes to grain filling during ripening stage and carbohydrate accumulation in culms and leaf sheaths during pre-heading stage of rice (Bahmanyar and Ranjbar, 2007).

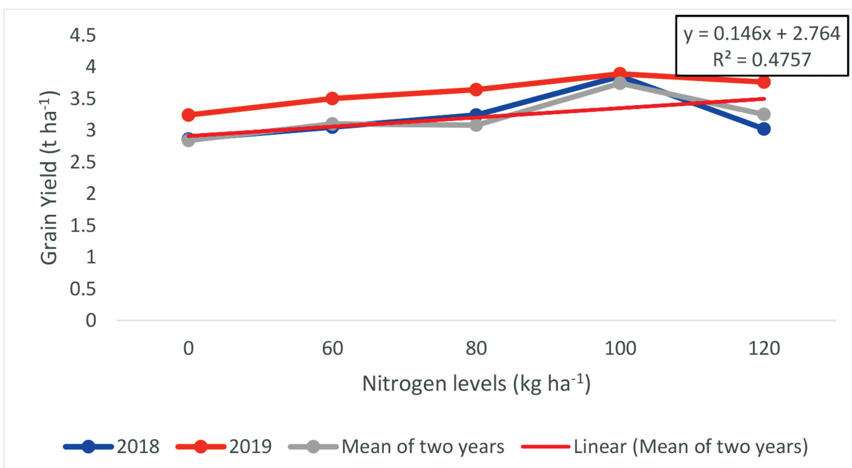

Figure1. Grain yield of promising rice genotypes as affected by different nitrogen levels

Statistically, grain yield was found to be not affected for mean interaction between promising genotypes and nitrogen levels. This result is supported by Bhattarai and Gautam (2003) and Gyawali et.al (2020). Highest grain yield was obtained with genotype BP 9474C-1-1-B (3.95 t ha^{-1}) followed by CT 19021-3-5-2V1-1 (3.947 t ha^{-1}),

NR 2157-122 (3.74 t ha^{-1}), IR 10L 185 (3.58 t ha^{-1}) and the lowest yield was obtained with genotype WAS 122-IDSA-1-WAS-B (3.50 t ha^{-1}) respectively with application of 100 N kg ha^{-1}. Moreover, decrease in grain yield was observed with increase in nutrient level from 100 N kg ha^{-1} to 120 N kg ha^{-1} for all promising genotypes (Figure 2).

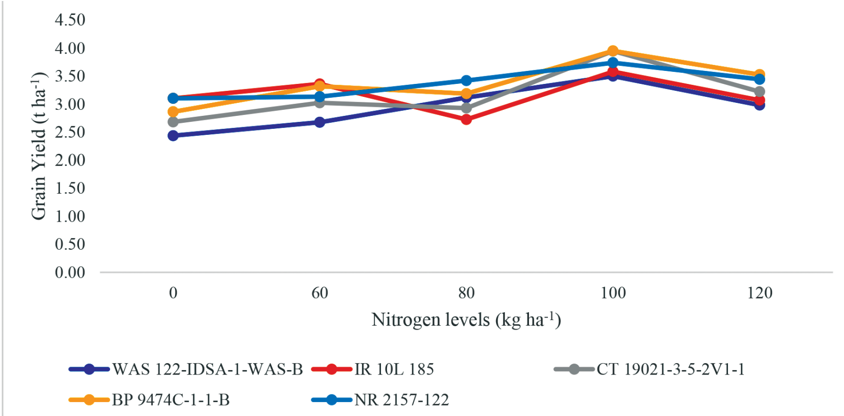

Figure 2. Interaction effect of promising rice genotypes and nitrogen levels on grain yield (two years mean)

Straw yield

Non-significant effect of genotypes was found on straw yield for both season rice and combined analysis. However, straw yield was significantly affected by nitrogen level during 2018 and 2019. The combined mean analysis of two-year result also revealed that there was significant relationship between straw yield and nitrogen levels. During 2018, increasing nitrogen levels from 0 N kg ha^{-1} to 120 N kg ha^{-1}, highest straw yield was obtained with 100 N kg ha^{-1} and yield was found to be decreasing with increase in level upto 120 N kg ha^{-1}. However, straw yield was found to be highest at 120 N kg ha^{-1} during 2019. In case of combined mean analysis of two-year experiment, highest straw yield of 5.96 t ha^{-1} was found with application of 100 N kg ha^{-1} while minimum straw yield of 4.69 kg ha^{-1} was found with control (Figure 3). Similar results were observed by Paneru et al (2020) and Gyawali et al (2020).

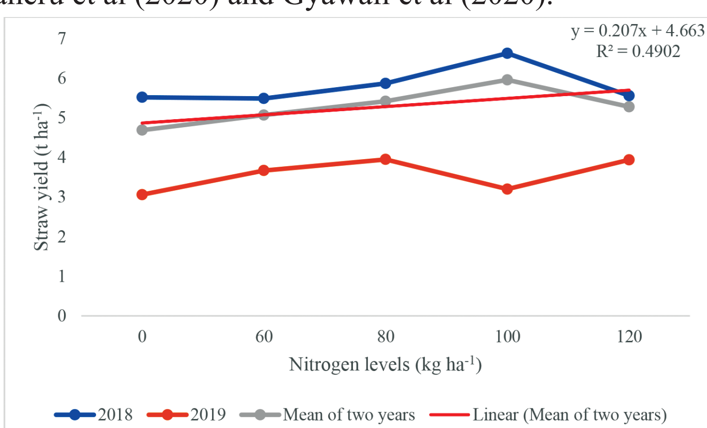

Figure 3. Straw yield of promising rice genotypes as affected by different Nitrogen levels

The mean interaction between genotypes and nitrogen levels with respect to straw yield was found to be significant. Similar result was obtained by Rajesh et al (2015). At 100 N kg ha^{-1}, four genotypes namely, IR 10L 185 (5.51 t ha^{-1}), BP 9474C-1-1-B (5.55 t ha^{-1}), WAS 122-IDSA-1-WAS-B (6.21 t ha^{-1}), and NR 2157-122 (6.77 t ha^{-1}) obtained highest yield. However, genotype CT 19021-3-5-2V1-1 obtained the highest yield of 5.76 t ha^{-1} with application of 80 N kg ha^{-1} (Figure 4). Most of the genotypes showed decreased in straw yield with increase in nitrogen level from 100 N kg ha^{-1} to 120 N kg ha^{-1} and lowest yield were obtained at unfertilized plot (Figure 4).

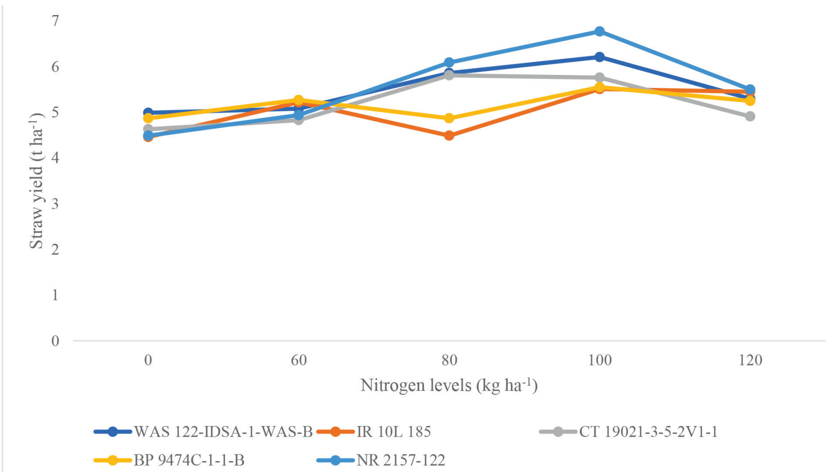

Figure 4. Interaction effect of promising rice genotypes and nitrogen levels on straw yield (two years mean)

Agronomic nitrogen use efficiency

Agronomic nitrogen use efficiency was affected with the application of nitrogen and increased with increasing nitrogen levels upto 100 N kg ha^{-1}. Likewise, there was found to be reduction in agronomic efficiency with further increment in nitrogen levels from 100 N kg ha^{-1} to 120 N kg ha^{-1} (Figure 5). There was found to be variation in agronomic nitrogen use efficiency among various genotypes. Such variations may be attributed due to various factors like genetic factors, biochemical and physiological processes such as translocation, assimilation and nitrogen remobilization (Fageria and Baligar, 2003).

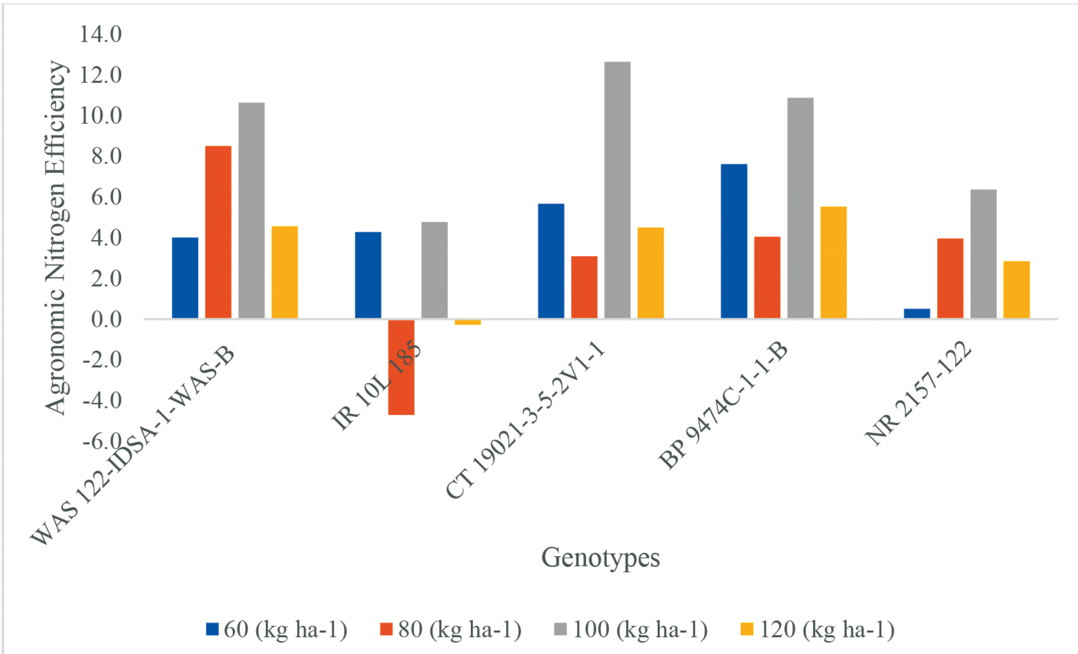

Figure 5. Effects of interaction between promising rice genotypes and nitrogen levels on nitrogen use efficiency during means of two-year growing seasons.

Economics of nitrogen levels

The economic analysis of different levels of nitrogen under central terai regions shows that application of 100 N kg ha^{-1} is the best option for the net benefit to rice growing farmers of Nepal which can earn NRs 23,793.00. Similarly, benefit by increment in Nitrogen levels is also highest in 100 N kg ha^{-1} which is Rs 18,358.00. Likewise, the for all the doses of nitrogen, highest marginal benefit of NRs 19,122.00 was also obtained at 100 N kg ha^{-1} (Table 3). Similar results were obtained from the study of Paneru et al, (2020). With the increment in Nitrogen level form 100 N kg ha^{-1} to 120 N kg ha^{-1} marginal benefit of rice farming was found to be negative which indicated that application of higher doses of Nitrogen rather than recommended incur losses to the farmers.

Table 3. Effect of different levels of nitrogen on net benefit of rice genotypes during rainy seasons of 2018 and 2019

N dose	Urea (kg/ha)	Price @25	Grain Yield (t/ha)	Straw Yield (t/ha)	Gross Income (NRs)	Cost Incurred (NRs)	Net Benefit (NRs)	Benefit by increment in nitrogen levels (NRs)	Marginal Benefits (NRs)
0	0	0	2.84	4.69	82637.5	85000	-2362.5	-2362.5	0
60	130.4	3260	3.1	5.07	90195.5	85000	5195.5	1935.5	7558
80	173.9	4347.5	3.08	5.42	89671	85000	4671	323.5	-524.5
100	217.4	5435	3.74	5.96	108793	85000	23793	18358	19122
120	260.9	6522.5	3.25	5.28	94554.5	85000	9554.5	3032	-14238.5

CONCLUSION

Use of appropriate levels of nitrogen fertilizers is one of the important factors to increase agronomic nitrogen use efficiency by promising rice genotypes and showed a positive effect on grain yield as compared to control. The application of nitrogen @ 100 kg ha^{-1} produced higher grain yield in BP 9474C-1-1-B (3.95 t ha^{-1}) followed by CT 19021-3-5-2V1-1 (3.947 t ha^{-1}), NR 2157-122 (3.74 t ha^{-1}), IR 10L 185 (3.58 t ha^{-1}) and WAS 122-IDSA-1-WAS-B (3.50 t ha^{-1}) in central terai region of Nepal. Economic analysis of nitrogen levels also indicated that application of Nitrogen at 100 kg ha^{-1} gave highest net income and marginal benefits as compared to other levels and NRs. 2157-122 would most promising rice genotypes for variety release based on responsiveness to fertilizer and yield potential.

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YIELD AND YIELD ATTRIBUTES OF RICE-WHEAT CROPPING SYSTEM UNDER DIFFERENT SOIL FERTILIZATION PRACTICES IN EASTERN TERAI OF NEPAL

Shukra Raj Shrestha[1] and Damali Sherpa[1]

ABSTRACT

Field trials including two crops; rice (July to November) and wheat (November to April) were conducted for three years 2017 to 2020 on a clay loam soil at Directorate of Agricultural Research, Tarahara, Sunsari. Different soil fertility management practices like application of chemical fertilizers, organic manures in the form of Farmyard manure and buffalo urine and green manures through in-situ cultivation were tested in rice-wheat cropping system during the trial. The trial was laid out in a randomized complete block design (RCBD) with seven treatments. Every treatment was replicated three times for a total of twenty one plots of 6 m x 5 m = 30 m^2. All the yield components and yields of rice and wheat varied significantly ($p \leq 0.05$) with different treatments but the effect of interaction between treatments and duration (years) on all parameters was not significant. The highest grain yield of rice (5034.09 kg/ha) wheat (4646.30 kg/ha) was obtained from recommended dose of chemical fertilizers containing NPK followed by treatment where half of recommended dose of chemical fertilizers and FYM was applied. Over the trial period the rice grain yield in dhaincha incorporated plot with two top dressing of nitrogen (4551.32 kg/ha) was significantly higher than single top dressing of N (4389.08 kg/ha). The grain and straw yield and all the yield attributing parameters of both crops were lowest in urine treated plot.

Keywords: Organic and inorganic fertilizers, Rice-wheat cropping system and Yield attributes

INTRODUCTION

Rice-wheat, and rice-based cropping system are the most practiced farming system of eastern Terai region of Nepal (Shrestha et al., 2020). Rice-wheat cropping system in this region accounts about 60% of total agricultural area and contributes approximately one-third of GDP with more than 50% of the working population engagement (Lamsal and Khadka, 2019). This part of country has experienced widespread stagnation and occasional decline in rice-wheat productivity as the growth rate of paddy production has been limited to 1.4% per year for past two decades (Adhikari et al., 2017). In addition, rice yield in Nepal was highest among south Asian countries in 1960s, but it is lowest in recent years (Tripathi et al., 2019). Continuous decline of soil fertility is amongst the one behind the fact. The long term soil fertility study during 2007-2016 at Directorate of Agricultural Research, Tarahara, Sunsari revealed the decline of soil organic matter and potassium by 17.8 and 5.3% respectively where balanced

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forms of nutrients; NPK were applied (Shrestha et al., 2019). Furthermore, long-term study done by Regmi et al., (2002) at National Wheat Research Program, Bhairahawa, Nepal showed net loss of 62.3 and 15.2 kg/ha/year of potassium in NPK and FYM treatments respectively at the end of 20 years. Increasing the productivity of land through intensive cropping system depletes nutrient reserves of the soil at faster rate while unbalanced fertilizer application disturbs nutrient availability to crops, leading to a reduction in yield (Bhandari et al., 1992). To meet the ever increasing food demand, farmers are compelled to go for intensive cereal crop cultivation. Therefore, soil fertility and organic matter reduction have emerged as major threats to crop production resulting productivity loss of cultivable land (Yadav et al., 2000).

Improving productivity of rice-wheat cropping system, sustain their yields and meeting the future food needs requires adequate soil fertility management schemes (Mahajan and Gupta, 2009). Nepalese agriculture with its limited land and other resources has to feed growing population and simultaneously responsible for maintaining soil quality. On the other hand, traditional farming system which occupy majority of agricultural land is heavily based in organic source of input and subsistence. Such farming system has to be upgraded through multiple agricultural management tools. Among them maintenance of proper soil health and lessening nutrient mining have to be prioritized at the top. Fertility status of soil is therefore an issue of growing concern that has to be maintained/increased by integrated nutrients management approach involving the judicious use of organic and inorganic fertilizers, proper crop rotation in a feasible way. Admittedly, Nepal is not able to manufacture chemical fertilizers like urea, Diammonium phosphate (DAP) and Potash for which we rely on India. We are spending heavy amount of budget on importing these chemical fertilizers but since Nepalese farmers are deprived of timely availability of these fertilizers. Despite this harsh fact, application of synthetic fertilizers increased at the rate of 0.78 kg/ha/year from year 1994/95 to 2015/16 and average fertilizer consumption in a year 2015/16 was found to be 83.81 kg/ha across the country (Pandey et al., 2017). A study further showed that consumption of chemical fertilizers increased at the rate of 882.43 metric tons/year from 1990/91 to 2015/16 in Nepal and it was 42,828 metric tons in 2016. This situation has led to growing interests in the use of organic sources/fertilizers as a source of nutrients. Realizing these facts, green manure crops like Dhaincha and Mungbean, Farmyard manure (FYM) and cattle urine were tested and compared with chemical fertilizers in rice-wheat cropping system. Green manure is the ideal source of organic matter, which influences on the crop production quality and soil fertility (Sarwar et al., 2017) and enhances soil physical properties and water holding capacity, reduces the leaching of nutrients from the soil, and increases the crop yield (Abro and Abbasi, 2002). Dhaincha is the cheapest green manure crop and good source of organic matter to rice-wheat cropping system. It is widely grown in pre-monsoon season after wheat harvest. It is quick growing, succulent, easily decomposable and produce maximum amount of organic matter, as well as nitrogen in soils (Palaniappan and Siddeswaran, 2001). FYM improves soil physical, chemical and biological properties (Khan et al., 2010) and its regular application improves soil structure and leads to better environment for root development.

Hence, to maintain land productivity for crop production, address emerging nutrient deficiencies or imbalances and identify core problem of soil fertility issues in rice-wheat cropping system, the study entitled 'Yield and yield attributes of rice-wheat cropping system under different soil fertilization practices in eastern terai of Nepal' was conducted at Directorate of Agricultural Research, Tarahara, Sunsari.

MATERIALS AND METHODS

Site and duration of field trials

On station field trials were conducted during 2017 to 2020 at Directorate of Agricultural Research, Tarahara, Sunsari of Province 1. The experimental site is situated in Eastern terai of Nepal at $26^0 42'$ North latitude and $87^0 16'$ East longitude located at an elevation of 127 meters above mean sea level. It is a tropical zone with warm climatic condition having majority of the area under irrigated condition.

Research design and treatments

The field trials were conducted in randomized complete block design (RCBD), comprising seven treatments (Table 1) replicated thrice with each plot assigned 30 m^2 (6 m x 5 m).

Table 1. Details of treatments for field trials at Directorate of Agricultural Research, Tarahara, Sunsari

Symbol	Rice (Radha 12)	Wheat (Vijay)
T1	Dhaincha – GM + TD of N (twice @ 40 kg/ha)	60: 20: 20 kg/ha N: P_2O_5: K_2O
T2	Dhaincha – GM + TD of N (once @ 40 kg/ha)	80: 40: 40 kg/ha N: P_2O_5: K_2O
T3	Mungbean – GM	120: 40: 40 kg/ha N: P_2O_5: K_2O
T4	120: 40: 40 kg/ha N: P_2O_5: K_2O	120: 40: 40 kg/ha N: P_2O_5: K_2O
T5	5 t/ha FYM + 60: 20: 20 kg/ha N: P_2O_5: K_2O	5 t/ha FYM + 60: 20: 20 kg/ha N: P_2O_5: K_2O
T6	10 t/ha FYM	10 t/ha FYM
T7	Foliar spray (Urine + water @ 1:3)	Foliar spray (Urine + water @ 1:3)

Note: GM-Green manuring; TD-Top dressing; N-Nitrogen; FYM-Farmyard manure; t-tonnes; ha-hectares

Field trials and cultural practices

In treatments 1 and 2, after wheat harvest land was tilled once and seeds of Dhaincha (Sesbania rostrata L.) was broadcasted at the rate of 35 kg/ha and incorporated into soil with puddling at 50 days after sowing (DAS) a week before rice seedlings transplantation. In treatment 1, nitrogen was top dressed twice, first at maximum tillering stage, 25 days after transplanting (DAT) @ 40 kg/ha and second at panicle initiation stage at 45 DAT @ 40 kg/ha. Similarly, in treatment 2, nitrogen was top dressed once to rice at maximum tillering stage @ 40 kg/ha. In treatment 3, after wheat harvest, land was tilled once and seeds of Mungbean (*Vigna radiata* L.) was broadcasted at the rate of 25 kg/ha and incorporated into soil with puddling at the time of rice seedlings transplantation as green manure. The assigned amount of FYM was applied in dry weight basis when the trial plots were finally prepared. In treatment 7, both crops were treated with buffalo urine @ 4L/30 m^2 by diluting it with water (urine: water = 1: 3). The mixture was sprayed for 3 times at the interval of 25 days, beginning from 25 DAT in rice and 25 DAS in wheat. As per the treatments whole dose of phosphorus, potassium, FYM and 1/3 of nitrogen were applied at final land preparation before rice seedlings transplantation. Second split of 1/3 N was applied at the time of maximum tillering and final 1/3 at the time of heading. In wheat, whole dose of phosphorus, potassium, FYM and 1/2 of nitrogen were applied at the time of final land preparation before sowing. Remaining half of N was applied at the time of Crown root initiation (CRI); 25 days after sowing (DAS). Nitrogen was provided through Urea and Diammonium phosphate (DAP). The source of phosphorus and potassium was DAP and Muriate of potash (MOP) respectively. The 25 days old seedlings of rice variety 'Radha 12' was raised adopting wet bed method by making the bed height upto15 cm. The seedlings were transplanted in puddled land maintaining spacing of 25 cm between rows and hills as well. The seed rate of rice was 45 kg/ha. The seeds of wheat variety 'Vijay' were sown continuously in rows maintaining spacing of 25 cm at the rate of 120 kg/ha. All the intercultural operations including plant protection measures were performed according to the requirement.

Soil sampling and analysis

The soil samples of upper layer (0-25 cm depth) were collected initially in May 2017 before rice transplantation. The soil samples were examined for total nitrogen, available phosphorus, available potassium, pH, soil organic matter and two micronutrients; available Zinc and Boron and soil texture (sand, silt and clay percentage). The general characteristics of experimental soil is presented in table 2.

Table 2. Soil chemical and physical properties with parameters and methods adopted for the laboratory analysis at DoAR, Tarahara, Sunsari

Parameters	Method	Results
pH	Potentiometric 1:2.5 (Jackson., 1973)	6.31
Soil Organic Matter (%)	Walkley and Black (Walkley and Black., 1934)	2.37
Total Nitrogen (%)	Kjeldahl Digestion (Bremner and Mulvaney., 1982)	0.08
Available P_2O_5 (ppm)	Olsen (Olsen et al., 1954)	10.6
Available K_2O (ppm)	Ammonium acetate extraction (Jackson., 1967)	45.6
Available Zn (ppm)	DTPA (Lindsay and Norvell., 1978)	0.4
Available B (ppm)	Hot water (Berger and Truog., 1939)	0.3
Sand (%)	Hydrometer (Bouyoucos, 1962)	33.6
Silt (%)	Hydrometer (Bouyoucos, 1962)	28.8
Clay (%)	Hydrometer (Bouyoucos, 1962)	37.6
Soil textural class		Clay loam

Statistical analysis

Data entry and processing was carried out using Microsoft Office Excel 2016. Analysis of variance (ANOVA) and mean estimation were done with the software- R of version 3.6.2. The treatment means were compared by the Least Significant Difference (LSD) test at 5% level (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Plant growth and yield attributes of rice

All the tested parameters varied significantly with different treatments in rice (Table 3). Of all the parameters, filled grains per panicle, grain and straw yield were significantly ($p \leq 0.05$) influenced in three years of trial period. The yield attributing characters like plant height, panicle length, productive tillers/m^2 and test weight in rice were significantly higher where inorganic fertilizers containing NPK were applied i.e., 120:40:40 kg/ha NPK (Treatment 4). The highest plant height of rice (154.27 cm) was obtained from the application of inorganic fertilizers containing NPK, followed by dhaincha incorporated plot with two top dressing of nitrogen (150.41 cm). Similarly, the highest value of panicle length (28.29 cm), productive tillers/m^2 (261.44), filled grains per panicle (169.93), 1000 grains weight (27.29 g), grain yield (5034.09 kg/ha) and straw yield (4556.20 kg/ha) over the trial period were resulted from treatment 4 where inorganic fertilizers containing NPK were applied to both crops (Table 3). The highest result from treatment 4, for all the parameters except plant height was followed by the combined application of 60: 20: 20 kg/ha NPK and 5 t/ha FYM applied plots, which resulted panicle length (26.92 cm), productive tillers (243.58), filled grains per panicle (157.77), test weight (26.68 g), grain yield (4556.22 kg/ha) and straw yield (4234.68 kg/ha). The inorganic fertilizers containing NPK applied plots recorded 9.6% more grain yield than the dhaincha incorporated plot with two top dressing of nitrogen (Treatment 1) and 12.8% more with single top dressing of nitrogen (Treatment 2). Dhaincha incorporated plot with two top dressing of nitrogen has 3.5% more grain yield than once top dressing of nitrogen. The mean grain yield obtained from mungbean incorporated plot (treatment 3) was 3723.20 kg/ha and the increment over the trial period was 10.75%. The grain and straw yield of rice and all the yield attributing parameters were lowest in urine treated plot (Table 3) indicating insufficiency of nutrients from sole source of foliar spray. The data revealed the slight increment of rice grain yield by 3.3% over the trial period in FYM treated plot (Treatment 6) indicating slow process mineralization and gradual supply of nutrients especially micronutrients to crops. But the yield was significantly lower as compared to treatments 1, 2 and 4, mainly because of inadequate amount of major nutrients like NPK in FYM. The direct use of inorganic fertilizers with recommended level of NPK in treatment 4 might have offered balanced and sufficient nutrition, which positively affected panicle length, productive tillers and filled grains per panicle and subsequently increased grain and straw yields. Dhaincha incorporated plots in treatments 1 and 2 have more than 4380 kg/ha grain yield which is significantly higher as compared to FYM and urine treated plots. Incorporation of dhaincha might have enhanced the availability of nutrients released after decomposition of plant biomass. It may be occurred due to the sufficient nitrogen efficiency and organic matter in dhaincha incorporation plots. The slow released nitrogen remains available throughout the growth period of rice. These results are supported by Sarwar et al., (2017). Furthermore, Ehsan et al., (2014) also reported that green manuring of dhaincha gave the highest yield of T. Aman over the control (no fertilizer used) in rice-based cropping system as the rice grain yield increased from 32 to 77% over control due to (dhaincha) green manure incorporation with different doses of NPK fertilizers application. The plots where mungbean was incorporated in the form of green manures resulted 3723.2 kg/ha mean grain yield which was 5.4% more than that obtained from urine treated plot. This result signified that the nutrients released after decomposition of mungbean biomass were not sufficient for potential yield.

Table 3. Yield and yield attributing characters of rice (2017 to 2020) at DoAR, Tarahara, Sunsari

Particulars	Plant height (cm)	Panicle length (cm)	Productive tillers/m^2	Filled grains /panicle	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Years (Y)							
2017	143.41	25.09	219.43	149.44	25.42	4129.64	3782.61
2018	145.28	24.97	221.86	150.41	25.60	4197.72	3846.76
2019	145.10	25.41	227.90	152.08	25.65	4366.01	3898.45
p-value	0.24	0.13	0.12	0.01	0.10	0.02	0.03
LSD (0.05)	-	-	-	1.75	-	168.79	86.22
SEm (±)	0.98	0.22	3.89	0.87	0.24	83.52	42.66
Treatments (T)							
T1	150.41	25.93	224.56	154.37	26.17	4551.32	4076.93
T2	147.04	24.83	216.44	148.13	25.50	4389.08	3902.42
T3	140.23	24.24	208.06	137.44	24.70	3723.20	3458.82
T4	154.27	28.29	261.44	169.93	27.29	5034.09	4556.20
T5	146.71	26.92	243.58	157.77	26.68	4556.22	4234.68
T6	137.99	24.04	221.14	151.78	25.18	3904.43	3474.33
T7	135.18	21.82	189.85	135.07	24.07	3521.20	3194.84
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (0.05)	3.04	0.68	12.01	2.68	0.75	257.83	131.70
SEm (±)	1.50	0.34	5.95	1.33	0.37	127.57	65.16
Interaction (YxT)							
p-value	0.99	0.48	1.00	0.99	0.11	0.76	1.01
LSD (0.05)	-	-	-	-	-	-	-
SEm (±)	2.60	0.59	10.30	2.30	0.64	220.96	112.87
CV (%)	2.21	2.83	5.64	2.03	3.05	6.41	4.68

Plant growth and yield attributes of wheat

Over the trial period in three years all the yield attributing characters and yields of wheat varied significantly ($p \leq 0.05$) with different treatments (Table 4) but the effect of interaction between treatments and duration (years) on all parameters was not significant ($p \leq 0.05$). The highest plant height (101.94 cm) was obtained from the plot where inorganic fertilizers containing NPK were applied i.e., 120:40:40 kg/ha NPK (Treatment 4) in both crops. Similarly, the highest value of spike length (19.14 cm), productive tillers/m^2 (248.89), filled grains per spike (53.18), 1000 grains weight (37.42 g), grain yield (4646.30 kg/ha) and straw yield (4203.32 kg/ha) were obtained from treatment 4. The highest result from treatment 4, for all the parameters was followed by treatment 3 where rice was grown with mungbean incorporation as green manure and wheat with 120: 40: 40 kg/ha NPK, which resulted plant height (100.16 cm), spike length (18.22 cm), productive tillers/m^2 (237.26), filled grains per spike (50.42), 1000 grain weight (36.68 g), grain yield (4526.31 kg/ha) and straw yield (4069.97 kg/ha). The highest yield of wheat grain and straw obtained from treatment 4 was statistically at par with the yield obtained from treatment 3. Same as in case of rice, direct use of inorganic fertilizers with recommended level of NPK in treatment 4 and treatment 3 might have offered balanced and sufficient nutrition, which positively affected spike length, productive tillers and filled grains per spike and subsequently increased grain and straw yield of wheat. The grain yield obtained from treatment 4 was 18 and 13.5% less as compared to combined application of 5 t/ha FYM and 60: 20: 20 kg/ha NPK treated plot (Treatment 5) and 10 t/ha FYM applied plot (Treatment 6) respectively (Table 4). Residual effect of dhaincha incorporation during rice transplantation was not prominent in wheat grain yield as its increment in 60: 20: 20 kg/ha NPK and 80: 40: 40 kg/ha NPK was by 1.5 and 2% respectively (Table 4 and Figure 1). Information on the residual effect of dhaincha incorporation in soil after the succeeding crop harvest is scanty as suggested by Rahman et al., (2013) and Ganapathi et al., (2014). Alike rice, the grain and straw yield of wheat and all the yield attributing parameters were lowest in urine treated plot (Table 4). The positive response of 10 t/ha FYM was observed in grain and straw yield of wheat as the data analysis revealed the grain yield increment by 4.4% over the trial period.

Table 4. Yield and yield attributing characters of wheat (2017/18 to 2019/20) at DoAR, Tarahara, Sunsari

Particulars	Plant height (cm)	Spike length (cm)	Productive tillers/ m^2	Filled grains /spike	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Years (Y)							
2017/18	92.30	16.68	219.84	42.74	34.95	3582.92	3198.07
2018/19	93.28	16.73	222.67	44.46	34.92	3642.98	3247.33
2019/20	93.14	17.02	223.71	44.04	35.50	3655.25	3307.21
p-value	0.15	0.14	0.48	0.27	0.01	0.50	0.09
LSD (0.05)	-	-	-	-	0.41	-	-
SEm (±)	0.53	0.1	2.77	0.79	0.20	54.11	48.63
Treatments (T)							
T1	87.96	15.86	210.56	37.67	34.04	2997.24	2631.60
T2	92.27	16.67	224.00	42.37	34.69	3353.77	3024.67
T3	100.16	18.22	237.26	50.42	36.68	4526.31	4069.97
T4	101.94	19.14	248.89	53.18	37.42	4646.30	4203.32
T5	96.70	17.26	237.48	46.87	35.88	4019.82	3658.24
T6	95.09	16.93	222.39	44.17	34.54	3810.27	3351.60
T7	76.24	13.63	175.33	29.23	32.58	1988.98	1816.68
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (0.05)	1.62	0.56	8.57	2.45	0.62	167.05	150.14
SEm (±)	0.81	0.28	4.23	1.21	0.31	82.65	74.29
Interaction (YxT)							
p-value	0.07	0.99	1.06	0.94	0.97	1.00	0.98
LSD (0.05)	-	-	-	-	-	-	-
SEm (±)	1.40	0.48	7.34	2.10	0.53	143.16	128.67
CV (%)	1.85	3.57	4.04	6.08	2.13	4.84	5.04

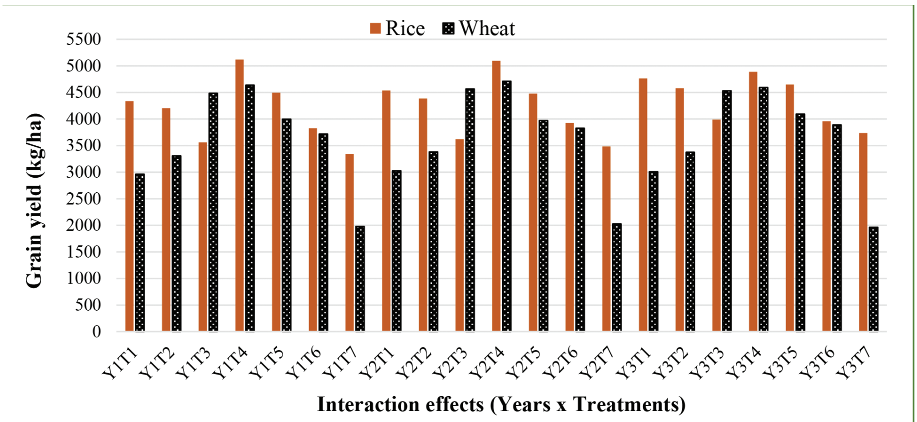

Figure 1: Change in grain yield of rice and wheat over the trial period (2017-2020) at DoAR, Tarahara, Sunsari.
Note: Y1- 2017/18; Y2- 2018/19 and Y3- 2019/20; T- Treatments

Changes in soil properties

The major changes in chemical properties of soil that occurred over the trial period were included in this section. The data showed that the total N status ranged from 0.06 to 0.11% at the end of trial with net increment in green manures applied plots (Treatments 1, 2 and 3) and FYM applied plot (Treatment 6). The increase in total N content of soil due to application of organic manure may be attributed to the mineralization of N and greater multiplication of soil microbes, which could convert organically bond N to inorganic form (Rahman et al., 2013). The available phosphorus and potassium in soil varied significantly under different treatments. FYM, combined application of 5 t/ha FYM and 60: 20: 20 kg/ha NPK fertilizers and urine treated plots resulted a negative balance of available phosphorus and potassium. The uptake of these nutrients might be more than the amount supplied by the organic sources of fertilization in treatments 5, 6 and 7 as the tested varieties of crops are very responsive to applied phosphorus and potassium. All the tested treatments except urine treated plot showed improved SOM content in soil. The data exhibited positive SOM content in the plots where dhaincha and mungbean was incorporated for rice transplanting with inorganic NPK fertilizers in wheat. The SOM content at initial and final test in soil positively changed by 3.27, 2.87 and 2.07% respectively. Roots, leaf and stubble of dhaincha and green manure after decomposition improved the organic matter status of soil. This could probably be due to the breakdown of residue by soil microorganisms, as they were incorporated into the soil during rice transplanting. This result agrees with the findings of studies conducted by Lehtinen et al., 2014. SOM significantly increased with the lapse of year in the C input treatments (FYM and FYM+NPK). The sole application of FYM in treatment 6 provided the highest positive change (4.4%) of SOM content.

This effect is mainly due to the direct application of decomposed form of FYM which acted as rich source of organic carbon. Overall, the soil pH ranges from 6.11 to 6.68 at the end of trial. The increased acidity of soil (lowering trend of soil pH) was identified in the plots (Treatments 1, 2 and 3) where dhaincha and mungbean was incorporated for rice transplanting with inorganic NPK fertilizers in wheat. This acidity of soil could probably be due to the dissociation of organic acids released from dhaincha and mungbean residue, as outlined by Nierves and Salas., 2015. Generally, soil health and productivity are always predicted to be more sustainable with the integrated application of inorganic fertilizers and organic sources of fertilizers rather than the use of inorganic fertilizers alone. But, in this study combined application of 5 t/ha FYM and 60: 20: 20 kg/ha NPK fertilizers showed static total nitrogen, negative PK and slightly increased soil organic matter indicating insufficient supply of major nutrients to this particular cropping system. FYM has been receiving much attention in this study as it has significantly increased soil organic matter. Dhaincha and mungbean biomass incorporation in soil before rice transplantation in R-W cropping system has potential effect on soil fertility and nutrient availability.

CONCLUSION

The application of NPK @ 120: 40: 40 kg/ha NPK produced significant effect on yield and yield attribuites of rice in both rice and wheat crops. But the results from this study with the initial and final result of soil chemical properties provided evidence that the rice production can be sustained to greater extent through proper dhaincha biomass incorporation in soil with satisfactory residual effect for succeeding crop as it has potential effect on soil fertility and nutrient availability. Regular use of dhaincha with appropriate cropping pattern may be of significant benefit to smallholder farmers with limited resources to purchase sufficient chemical fertilizers. Integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is proved to be effective method to maintain a crops production. The long-term field trials are still necessary to validate the results in terms of the synchrony between soil nutrients release by the residue of green manure crops like dhaincha and mungbean.

ACKNOWLEDGEMENTS

The author expresses his gratitude to the government of Nepal, Nepal Agricultural Research Council (NARC) for supporting this study. The author is thankful to Directorate of Agricultural Research, Tarahara, Sunsari and National Soil Science Research Center, Khumaltar, Lalitpur for technical supports.

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EFFECTS OF DIFFERENT PLANTING DATES ON GROWTH AND YIELD TRAITS OF POTATO UNDER RAINFED CONDITION

Binod Prasad Luitel and Bishnu Bahadur Bhandari

ABSTRACT

This study was conducted at Horticulture Research Station (HRS), Dailekh during the years 2019 and 2020 to determine appropriate planting time for potato genotypes in the rainfed condition. The treatments consisted of three planting times (March 8, March 23, and April 8) of the years 2019 and 2020, was considered as main plot and twelve potato genotypes allotted as sub-plot. The treatments were arranged in split-plot design with three replications. Ground cover, plant uniformity, plant height, stems number/plant, total tuber weight/plot and tuber yield were taken as growth and yield components. The combine analysis of variance revealed that planting time significantly affected the yield components except ground cover and stem number/plant. Genotypes exhibited highly significant effect on all the yield traits. Tuber planting on March 23 produced significantly the higher yield (19.5 Mt/ha) than the tuber planting on April 8 (12.4 Mt/ha). Genotype CIP 392797.22 and CIP 303381.106 produced significantly the highest yield (23.2 Mt/ha and 22.9 Mt/ha, respectively). Tuber weight/plot and tuber yield were declined significantly at late planting time. Thus, the suitable potato planting date for the genotypes CIP 392797.22 and CIP 303381.106 were found March 23 for obtaining high tuber productivity in rainfed condition of Karnali province.

Keywords: *Genotypes, ground cover, productivity, planting dates, yield components*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the world's fourth most important food crop (after rice, wheat and maize) in terms of production (Haile et al., 2019). It is a good source of antioxidants (Vanaei et al., 2008) and is regarded as a high-potential crop for food security because the crop produces large quantities of dietary energy and has relatively stable yields under conditions in which other crops may fall (FAO, 2010). Potato produces more protein per unit area and per unit of time than other food crops; it is fat free and contains substantial amounts of minerals (Lutaladio and Castaldi, 2009).

In Nepal, potato is considered as an important staple food in mountains whereas mid-hills and in terai, it is consumed as a major vegetable. This is an important crop to rural people living in hills and mountains especially for their food and nutritional security. The recent status shows that the potato is grown over an area of 1,93,997 ha with production of 3.1 million tons (MoAD, 2019) in Nepal. In Karnali province, this crop is cultivated in 11,385 ha with production of 1.7 million tons. It occupies the fifth position in area coverage, second in total production and first in productivity among the food crops grown in Nepal (NPRP, 2017). In Dailekh district, potato is cultivated over an area of 1,672 ha with production of 30.3 Mt (MoAD, 2019). The low area of production and productivity in Karnali province are attributed to many factors such as lack of improved crop varieties for rainfed conditions, inappropriate agronomic practices (planting time, input management cultural practices etc.), low quality seed potatoes, poor diseases and pest management practices, lack of transport, storage and marketing facilities (HRS, 2019). In addition, the lack of knowledge in selecting proper time for planting tuber, water scarcity for irrigation and unpredictable drought are also limiting the potato production in Karnali province.

Potato is a suitable crop for temperate region and it does not perform well in the heat (Hijmans, 2003). Generally, haulm growth is fast in the temperature range between 20 - 25 ˚C whereas optimal range for tuberization and tuber growth is between 15 - 20 ˚C. Tuberization is inhibited and photoassimilate partitioning to tubers is greatly reduced under high temperature condition (Lafta and Lorenzen, 1995). Under the climatic condition of Nepal, potato yield depends on seed quality, varieties, soil, cultivation practices, irrigation and weather in particular temperature and precipitation. Soil moisture and irrigation water conditions are especially important for potato cultivation (Solomon et al., 2013). High temperature during growing season affects its development and may lead to a drastic reduction in economic yield. Potato production is greatly reduced at temperature higher than optimum (Rykaczewska, 2015).

Planting time of potato depends on altitude and climate of the particular location. Studies on effect of planting time of potato on growth and yield were carried out previously by various researchers (Rab et al., 2013; Haile et al., 2019; Darabi, 2019; Arslan, 2019) but response of planting time to potato genotypes with special reference to Karnali province is not studied so far. In Dailekh, an altitude of 1,300 masl, potatoes are commonly grown at two seasons of the year i.e., September and February planting. After March, temperature increases which hinder tuberization of potato tubers and subsequent tuber bulking. However, the potato clones bred either from International Potato Center (CIP), Lima, Peru or National Potato Research Program (NPRP), Khumaltar can perform well under late sowing condition at Dailekh. Therefore, this study was conducted to identify the appropriate planting time and genotypes for rainfed potato production in Karnali province.

MATERIALS AND METHODS

Plant materials and experimental site

A total of twelve Potato genotypes (CIP 394600.52, CIP 393371.164, PRP 146871.20, PRP 296667.2, CIP 392797.22, CIP 392025.7, PRP 016567.6, CIP 393371.159, CIP

303381.106, Kufri Jyoti, Desiree, and Cardinal) were used in this study. The seed tubers for planting were from National Potato Research Program (NPRP), Khumaltar, Lalitpur. This experiment was conducted at Horticulture Research Station (HRS), Dailekh which represents the mid-hills of Karnali province. It is located at an altitude of 1,290 masl, on latitude of 28º13'6.18" north and longitude 83º58'27.72" east (HRS, 2019). Annual temperature and averages rainfall are 19 ˚C and 150 mm, respectively. The maximum temperature of the study site during March to June in 2019 was varied from 25.1 ˚C to 30.9 ˚C whereas in 2020, it was varied from 23.4 ˚C to 27.9 ˚C. Likewise, the minimum temperature of each month in both years were recorded as increasing trend but rainfall pattern was inconsistent in the year 2020 (Figure 1).

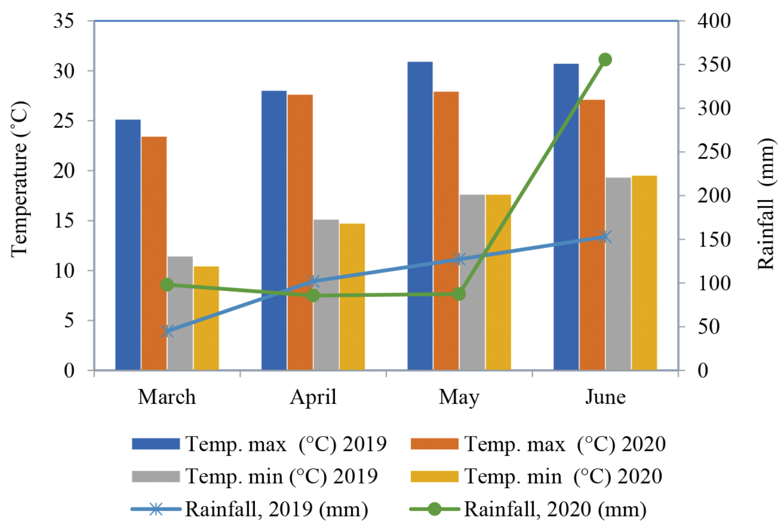

Figure 1. Monthly temperature and rainfall during growing season of Potato in 2019 and 2020 at HRS, Dailekh, Nepal

Experimental design and cultural practices

This experiment was laid out in a split-plot design where three planting times (March 8, March 23, and April 8) in 2019 and 2020 were considered as main-plot and twelve potato genotypes were adjusted as a sub-plot with three replications. The released potato varieties namely; Kufri Jyoti, Desiree and registered popularly grown cultivar Cardinal were used as check varieties. The planting dates were chosen in such a way that the first planting date can be considered as normal whereas remaining two planting dates were not normal practice in the study site. The experimental land was cleared and ploughed three times by oxen plough. The whole field was divided into nine blocks each containing 12 plots. The size of each unit plot was 1.8 m^2 having intra and inter row spacing of 25 cm and 60 cm, respectively. A distance of 50 cm and 1 m was maintained between plot and blocks, respectively. Each plot had two rows which consisted of 12 hills and well-sprouted seed tubers were hand planted in furrows at 15 days interval starting from March 8, to April 8, in 2019 and 2020. Fertilizer was applied at the rate of 100:100:60 N:P_2O_5:K_2O along with 20 Mt FYM/ha. Half amount of nitrogen, full amount of phosphorus, potassium, and farmyard manure (FYM) were applied at the time field preparation, and the remaining half amount of nitrogen was applied at 40 days after emergence as a top-dressing during the first earthing-up. Other management practices were practiced as per the general recommendation for potato (NPRP, 2017) but irrigation was not provided under rainfed condition.

Data collection and Analysis

Data on ground cover was taken at 60 days after emergence. Each plot was assessed for the percentage of ground cover by foliage converted to a 1-9 scale using following key; 1 = No emergence; 2 = Less than 20% ground cover, 3 = 29-35% ground cover, 4 = 36-50% ground cover, 5 = 51-65% ground cover; 6 = 66-75% ground cover; 7 = 76-90% ground cover; 8 = 91-99% ground cover and 9 = 100% ground cover. Plant uniformity was recorded at 45 days after tuber emergence using 1 to 5 scale (1 = least uniform, 5 = most uniform and 2-4 in between) (Khatri and Luitel, 2014). Plant height (cm) was measured from the soil surface to the top most growth point of the main shoot apex when 50% of the plants produce flowers. The numbers of stem/plant were recorded (the stems that emerged independently above the soil was taken as a single stems) at 50% flowering time. Tuber was harvested at the end of June in the years 2019 and 2020. Total tuber weight/plot was measured using the digital balance and tuber yield was calculated in hectare basis. The data were subjected to analysis of variance (ANOVA) using GenStat Release 10.3 DE Software (VSN International Ltd.). Treatment means that showed significant difference were compared by using Least Significant Difference (LSD) test at 5% significant level. Correlations among the quantitative variables were also analyzed using SPSS 10.0 for Windows software.

RESULTS AND DISCUSSION

Effect on plant characters

The planting time showed non-significant effect on ground cover and stem number/plant but it showed significant variation in plant uniformity and plant height (Table 1). Plant uniformity remained uniform (4) in all the planting dates but the highest (52.9 cm) plant height observed in the plants planted on March, 23. In contrast, genotypes showed highly significant ($p \leq 0.01$) differences in ground cover, uniformity, plant height and stem number/plant. Genotype CIP 392797.22 produced the highest (71.0 %) ground cover but it was the lowest (33.0 %) in Cardinal. The combined analysis showed that the highest (5.0) plant uniformity was recorded in genotype CIP394600.52 and CIP 392797.22. The lowest (3.0) uniformity was recorded in genotypes PRP146871.20, PRP 296667.2 and Cardinal. Genotypes PRP016567.6 and CIP 393371.159 was measured the tallest (61.3 cm) plants while the shortest plant height (31.8 cm) was measured in genotype PRP146871.20. Genotype CIP 392797.22 and CIP 392025.7 exhibited the highest (6.0) numbers of stem/plant and it was counted the lowest (3.0) in genotypes PRP 146871.20 and Cardinal.

In this study, planting time showed the significant differences in plant uniformity and plant height. This might be due to variation in weather pattern (Figure 1). Our study showed that planting time did not show significant effect on stem number/plant. In contrast, in the study of Rab et al. (2013), they reported, sowing time had significantly affected the numbers of stem/hill. Variation in ground cover, plant uniformity, plant height and stem number/plant in potato genotypes had been reported by previous researchers (Jaime et al., 2007; Khan et al., 2013; Luitel et al., 2016; Fantaw et al., 2019). Generally, plant height and the numbers of stem are related to the number of branch and number of leaves which contributes to leaf area of a plant. The significant variation in plant height and numbers of stem/plant in potato genotypes were also reported by researchers (Abu-Zinada and Mousa, 2015; Alemayehu et al., 2018; Ebrahim et al., 2018).

Effect on Tuber Yield

Pooled mean over the years showed that planting time had highly significant difference in total tuber weight and tuber yield (Table 2). Planting the tuber on March 23 showed the greatest tuber weight (3.5 kg/plot) and tuber yield (19.5 mt/ha). In contrast, planting the tuber on April 8 imparted the lowest tuber weight (2.2 kg/plot) and tuber yield (12.4 mt/ha). Genotypes showed highly significant variation in total tuber weight/plot and tuber yield. As compared to check varieties (Kufri Jyoti, Desiree, and Cardinal), genotype CIP 392797.22 and CIP 303381.106 gave higher tuber weight (4.2 kg and 4.1 kg) and tuber yield (23.2 mt/ha and 22.9 mt/ha), respectively.

This study showed the declined tuber weight and yield in late tuber planting date. This is due to increased temperature and rainfall pattern (Figure 1.). Year had significant effect on tuber weight and yield and this variation might be due to changing pattern of temperature and rainfall. Tuber planting on April 8 faced the high temperature and heavy rainfall during tuber development phase thereby reduced the tuber weight and yield. Rab et al (2013) reported that delaying potato planting on October 8 declined tuber yield in Pakistan. Late planting of tuber could be detrimental to the tuber yield (Iwama et al., 2005). Lafta and Lorenzen (1995) reported that high temperature reduced growth of tuber and tuber yield which confirmed the findings of this study. In this study, planting tuber on April 8 might be attributed to the short growing season due to high temperature and heavy rainfall. Reduced tuber yield due to high temperature encountered during tuber bulking stage was also reported by Darabi (2019). Arslan (2019) had also reported that planting of potatoes in March showed the highest tuber yield and similar results were found in this study. Reduction in tuber yield in delayed planting date was also reported by Ahmed et al. (2017). Generally, early planting did not lead to an increase in potato productivity (Vasiliev and Garbunov, 2019) and this study showed the similar results. High temperature delay or prevent tuberization, promote secondary growth and divert dry matter to the shoot rather than tuber (Menzel, 1985). In the study of Rymuza et al. (2015), they found that precipitation affected potato yields in June and July which is close to the findings of this study.

Table 1. Effect of planting time on plant and growth characters of potato genotypes during the years 2019 and 2020 at HRS, Dailekh

Planting Time (PT)	Ground cover (%)		Mean	Uniformity (1-5 score)		Mean	Plant height (cm)		Mean	Stem/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020		2019	2020	
March, 8	53.0	35.0	44.0	4.0	4.0	4.0	42.3	48.3	45.3	5.0	3.0	4.0
March, 23	63.0	65.0	64.0	4.0	4.0	4.0	46.7	59.1	52.9	5.0	4.0	4.0
April, 8	42.0	67.0	54.0	3.0	4.0	4.0	35.0	58.8	46.9	4.0	4.0	4.0
F-Test			NS			*			**			NS
LSD (0.05)			4.418			0.239			4.531			0.390
Genotypes (G)												
CIP 394600.52	73.0	66.0	69.0	5.0	4.0	5.0	45.4	66.9	56.2	5.0	5.0	5.0
CIP 393371.164	57.0	47.0	52.0	4.0	4.0	4.0	45.0	62.9	53.9	5.0	4.0	4.0
PRP 146871.20	32.0	45.0	38.0	3.0	3.0	3.0	25.6	37.9	31.8	4.0	3.0	3.0
PRP 296667.2	28.0	42.0	35.0	3.0	4.0	3.0	43.1	55.1	49.1	4.0	4.0	4.0
CIP 392797.22	75.0	68.0	71.0	5.0	5.0	5.0	48.6	62.2	55.4	6.0	5.0	6.0
CIP 392025.7	63.0	63.0	63.0	5.0	4.0	4.0	42.3	55.3	48.9	6.0	5.0	6.0
PRP 016567.6	61.0	70.0	65.0	4.0	5.0	4.0	50.9	71.6	61.3	3.0	4.0	4.0
CIP 393371.159	52.0	68.0	60.0	4.0	5.0	4.0	46.1	76.5	61.3	3.0	4.0	4.0
CIP 303381.106	69.0	53.0	61.0	4.0	4.0	4.0	46.8	48.6	47.7	5.0	4.0	5.0
Kufri Jyoti (Ch)	46.0	46.0	46.0	4.0	4.0	4.0	33.8	38.6	36.2	4.0	3.0	4.0
Desiree (Ch)	49.0	61.0	55.0	4.0	4.0	4.0	39.5	44.6	42.1	4.0	3.0	4.0
Cardinal (Ch)	28.0	38.0	33.0	3.0	3.0	3.0	28.7	44.7	36.7	3.0	3.0	3.0
Mean	52.6	55.4	54.0	3.83	4.0	3.92	41.35	55.41	48.38	4.36	3.88	4.126
F-Test			**			**			**			**
LSD (0.05)			12.9			0.591			8.330			0.780
CV (%)			29.3			18.5			21.2			23.2
PT x G			NS			NS			NS			NS

NS = non-significant; * and ** significant at 0.05 and 0.01 levels, respectively.

Table 2. Effect of planting time on tuber yield of potato genotypes during the years 2019 and 2020 at HRS, Dailekh

Planting Time (PT)	Total tuber wt./plot (kg)		Mean	Tuber yield (mt/ha)		Mean
	2019	2020		2019	2020	
March, 8	2.8	3.0	2.9	16.0	16.7	16.4
March, 23	3.7	3.3	3.5	20.8	18.4	19.5
April, 8	2.8	1.7	2.2	15.6	9.2	12.4
F-Test			**			**
LSD (0.05)			0.79			4.422
Genotypes (G)						
CIP 394600.52	4.8	2.7	3.8	26.5	15.1	20.8
CIP 393371.164	2.5	2.8	2.7	13.8	15.6	14.7
PRP 146871.20	1.2	2.2	1.7	6.9	11.9	9.4
PRP 296667.2	1.3	2.0	1.7	7.3	11.2	9.2
CIP 392797.22	5.2	3.2	4.2	28.6	17.8	23.2
CIP 392025.7	3.2	2.5	2.9	17.7	14.3	16.0
PRP 016567.6	3.7	3.3	3.5	20.6	17.8	19.2
CIP 393371.159	3.6	3.5	3.6	19.9	19.5	19.7
CIP 303381.106	5.5	2.8	4.1	30.5	15.3	22.9
Kufri Jyoti (Ch)	2.6	2.2	2.4	14.4	12.2	13.3
Desiree (Ch)	2.9	2.9	2.9	16.6	16.2	16.4
Cardinal (Ch)	1.2	1.8	1.5	6.7	9.9	8.3
Mean	3.14	2.66	2.9	17.4	14.76	16.11
F-Test			**			**
LSD (0.05)			1.592			3.844
CV (%)			27.4			28.4
PT x G			NS			NS

NS = non-significant; ** significant at 0.01 level.

Phenotypic correlation

The association among the growth and yield characters of potato genotypes is presented in Table 3. Ground cover showed highly significant positive association (r = 0.71) with plant uniformity and stem number/plant (r = 0.54). Similarly, plant uniformity showed the significant positive association with plant height (r = 0.52), stem number/plant (r = 0.50) and tuber yield (0.42). The numbers of stem/plant exhibited moderate significant positive association with total tuber weight (r = 0.56) and yield (r = 0.60) but total tuber weight had strongly correlated with tuber yield (0.82). Arslan (2007) reported the positive significant correlation between stem number/plant, tuber weight and tuber yield. Morphological characters including ground cover, plant uniformity and plant height showed weak association with tuber yield and similar results were reported by Kaur et al. (2017). Yildirium et al. (1997) had reported that tuber weight was positively associated with tuber yield.

Table 3. Correlation among the growth and yield characters of potato genotypes during the years 2019 and 2020 at HRS, Dailekh

Variables	Ground cover	Uniformity	Plant height	Stem/ plant	Total tuber wt.	Tuber yield
Ground cover	1.0	0.71**	0.54**	0.54**	0.37**	0.38**
Uniformity		1.0	0.52**	0.50**	0.41**	0.42**
Plant height			1.0	0.29**	0.21**	0.22**
Stem/plant				1.0	0.56**	0.60*
Total tuber wt.					1.0	0.82**
Tuber yield						1.0

* and ** significant at 5% and 1%, respectively.

CONCLUSION

The result of the study revealed that the planting times significantly affected plant uniformity, plant height, tuber weight and tuber yield. Similarly, genotypes also showed the significant differences in all the characters. The combined effect of planting dates and genotypes did not show any significant differences in the studied characters. However, tuber planting on April 8 coincided with high temperature and heavy rainfall during tuber bulking and development stage thereby reduced the tuber yield. The number of stem/plant and tuber weight showed positive significant association with tuber yield. Genotypes CIP 392797.22 (UNICA), a red skinned genotype, gave the highest yield (23.2 t/ha) followed by CIP 303381.106 (22.9 t/ha). Therefore, the appropriate time of tuber planting was found on March 23 for rainfed condition in Karnali province. CIP 392797.22 and CIP 303381.106 gave higher tuber yield than other studied genotypes in rainfed condition of Karnali province.

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STUDY ON SUGARCANE INSECT PESTS AND THEIR NATURAL ENEMIES IN CENTRAL AND WESTERN TERAI REGION OF NEPAL

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ABSTRACT

This survey was conducted in sugarcane fields in plant canes near sugar factory's command area in central and western terai region of Nepal during 2014/15 with an objective to identify the sugarcane insect pests causing damage and prevalence of their natural enemies. This survey was conducted on plant cane crop on March- May at 45-60 Days After Planting (DAP), June-August at 150 DAP. Among the various insect pests found early shoot, top and internode borers, Pyrilla, termites, grasshoppers and mealybugs were found to be the major pest and white grub, scale insect and whitefly as minor pests. The major pests were classified as per the observation of visual damage to the sugarcane crop. The population of Pyrilla was found damaging in Nawalparasi and Sarlahi districts. In the areas of severity of Pyrilla its external parasite, Epiricania melanoleuca as also reported in abundance. Various natural enemies viz. Green lacewing, Robber fly, Cotesia spp.*, Rove beetle, and Coccinellids were also found in sugarcane field. This study has helped to explore the presence severity of the pest in the survey area which shows ways towards the exploration of the management tools of the major pests in this region of Nepal.*

Keywords: Dead hearts, Epiricania, Pyrilla, Top borer infestation, Sugarcane

INTRODUCTION

Sugarcane is one of the most important cash crops of Nepal but it's per hectare yield is low as compared to many other sugarcane growing countries (Ansari et al. 2016). The reason behind the low productivity is lack of improved varieties, improved practices of cultivation and insect pest infestation. Sugarcane crop is host for a wide range of insect pests damaging at the stages of plant (Williams, 1931; Box, 1953; Williams et al., 1969). Among these majority are minor pests and a few are major pests that causes significant damage to all parts of the crop from root to shoot (Williams et al., 1969; Hall, 1988). Insect pests alone cause 20-60% damage (Alam, 1967). Among various factors of yield reduction: insect pest inflicts considerable loss, which is estimated to be around 20% in cane yield and 15% in sugar recovery (Avasty, 1983). The infestation of insect pests especially borers, *Pyrilla*, mealybug, grasshopper and

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some subterranean pests such as termites, sugarcane black beetle and white grubs are the major cause of low yield and quality in India (Chaudhry and Ansari, 1988 and Srikanth, 2012). The damage caused by the various pests are studied in India. The yield loss due to early shoot borer was found to be 22-33% (Patil and Hapase, 1981), 21-48% by top borer (Karim and Islam, 1977), 8.2-12.6% by stem borer and 1.43% by scale insect (Khanna, 1957) and 8.55-10% by root borer (Gupta, 1959), 1.43% by scale insects, 24.1% by mealybug and 23.07-38.17% by white grubs (Miah et al. 1983). The incidence and intensity of pests and their impact on sugarcane differ considerably in the tropics and subtropics due to the different climatic conditions in Nepal. So it is different than the neighboring countries due to different agro climatic diversity in this region. The pest dynamics of sugarcane has also been changing with the change in cultivation practices. Due to the increasing rationing of the sugarcane crop without tillage intervention the severity of the pests like grasshopper has been increased (Ansari et al. 2016). The import of the various genotypes from the border areas of neighboring countries has also increased risk of import of the various diseases and insect pests. Till now no such study has been conducted in Nepal to explore the pest of sugarcane in present context. The identification of important pests of sugarcane is necessary to identify the economically important pests prevalence and have good management of them. Keeping in view the exploration of severity of various insect pests and prevalence of their natural enemies in various sugarcane growing areas of Nepal, a survey was of immense need. This study was also conducted for the exploration of pests and their intensity presence of potential control agents which is the first step in the development of an effective integrated pest management strategy to increase sugarcane production.

MATERIALS AND METHODS

The survey was conducted in various sugarcane growing districts, *viz.* Kapilvastu, Nawalparasi, Bara, Sarlahi, Rautahat and Mahottari on February planted sugarcane from 2016 to 2017. Survey was conducted in sugarcane growing areas of Bara, Sarlahi and Rautahat districts in 2016 and the remaining districts in 2017. In each district various locations were selected on the basis of the area covered by sugarcane. In each location five plots were randomly selected in which 2m border was separated from outer border in all direction. In each plot 10 rows each with 10m length were selected randomly for recording of dead hearts caused by the pests like sugarcane black beetle, top borer and early shoot borer infestation in early stage crop. The larvae of found in the dead the tillers were collected and reared to confirm the pest found in the sugarcane crop. Those emerged adults were identified and confirmed for their presence in the field. In case of sugarcane black beetle the soil beneath the dead hearts were dug to confirm the presence of the pest. Those pests collected were maintained in the entomology laboratory of NSRP, Jitpur, Bara.

In more than 120 day old crop five rows of 10m length were selected randomly to record the infestation of top borer and ten canes were randomly selected to record the infestation of pest like mealybug, *Pyrilla,* scale insect, whitefly, termites and other aerial insects as well. Total shoots/tillers and infested shoots/tillers from 10m length of each selected rows was counted. Observations on level of infestation of insects (top borer, early shoot borer, scale insects, mealybug, and sugarcane black beetle) and prevalence of natural predators and parasitoids were taken. Total number of shoots, number of damaged shoots, number of infested canes and pest per canes on March- May (at approx 45-60 DAP), June-August (at approx 150 DAP). In case of foliar pest in each randomly sampled cane three leaves one from bottom one from middle and one from top were taken. The number of adults or nymphs or egg mass were counted in each leaves sampled for *Pyrilla* and whitefly. The whorls were observed for recording of black bugs and other borers as well. Number of mealybugs was also counted per cane removing the leaves from top, middle and bottom. Insects found in sugarcane field during the survey were collected and identified at National Sugarcane Research Program, Jitpur and Entomology Division, Khumaltar. The data obtained were analyzed using R programming.

RESULTS AND DISCUSSION

Nine insect species viz., *Chilo infuscatellus, Saccharicoccus sacchari, Pyrilla perpusilla,* Scale insect, *Aleurolobus barodensis,* Termites, *Heteronychus spp., Hieroglyphus banian* were found to attack sugarcane in sugarcane cultivating areas (Table 1). Early shoot borer, top borer and *Pyrilla* were the most widely distributed and damaging insect pest as they have been found in almost all districts (Table 2). In few places sugarcane black beetle and termites were also found to cause damage in early stage (45-60 DAP) and to late stage (>150 DAP) sugarcane crops respectively. Some of the minor insect pests like scale insect and whitefly were also reported in sugarcane which were found not to cause any damage to sugarcane grown.

In early stage crop in February planted sugarcane in eastern part of sugarcane growing areas of Eastern Nawalparasi 1.81% dead hearts were found. In Mahottari, maximum percentage of dead hearts found was 12.32% in a row and the average percent dead hearts was 5.09%. In Bara, Sarlahi and Rautahat 8.5%, 6.13% and 5.26% dead hearts were reported in early stage crop respectively. In Bara, sugarcane black beetle (*Heteronichus sp.*) was found in Ramauli (Jitpur Simara-8) showing symptoms similar to dead hearts. In Kapilvastu, average dead hearts found was 2.16% and maximum of 17% dead hearts were recorded in a row (Table 3). Severe damage (above economic threshold level) was reported in Hariwon, Sarlahi in early stage sugarcane by mealybug.

Table 1: Insect pests found during survey in 2016 and 2017

Insect species and family	Common name	Damage symptoms on Sugarcane
Chilo infuscatellus (Snellen), Pyralidae	Early shoot borer	Bored early shoots and causes dead hearts
Scirpophaga sp. , Pyralidae	Top borer	Bored early shoots making dead hearts and matured cane tops damaged
Saccharicoccus sacchari Cockerell, Pseudococcidae	Sugarcane mealybug	Sucked the sap from cane in both early and grown up canes
Pyrilla perpusilla Walker, Lophopidae	Sugarcane leaf hopper	Sucked sap from the leaves and dries off
Unidentified, Coccidae	Scale insect	Sucked sap from the cane
Aleurolobus barodensis Mask., Aleyrodidae	Whitefly	Sucked the sap from under surface of leaf
Unidentified, Termitidae	Termite	Damaged young and grown up shoots
Heteronychus spp., Scarabaeidae	Sugarcane black beetle	Damaged on young shoots and roots below ground level
Hieroglyphus banian (Fabricius), Acrididae	Grasshopper	Feed on leaf blades making saw like appearance

Table 2: Distribution of Sugarcane pests in various districts

Common name	Districts of Distribution
Early shoot borer	Bara, Kapilvastu, Mahottari, Nawalparasi, Rauthat, Sarlahi
Top borer	Bara, Kapilvastu, Mahottari, Nawalparasi, Rauthat, Sarlahi
Sugarcane mealybug	Bara, Mahottari, Nawalparasi, Rauthat, Sarlahi
Sugarcane leaf hopper	Bara, Mahottari, Nawalparasi, Rauthat, Sarlahi
Scale insect	Bara
Whitefly	Bara, Nawalparasi, Rauthat, Sarlahi
Termite	Bara, Nawalparasi, Rauthat, Sarlahi
Sugarcane black beetle	Bara
Grasshopper	Sarlahi

In case of *Pyrilla* 0.79 egg mass per cane, 4.06 nymphs per cane were reported in Bara. In the district, highest number of egg mass of *Pyrilla* found was 16 in a single leaf. Average number of egg mass per cane and nymphs per cane was found to be 0.63 and 7.22 in Nawalparasi. In case of Rautahat, on an average 0.4 pyrilla egg and 1.62 nymphs per cane was reported. Heavy infestation of *Pyrilla* was found in Laxmipur of Nawalparasi where 30 nymphs in a single leaf was found. The maximum egg mass in a single leaf was found to be 12 in Laxmipur, Nawalparasi. In Kapilvastu intensity of *Pyrilla* and mealybug was very low. In sarlahi on an average 0.64 egg mass per cane, 3.53 nymphs per cane of pyrilla were reported. In Mahottari, on an average 0.12 egg mass per cane, 2.30 nymphs per cane were reported. Mealybugs were also reported to be feeding on sugarcane in Bara, Nawalparasi, Rauthat, Sarlahi and Mahottari. In Sarlahi, on an average 4 mealybugs per canes were recorded in late stage crop. About 0.59, 0.83, 0.96 and 0.25 whitefly nymph was reported in each leaf in Nawalparasi, Bara, Sarlahi and Rauthat respectively. No evidence of whitefly was found in Kapilvastu and Mahottari district. Scale insect was recorded in some areas of Bara district (Table 3).

Table 3 Severity of various pest in various districts

Districts	Dead hearts (%) caused by beetles and borers	Pyrilla Egg mass per cane	Nymphs per cane	Top borer infestation (%) in matured cane	Whitefly per leaf
Kapilvastu	2.16	-	-	-	-
Nawalparasi	1.81	0.63	7.22	0.72	0.59
Bara	8.5	0.79	4.06	0.98	0.83
Sarlahi	6.13	0.64	3.53	0.57	0.96
Rauthat	5.26	0.4	1.62	0.26	0.25
Mahottari	5.09	0.12	2.30	0.48	-
Mean	4.14	0.52	3.75	0.6	0.66
LSD(0.05)	-	-	2.71	-	-
F test	ns	ns	***	ns	ns

In Sarlahi, 0.57% of the apical tops were infested with top borer. In Rauthat, Mahottari, Bara and Nawalparasi 0.26%, 0.48%, 0.98% and 0.72% apical tops were infested respectively causing bunchy top or shoot holes (Table 3). In Kapilvastu, top borer infestation was very low. Bhatti et al (2008) reported that the maximum damage is done by the stem borer from April-July which partially supports our findings. Termites were also found causing damage to sugarcane crop in Sarlahi, Rauthat, Bara and Nawalparasi. Patel and Hapase (1981) and Ahad et al (2015) had reported that most important pests of sugarcane as early shoot borer, top borer, stem borer, root stock borer, mealybug, scale insect and white grubs which more or less supports the result of the present study. In Sarlahi, maximum of 6 adult grasshoppers per m^2 with 65% of the foliage eaten was recorded in plant cane. The population of grasshoppers was in damaging level in few locations of Sarlahi in plant cane near ratooned sugarcane.

In Bara, natural enemies like syrphid fly, rove beetle, robber fly, *E. melanoleuca* and other *Coccinellids* were also reported in the field. On an average, 0.1 and 0.25 *E. melanoleuca* coccon per cane was found in Nawalparasi and Bara districts respectively. Maximum of 10 *E. melanoleuca* coccons were reported in a single leaf in Narsahi VDC of Nawalparasi. In case of severity of *Pyrilla* numerous nymphs and adults of *Chrysoperla spp.* were also found in the field in various locations of Sarlahi and Nawalparasi (Table 4).

Table 4: Predators and parasitoids found during survey in 2016 and 2017

Predators or parasites	Common Name	Family	Probable Host found in sugarcane
Chrysoperla sp.	Green lacewing	Chrysopidae	*Pyrilla perpusilla* Walk.
	Robber fly	Asilidae	
Cotesia spp.	*Cotesia*	Braconidae	Borers and foliage feeding larvae
Paederus littoralis Gravenhorst	Rove beetle	Staphylinidae	
Coccinellids	Ladybird beetle	Coccinellidae	*Pyrilla perpusilla* Walk.
Cicindela sexguttata Fabricius	Six spotted tiger beetle	Carabidae	
Epiricania melanoleuca (Fletcher)	*Epiricania*	Epipyropidae	*Pyrilla perpusilla* Walk.

In Bara, there was evidence of larval parasitoid *Cotesia* spp. parasitizing various foliage feeding and cane boring and foliage feeding larvae in sugarcane field. Lepidopteron parasite of *Pyrilla* was also reported in various locations of Rautahat and Sarlahi in abundance. In some areas of Rautahat, rove beetles, robber fly, *Chrysoperla spp.* and *Coccinellids* were also found in sugarcane field. Khan 1967, reported that several *Coccinellids* feed on *Pyrilla. Cicindella sexgutata* Fabricius was also found in sugarcane field in abundance in Rautahat but no evidence was found of predation of any sugarcane insect pests. *E. melanoleuca* were found widely spreading in various sugarcane growing areas with its host distribution. The *E. melanoleuca* has been reported as successful biocontrol agent of *Pyrilla* in Srilanka (Seneviratne and Kumarasinghe, 2002). Common (1990) reported that the larvae of *E. melanoleuca* sucks the body fluid through cuticle. *E. melanoleuca* causes parasitic castration in both the sexes of *Pyrilla* (Gupta, 1940).

CONCLUSION

This survey revealed that *Pyrilla,* early shoot borer and top borer were the major damaging insects in plant cane of sugarcane. *E. melanoleuca, Chrysoperla,* Coccinellids Robberfly, Rove beetle and Cotesia were the natural enemies found in sugarcane field. Some larval and nymphal parasites were also recorded in various locations of Sarlahi, Rautahat and Bara districts.

ACKNOWLEDGEMENTS

The authors acknowledge Nepal Agricultural Research Council (NARC) and the staffs working at National Sugarcane Research Program (NSRP), Jeetpur and Entomology Research Centre for the support during this research. Thanks to sugar mills and their staffs for providing support in conducting the survey in central and western part of Nepal.

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EFFICACY OF PROTEIN BAITS AGAINST BACTROCERA MINAX (ENDERLEIN) IN EASTERN HILLS OF NEPAL

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ABSTRACT

The Chinese citrus fruit fly, B. minax, is the devastating pests of economic importance in citrus crops. A study was conducted in 2015 to evaluate the effectiveness of locally prepared protein baits and commercially available baits against B. minax in National Citrus Research Program, Paripatle, Dhankuta. Also the efficacy assessment of different bait solutions as autolysed protein, sofri protein, beer supernatant, beer supernatant and debris (1:1) and beer supernatant and debris (1:1) plus honey used in McPhail traps in combination with the insecticide spinosad as spot sprays in citrus trees was studied. The results showed that Traps with beer supernatant and debris (1:1) plus honey was the most attractive bait capturing significantly more flies than beer supernatant and debris (1:1), beer supernatant, sofri protein and autolyzed protein, in decreasing efficiency order. Similarly, spot spray of beer supernatant and debris (1:1) plus honey killed significantly more female and male flies within three hours than those with supernatant and debris (1:1), beer supernatant, sofri protein, autolysed protein and control. In addition, total number of flies killed by supernatant and debris (1:1) plus honey during the spot application was higher than other treatments. Hence, the study indicated that the beer supernatant and debris plus honey was found to be the useful option to monitor as well as manage the B. minax fruit fly pest when used as trap and spot sprays. This result paved the way for the substitute of the commercial products by locally produced baits as a cheaper alternative in B. minax fruit fly management.

Keywords: Bait, Citrus, Dhankuta, Effectiveness, Mc Phail trap, Spot application

INTRODUCTION

The Chinese citrus fruit fly, *Bactrocera minax* (Enderlein) (Diptera: Tephritidae), is one of the most important citrus pest in Nepal (Bajracharya et al., 2008) as well as at neighboring countries like, China, Bhutan and north-west India (Wang and Luo, 1995; Dorji et al., 2006). For more than two decades, *B. minax* is recognized as a dominant pest of sweet orange especially in the eastern regions but nowadays, it has spread around central and the western hills (Sindhuli, Ramechhap, Gorkha, Lamjung, Myagdi and Parbat districts) of Nepal. It has caused a serious hindrance in production

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of citrus fruits (Bhandari et al., 2017). *B. minax* is an oligophagous pest and largely restricted to different citrus crops. Like almost all *Bactrocera* species, the fly lays its eggs inside the fruit, where larvae emerge and start to feed the contents (Dhillon et al., 2005; Nardi et al., 2005; Han et al., 2011). Maggot feeding causes the fruits to ripen prematurely and ultimately the fruit drops (Van Schoubroeek, 1999), resulting in yield loss that commonly reaches 20-30% in mandarin but may even reach as high as 90-100% in sweet orange and hill lemon when host plants are severely damaged (Bhandari et al., 2017).Therefore, effective integrated pest management programs are required for areas where the sweet orange is cultivated commercially.

Traps, lures, and mass trapping techniques are adopted as common strategies for management of fruit flies in Nepal (G.C., 2001) and abroad (Stonehouse et al., 2002; Vargas et al., 2009). Protein baits spray mixed with insecticides were first used for Caribbean fruit fly control (Steiner, 1952), since then, it has been used as a successful method of suppressing fruit fly populations in many parts of the world. Female tephritids require abundant protein meal for ovarian development and egg production (Mangan, 2003), and protein sources, such as bacteria in bird feces, are thought to be scarce in natural conditions (Drew et al., 1983). So, tephritid adult female flies are highly attracted to protein sources after its emergence and thus bait sprays with protein sources are successfully used to manage the tephritid species (Yee and Chapman, 2005; Mangan et al., 2006; Vargas and Prokopy 2006).

In Nepal, after the proper taxonomic description and thorough biology and ecological studies of *B. minax* at eastern hills (Bhandari et al., 2017), efforts were made on the management aspects. Though most fruit flies can be monitored by traps with sexual pheromone and parapheromones, *B. minax* is not known to be attracted to any male lures (Drew et al., 2006). Hence, protein bait is the best option for monitoring as well as management of the insect for mass killing. To our knowledge, potential use of protein baits to manage *B. minax* has not been documented in Nepal.

In 2015, we assessed the effectiveness of commercially available protein (i.e., autolysed protein) at fruit orchard. The commercial protein bait currently used is imported from Australlia and United Kingdom that costs more than NRs 15000 per litre (1 US$=NRs 118.0). In this context, the local formulation of protein bait from locally available brewery yeast waste could make a major contribution in reducing the cost and enhancing the sustainability of fruit fly control activities in the country. So, the research was initiated to study on comparative efficacy of commercial and locally prepared protein baits in attracting fruit flies.

MATERIALS AND METHODS

Experimental site

The experiment was carried out from early May to early August, 2015 during the fruiting season, in citrus orchard of National Citrus Research Program, Paripatle, Dhankuta. The GPS coordinates of experimental site is 27^o 1" north latitude and 87^o 18" east longitude lying at altitude of 1247 masl. The orchard consists of mandarin (*Citrus reticulate* Blanco), sweet orange (*Citrus sinensis* Osbeck), hill lemon (*Citrus maxima* Burm. Merri), acid lime (*Citrus aurantifolia* Swingle) and other citrus trees. The study was conducted at sweet orange block where fruit fly caused more than 90 percent damage annually. Density of trees in the orchard was 625 trees per hector. No pest management tactics were applied in the studied orchard.

Experimental materials

The following materials were prepared for baiting and placed in McPhail trap: i) Autolysed protein from Australlia @ 20 mL/L; ii) Sofri protein from Vietnam @ 20 mL/L; iii) Beer supernatant;iv) Beer supernatant and debris (1:1); and v) Beer supernatant and debris (1:1) plus honey @ 5 g/L

Preparation of locally produced beer supernatant

Beer autolysate was locally prepared following the method developed by Gopaul and Price (2000). Brewery yeast waste obtained from beer factory was placed in bottles and pasteurized in an oven at 70^{0}C for 9 hours. Then it was allowed to cool overnight at ambient temperature. This process causes a degree of yeast cell autolysis and release of cell contents. Proteolysis of released yeast cell proteins occurred by addition of papain enzyme powder to each bottle at a rate of 4 g/L, then the bottles were placed in the oven for further 9 hours at 70^{0}C. After that bottles were again allowed to cool with potassium sorbate added at a rate of 5 g/bottle as a preserving agent. The process results in the formation of a clear brown "supernatant" and cloudy "sediment" containing a mixture of the supernatant and "debris" of cell wall material.

Evaluation of attractiveness of baits in citrus orhard

The experiment was laid out in Completely Randomized Block Design (RCBD) with five treatments and five replications. The following baiting materials were used as treatments and placed in McPhail trap: i) Autolysed protein from Australlia at the rate of 20 mL/L; ii) Sofri protein from Vietnam at the rate of 20 mL/L; iii) Beer supernatant; iv) Beer supernatant and debris (1:1); and v) Beer supernatant and debris (1:1) plus honey at the rate of 5 g/L. The evaluation of the baits was carried out from early May to early August, 2015 at weekly interval using above mentioned baiting materials in McPhail trap. Borax, at the rate of 22.5 g/L, was added to all bait solutions to prevent decaying of the trapped insects. Each trap was baited with 250 ml of aqueous solution and attached at the height of 1.5 m in sweet orange tree branches. The bait in each traps were replaced weekly and the entire traps were moved at new position within same experimental site. The trapped *B. minax* adult fruit flies were collected and separated according to their sex and later preserved in 75% ethanol.

Efficacy assessment of baits as spot sprays

An experiment was conducted to evaluate the efficacy of commercial as well as locally produced protein baits as spot spray from early May to early August, 2015. The trial was designed to determine the overall effectiveness of baits when used in spot spray under field conditions. The following baits were used as treatments:

I. Autolysed protein (55% Protein) at the rate of 20 mL/L
II. Sofri protein (50% Protein) at the rate of 20 mL/L
III. Beer supernatant
IV. Beer supernatant and debris (1:1)
V. Beer supernatant and debris (1:1) + honey @ at the rate of 5 g/L
VI. Control (Water)

The entire sprays were added with spinosad (Tracer 17.5% SC) at the rate of 0.25 ml per liter of solution. For each replicate, 150 ml solution were applied to citrus foliage using hand-held sprayer (1 liter in capacity) covering at least 5 percent area of the plant canopy. Five trees were selected at least 15 m apart and sprayed. The spot spray was applied at 9 to 10 AM during the peak activity of fruit flies. The following observations were recorded to assess the effectiveness of baits as spot spray.

i) Number of dead *B. minax* adults below the sprayed trees at three hours after spray, and
ii) Number of dead fruit flies counted at the sprayed plants till the number dropped to zero level.

Hence, overall efficacy of sprays was evaluated according to the baits used. The number of male and female flies killed by spot sprays was analyzed using general linear model (SPSS, 2020) with protein bait and sex as factors, also the interaction between factors were assessed at 0.05 level of significance.

RESULTS

Evaluation of attractiveness of baits in citrus orchard

A Poisson regression was run to analyze the effectiveness of baits for male and female flies in Mc Phail trap in different dates. The statistical result has been presented in Table 1. The number of flies caught in Mc Phail trap differed significantly between baits used (bait factor: χ^2 = 299.47, df = 4, p < 0.05) and dates (date factor: χ^2 = 7508.69, df = 15, p < 0.05), and two factors interacted significantly (χ^2 = 5.87, df = 60, p < 0.05). Similarly, there was significant difference between female and male flies (sex factor: χ^2 = 29.91, df = 1, p < 0.05). However, sex factor and baits did not interact significantly (χ^2 = 240.06, df = 4, p = 0.2).

Table 1: Statistics to analyze attractiveness of baits for B. minax in Mc Phail trap

Source of variation	Df	χ^2	P-value
Protein bait attractiveness			
Protein bait	4	299.47	0.00
Sex	1	29.91	0.00
Date	15	7508.69	0.00
Protein bait X Date	60	5.87	0.00
Protein bait X Sex	4	240.06	0.20
Date X Sex	15	57.55	0.00

Adult flies ensnared during the course of the experiment in McPhail trap among the various baits tested (Bait factor), as function of flies sex (Sex factor) and also as function of date of sampling (Date factor).

The mean number of fruit flies caught in Mc Phail trap in different bait materials during May-August has been depicted in Fig. 1. A total of 7243 *B. minax* flies (males 3213 and females 4030) were caught in McPhail trap during the entire experimental period. The bar diagram presented in Fig. 1 showed that traps with beer supernatant and debris (1:1) plus honey trapped more flies followed by beer supernatant and debris (1:1), beer supernatant, sofri protein and autolysed protein. Hence, locally produced protein plus honey could be the best option for displacing commercial protein. The number of flies varied significantly according to the date. The fruit flies were trapped from early May to early August and a peak was observed on 4 June.

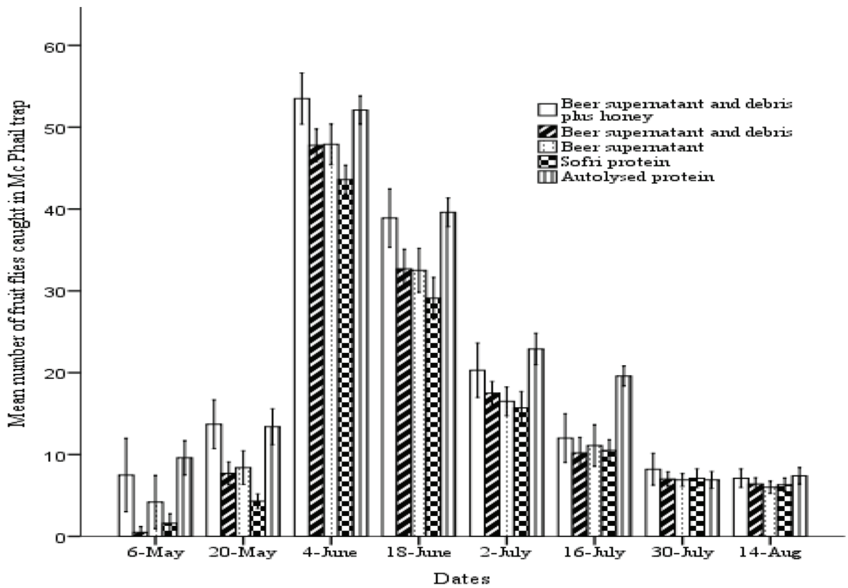

Figure. 1: Mean number of *B. minax* fruit flies (mean±SEM) captured in various bait materials during different observation dates at citrus orchard in NCRP, Paripatle, Dhankuta during May-August, 2015.

Efficacy assessment of baits as spot sprays

The effect of bait materials on mortality of male and female flies were tested using a generalized linear model using log-link function. The result obtained from statistical analysis of data has been depicted in Table 2A. The number of female and male flies killed within three hours varied significantly (bait factor: $\chi^2 = 93.01$, df = 5, $p < 0.05$) according to the bait materials used in spot sprays. However, similar number of male and female flies were killed on sprayed trees indicating insignificant ($\chi^2 = 1.47$, df = 1, p = 0.2) sex factor (Fig. 2). Similarly, there was no interaction between bait and sex factors ($\chi^2 = 1.371$ df = 5, p = 0.9).

Table 2: Statistics to analyze effectiveness of baits as spot spray

Source of variation	df	χ^2	P-value
A. Spot sprays- immediate effect			
Protein Bait	5	93.01	0.00
Sex	1	1.47	0.22
Protein Bait X Sex	5	1.31	0.93
B. Spot sprays –total effect			
Protein Bait	5	140.84	0.00
Sex	1	0.24	0.62
Protein Bait X Sex	5	0.24	0.99

(A) Adult flies found dead on the spot sprays during the first 3 hours after initial spray application (i.e. immediate effect), and (B) killed on the spot sprays until dead flies found dropped to zero on the spots (i.e., total effect) among the various baits tested (Bait factor), as function of flies sex (Sex factor).

The bar diagram shown in Fig.2 revealed that spot sprays of beer supernatant and debris (1:1) plus honey killed more number of male and female flies within three hours of treatment. Likewise, female flies were killed more than male in all baiting materials.

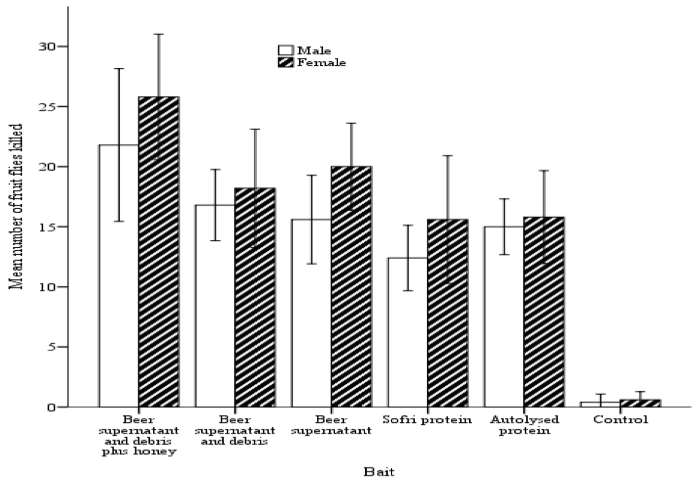

Figure. 2: Mean number of B. minax fruit flies (mean±SEM) killed by different bait materials as spot sprays within three hours after application in citrus orchard at NCRP, Paripatle during peak period (i.e., first week of June) in 2015.

As per the result depicted in Table 2B, total number of female and male flies killed on spot application (ie., until dead flies were no longer found on sprayed trees) differed significantly (bait factor: $\chi^2 = 140.84$, df = 5, $p < 0.05$) according to the baiting materials used. However, there was no significant difference in mortality of male and female flies ($\chi^2 = 0.24$, df = 1, p = 0.6). Despite of being statistically insignificant sex factor, spot sprays with all baiting materials killed more number of female than male flies (Fig. 3). Likewise, spot spray with beer supernatant and debris (1:1) plus honey killed more number of female and male flies than other baiting materials.

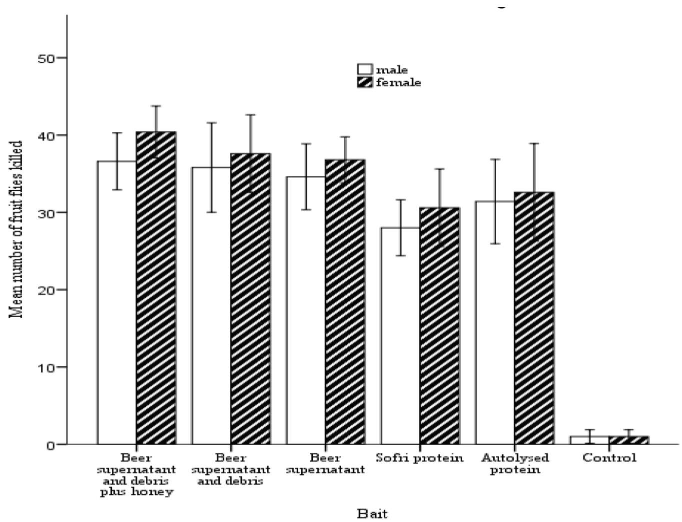

Figure. 3: Mean number of *B. minax* fruit flies (mean± SEM) killed by different bait materials as spot spray until dead flies dropped to zero level in citrus trees at NCRP, Paripatle during peak period (i.e., first week of June) in 2015

DISCUSSION

Application of bait/insecticides mixtures have been used with success in fruit fly management since many years throughout the world (Roessler, 1989). Protein hydrolysate bait mixed with parathion was first used in Hawaii (Steiner, 1952). Malathion was later used with protein hydrolysate baits successfully against Medfly (*Ceratitis capitata*) in Florida (Steiner et al., 1961). Drew et al. (2006) reported the effectiveness of various combinations of colors and shapes to *B. minax* in Bhutan. However, very little study has been conducted regarding application of protein baits for management of fruit fly in our country. Therefore, an attempt was made to test the response of *B. minax* flies to commercial protein baits and locally prepared bait. The study conducted to test the effectiveness of different baits for male and female flies *B. minax* showed that traps with beer supernatant and debris (1:1) plus honey trapped more flies followed by beer supernatant and debris (1:1), beer supernatant, sofri protein and autolysed protein. Hence, beer supernatant and debris (1:1) plus honey proved to be the most attractive bait to both sex of *B. minax* in McPhail traps. The present finding is in close agreement with Gopaul and Price (2000) who reported that there were no significant differences between the locally produced bait formulations and the imported bait in attracting the flies.

In this study, we found that beer supernatant and debris (1:1) plus honey was very effective on *B. minax* in both traps and spot sprays. However, protein-based baits used in traps may perform differently than when sprayed on tree foliage. Some proteins

sprayed on plants may be phytotoxic and thus may have to be diluted before potential use as spot sprays (Mangan et al., 2006), and protein mixtures containing ammonium acetate may not always work well for trapping purposes (Robacker et al., 1996).
The response of fruit flies to protein baits depends on their feeding status and sexual development (Robacker, 1991; Cornelius et al., 2000; Miller et al., 2004). Our study also indicated that highest number of female flies was trapped during June and it decreased drastically on July onwards. This could be due to the reason that adult emergence period of *B. minax* is from first week of April to third week of May in Dhankuta, and the egg laying period of *B. minax* ranges from 16th May to 16th July, reaching maximum on first week of June (Bhandari et al., 2017). Similarly, when females become sexually mature, they need proteins for the development of eggs. Therefore, more female flies might have been attracted to protein baits than male flies.

Our findings revealed that traps with protein baits captured more non-target insects than other lures. Thomas (2003) assumed the odor of protein baits might be the reason behind this. In our study, the non-target insects captured were mainly the species belonging to orders Diptera, Hymenoptera, and few Coleoptera and Lepidoptera, such as scarabs and moths. Among the order Diptera, the number of insects from families Muscidae, Calliphoridae, and Sarcophagidae were trapped. The pollinator insects like honey bees and other wild bees, were also trapped in small numbers. Thomas and Mangan (2005) and Desneux et al. (2007) believed when protein bait is used in sprays, these pollinators may feed on these baits and be affected or even killed by the effect of insecticides mixed. Looking to the further use of these baits against *B. minax* fruit flies, this problem can be resolved with the use of less toxic insecticides in bait spray.

Though various protein baits are available in our market, it costs very high NRs 15000 per litre (1 US$=NRs 118.0) and our marginal farmers can't afford the price. In this context, the locally prepared protein can be a promising bait to monitor *B. minax* fruit flies in citrus orchards and manage the pest when used as spot sprays. In addition, research in the preparation of local protein bait is continuing. The work reported here used laboratory grade papain enzyme which is expensive. Therefore, further research work needs to be done for reducing cost by using cheaper food-grade papain enzyme with minimum enzyme concentrations.

ACKNOWLEDGEMENTS
The authors would like to thank Nepal Agricultural Research Council and the staffs working at National Citrus Research Program (NCRP), Paripatle for the support during this research. Thanks to Yeti Brewery Pvt. Ltd. for providing brewery yeast

waste in conducting the research.

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AGRO-METEOROLOGICAL INDICES IN RELATION TO PHENOLOGY AND YIELD GAPS IN MAIZE CULTIVARS GROWN DURING SPRING IN INNER-TERAI, CHITWAN

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ABSTRACT

Temperature based agro-meteorological indices viz Growing Degree Days (GDD), Heat Use Efficiency (HUE) and Pheno-thermal Index (PTI) of maize were evaluated from the data sets of the field experiments conducted at National Maize Research Program, Rampur, Chitwan during January-July, 2019. Treatments of five sowing dates in horizontal strip and two pipeline cultivars in vertical strip were designed in strip- plot, replicated three times. The significantly higher heat unit (GDD) (2130.47-degree days) requirement at maturity stage of maize was observed on 1st February planting, whereas the lowest values of GDD (1774.07-degree days) for 12th March, which reduced significantly with subsequent delay in sowing date. The HUE (4.82 kg ha^{-1}day $^{o}C^{-1}$) and PTI (20.08-day ^{0}C day^{-1}) at maturity stage were found to be significantly higher in crop sown on March 12 and April 1. Physiological maturity of both genotypes of maize was well predicted using GDD and PTI which accounted for 95 % for OPV and 82 % for hybrid maize. Maximum grain yield(8.5 t ha^{-1}) was obtained when maize was planted on March 12 followed by April 1 (8.2 t ha^{-1}) and January 12 (7.4 t ha^{-1}), sowing which were significantly higher than the planting in February 1 and February 22. Hybrid RML 95/96 produced significantly higher yield (8.6 t ha^{-1}) than OPV ZM 401 (5.6 t ha^{-1}). Yield gap(38.83 %) was found significantly higher for OPVs than hybrid (33.0 %). Mean yield loss due to each cultivar was 9.74 %. By planting maize on March with RML 95/96, the stable heat use efficiency and higher grain yield were achieved and therefore, it could be concluded that hybrid is the best cultivar for spring planting at inner-terai condition of central Nepal.

Keywords: Growing Degree Days, Heat Use efficiency, Maize, Phenology, Pheno thermal index, Yield

INTRODUCION

Climatic parameters such as solar radiation, air humidity, precipitation, temperature, and wind speed, often determine the global distribution and productivity of crops and livestock (Ajadi et al. 2011). When growing maize, proper selection of varieties, management practices like planting dates, atmospheric condition like temperature and sunshine hours are considered key factors and has to be determined for higher yields (Khanal et al., 2019). It is also obvious that climate change and variability are foreseen to have direct and indirect effects on the existing agricultural production systems potentially threatening local, regional and/or global food security (Ajadi et al., 2011).

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In this line, several researchers have shown the influence of temperature on phenology and yield of crops and expressed it under field conditions through accumulated heat unit system (Sikdar, 2009). Plants including maize have a definite temperature pre-requisite before they attain certain phenological stages and to forecast the phenology and crop production attributes for a large acreage, there has been the development of crop models (Jones et al., 2003) which is relatively lacking in Nepal and negatively affected the crop yield (Amgain and Dhakal, 2019).

Models of agricultural systems, when coupled with appropriate data sources, have a great potential for bringing agricultural research and development into the age of information technology. Amongst the several crop models, agro-climatic model is very popular which simulates phenological development of crops and biomass accumulation based on light interception and temperature using degree-day accumulation; and agro- meteorological parameters could be managed safely by proper selection of crop varieties and planting dates. Temperature based agro-meteorological indices such as growing degree days (GDD), heat use efficiency (HUE) and pheno-thermal index (PTI) have been reported quite useful in predicting the growth and yield of crops (Jones et al., 2003). The heat unit system was adopted for determining the maturity dates of different crops (Bierhuizen, 1973) from which accurate yield and maturity prediction could be assessed. Thus, the information on the calculations of the heat summation unit (HSU), generally called the growing degree days and their further mathematical derivation like and heat use efficiencies (HUE) and Pheno-thermal index (PTI) will be the basic principle to understand the phenology and follow the proper planting times for different crop varieties over the spatial and temporal variations (Sreenivas et al., 2010).

Maize is ranked as second crop in production and productivity in Nepal (FAOSTAT, 2019). Planting date has direct influence on day and night temperature, light intensity, photoperiod which affect crop growth and yield (Akinnuove et al., 2017). Uneven distribution of rainfall, wind, lodging and prolonged drought during crop growing season are abiotic causes for reduction in yield (Khalili et al., 2013) Sowing date had a significant effect on yield and yield attributes of maize (Rahman et al., 2015). Hybrid maize was significantly better for grain yield, uniformity for plant height and ear height than OPVs (Sharma et al., 2007). There are several reports documented on sowing time and crop yield on winter maize (Amgain, 2015), but very few has analyzed and documented the specific reasons of yield fluctuation in different planting conditions in Nepal which is basically an agro-meteorology and physiology-based factors. By keeping the above facts in view, an attempt has been made to study the phenological behavior, heat use efficiency and pheno-thermal index of maize cultivars to obtain higher and stable grain yield.

MATERIALS AND METHODS

A field experiment was accomplished at National Maize Research Program, Rampur, Chitwan ($27^{0}37'$ north latitude, $84^{0}25'$ east longitude, and 256 masl.) during January-July, 2019. The study on maize was laid out in strip plot design with five sowing dates (January 12, February 1, February 20, March 12 and April 1) as horizontal factor, and two cultivars (OPV: ZM401, hybrid: RML 95/RML 96) in vertical factor as treatments along with three replications.

The daily weather data were procured from meteorological station of National Maize Research Program, Rampur, Chitwan. The average data of different weather parameters i.e., maximum and minimum temperatures, total rainfall and relative humidity recorded during the maize growing season at NMRP are presented at an interval of two weeks in Figure 1. There was record of heavy winds on April by which the crop sown on the early dates were lodged.

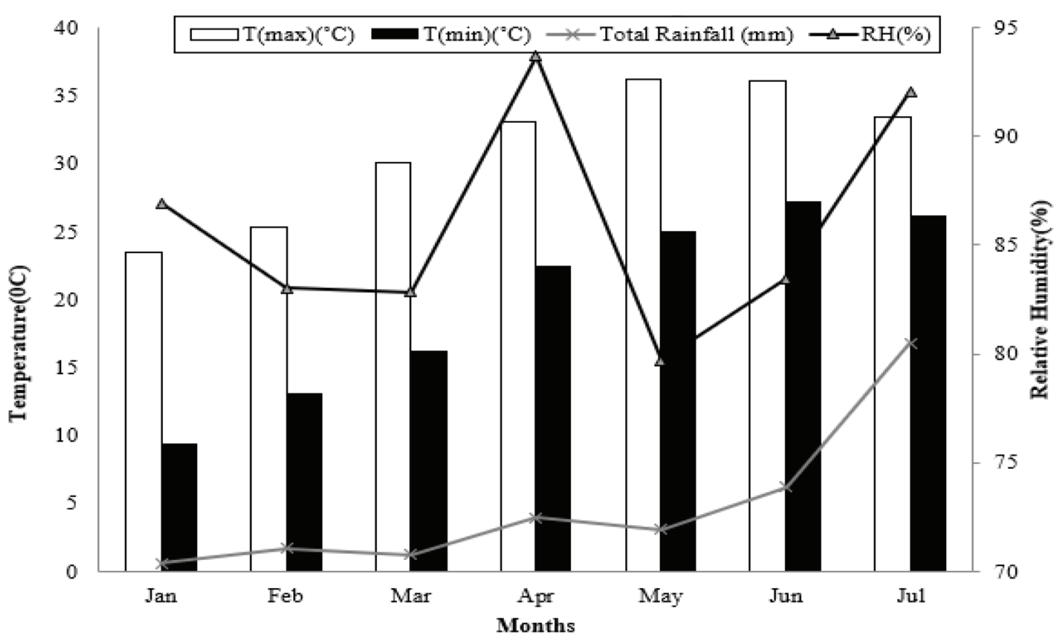

Figure 1: Weather condition during the maize experimentation at NMRP, Rampur Chitwan, 2019

Maize crop was grown as per the recommended practices developed by NMRP (2009).

The data were recorded on the major phenological stages i.e., emergence, tasseling, silking, and physiological maturity, and yield and dry matter were taken as standard international protocol of CIMMYT, in which five fixed maize plants in each plot were randomly selected from emergence and fixed up to the physiological maturity stages to visualize their different pheno-phases and data were recorded after 50% maturity of each developmental stages. The various measurements of accumulated heat units were calculated according to the following formulae given by Rao et.al (2000).

1. Growing degree days (GDD) = {(T max + T min) ÷2}-Tb
   (Tb= Base temperature=10^0C)
2. Heat use efficiency (HUE) = Grain yield (kg ha^{-1}) ÷ GDD
3. Pheno-thermal index (PTI) = GDD ÷ Growth days (calendar days)

Grain and stover yields were recorded from 10 m^2 net area and yield was converted in t ha-1 maintaining 14% seed moisture in the grain. Regression and correlation analysis was done with calendar days and phenology of maize cultivars sown for different dates. Yield gap was obtained dividing grain yield by total average yield and expressing into percentage as yield gap percentage. ANOVA was used to compare the data and DMRT was used when comparing the treatment mean using RSTAT statistical packages (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growing degree days (GDD)

Growing degree days showed that days for the attainment of different phenological stages differed significantly from cultivar to cultivar and sowing dates (Table 1).

The stable temperature and sunshine hours at the early vegetative phases of maize was resulting in increased number of days (5-10) for attaining different phenological stages under early planting than later planting. Due to higher temperature, late planting decreased the duration of phenology as compared to early planting. The similar results have been noted in spring maize (Khanal et al., 2019) and in winter maize (Amgain, 2011). Higher heat unit (GDD) was observed in late sowing than in early sowing except at physiological maturity (Table 1). This was supported by Shrestha et al. (2016) in which late spring planted maize had higher growing degree days 1007^0C at anthesis and 1072^0 C at silking than early spring because of higher daily average temperature. Likewise, Nielsen et al. (2002) also reported that there was decreased on additional 110 GDDs with late plantings maize at physiological maturity stage in eastern belt of USA.

Table 1. Growing degree days (GDD) during different pheno-phases of maize in Chitwan

Treatments	GDD (degree days) for 75% of phenological stages			
	Emergence (^{0}days)	Tasseling (^{0}days)	Silking (^{0}days)	Physiological maturity (^{0}days)
Sowing dates				
12th January	96.27	936.50^{c}	1034.52^{b}	1948.78^{b}
1st February	79.12	1004.94^{b}	1075.30^{b}	2130.47^{a}
20th February	114.50	1067.62^{a}	1138.57^{a}	1907.60^{bc}
12th March	91.29	1076.94^{a}	1167.62^{a}	1774.07^{c}
1st April	91.52	1060.88^{a}	1146.63^{a}	1908.57^{bc}
LSD $_{(=0.05)}$	22.77	47.87	53.94	109.98
CV $_{\%}$	18.09	3.49	3.64	3.62
Cultivars				
ZM 401	89.19^{b}	1000.04^{b}	1084.52^{b}	1859.63^{b}
RMl95/ RML96	99.89^{a}	1058.71^{a}	1140.53^{a}	2008.17^{a}
LSD $_{(=0.05)}$	3.28	15.76	11.73	133.64
CV $_{\%}$	2.21	0.97	0.70	3.67
Grand mean	94.54	1029.38	1112.53	1933.90

Note: ^{0}days, Degree days; CV, coefficient of variation; LSD, least significant difference; treatments mean followed by common letter(s) are not significantly different from each other based on DMRT at 5% level of significance.

Heat use efficiency and pheno-thermal index

Heat use efficiency is directly proportional to higher grain yield and lower GDD. The result revealed that Hybrid RML 95/ RML 96 showed higher HUE (5.67 kg/ ^{0}C) on 12 March sowing as grain yield was found higher (8.56 t ha^{-1}) in March 12. Similarly, in March 12 sowing there was existence of higher temperature (above 30^0 c) due to which phenological stages can easily completed with lower GDD. Thus, higher yield and lower GDD causes higher heat use efficiency in March 12. (Table 2). However, the heat use efficiency was higher with early sowing and reduced with late sowing because of the decrease in vegetative phase but the climatic threat cause reduction of HUE in early phases.

Likewise, Hybrid (RML 95/ RML 96) showed higher heat use efficiency than OPVs as hybrid cultivars were more heat use efficient than OPVs. This result was also supported by Kingra and Kaur (2012).

Higher PTI for all growth phases was observed in late sowing than in early sowing (Table 2). This finding was similar to Navaprakaash et al. (2007), who reported that phenological phases were attained earlier in late spring season and also relatively higher GDD values within short period influenced higher PTI values.

Table 2. Heat use efficiency and pheno-thermal index of maize cultivars in Chitwan during 2019.

Treatments	HUE ($ha^{-1} day^{o}C^{-1}$) Emergence (Day ^{0}C day^{-1})	PTI for 75% of phenological stages Tasseling (Day ^{0}C day^{-1})	Silking (Day ^{0}C day^{-1})	PM (Day $^{0}C day^{-1}$)	
Sowing dates					
12th January	3.77^{b}	6.27^{e}	10.63^{e}	11.03^{e}	13.97^{e}
1st February	2.31^{c}	7.91^{d}	12.69^{d}	12.95^{d}	15.91^{d}
20th February	2.37^{c}	10.05^{c}	14.85^{c}	15.13^{c}	17.02^{c}
12th Mar	4.82^{a}	14.80^{b}	17.31^{b}	17.51^{b}	18.60^{b}
1st Apr	4.29^{ab}	17.23^{a}	19.05^{a}	19.21^{a}	20.08^{a}
LSD(0.05)	0.56	0.53	0.13	0.18	0.32
CV (%)	11.99	3.54	0.70	0.93	1.43
Cultivars					
ZM 401	2.92^{b}	11.19	14.81^{b}	15.07^{b}	16.98^{b}
RML 95/RML96	4.11^{a}	11.31	15.01^{a}	15.26^{a}	17.25^{a}
LSD $^{(=0.05)}$	0.31	0.76	0.12	0.05	0.17
CV, $^{\%}$	5.62	4.30	0.51	0.20	0.63
Grand mean	3.51	11.25	14.91	15.17	17.12

Note: Kg, kilogram; ^{0}c, Degree centigrade; ha, Hectare CV, coefficient of variation; LSD, least significant difference; treatments mean followed by common letter(s) are not significantly different from each other based on DMRT at 5% level of significance.

Grain and stover yields of diverse maize cultivars grown under staggered planting

Hybrid maize cultivars sown on 12 March has been producing higher yield (Table 3). Yield advantage observed in the hybrid maize is linked to their maximum leaf growth, leaf area duration, and effective leaf area than the OPV. Higher assimilatory surfaces and high leaf angle of hybrid that could facilitate diffusion of light into the lower portion of canopy. These results were supported by Kabir (1988) and Torigoe et al. (1986).

March 12 sowing produce higher yield due to moderate climate with adequate amount of sunshine and low wind velocity which reduce lodging of maize also higher cob numbers and greater kernel numbers per plant at March sowing. Lower yields in early sowing due to source limitation caused by smaller leaf area, lower daily and seasonal intercepted photosynthetically active radiation, and cooler temperatures This result was supported by Stone et al., (1999).

Stover yield was higher in early spring sowing, but decreased in late spring because of the prolonged growing in early sowing. However, low stover yield in February planting due to high wind and lodging threat to maize crop reduce the plant population due to decay of plant ultimately low stover yield in February planting than others month. These results are similar with Tsimba et al. (2013), who reported that high temperature in late sowing cause disruption of photosynthesizing tissue and inability of a tissue or an organ to mobilize photo-assimilates.

Table 3. Grain and stover yield of maize cultivars in Chitwan.

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
Sowing dates		
12th January	7.46^{a}	12.08^{a}
1st February	4.99^{b}	9.48^{b}
20th February	4.51^{b}	8.71^{b}
12th Mar	8.56^{a}	10.00^{b}
1st Apr	8.21^{a}	10.13^{b}
LSD $^{(=0.05)}$	1.26	1.85
CV, %	14.05	13.80
Cultivars		
ZM 401	5.33^{b}	8.57^{b}
RM 95/RML96	8.16^{a}	11.58^{a}
LSD $^{(=0.05)}$	0.77	2.47
CV, %	7.27	15.66
Grand mean	6.75	10.08

Note: Treatments mean followed by common letter(s) within same column are not significantly different from each other based on DMRT at 5% level of significance.

Relationship between number of cobs and grain yield

Number of cobs per hectare had the positive co-relation with grain yield and has 68.41% coefficient of determination. That means number of cobs determines 68 .41% of grain yield of maize.

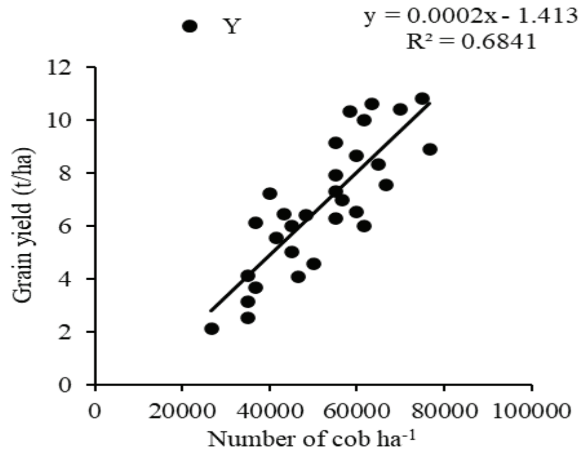

Figure 2. Simple linear regression relationships between number of cobs and grain yield as influenced by sowing dates and varieties at NMRP, Rampur, Chitwan, Nepal during 2019

Correlation and regression between maize yield and phenology

Correlation between the pheno-phases and PTI indicated that significant relationship between pheno-phases and PTI were obtained during emergence to physiological maturity stage of both hybrid and OPV maize cultivars, while relationship between pheno-phases and GDD was found to be negatively correlated and non-significant during emergence to physiological maturity except tasseling (0.30) for OPVs and non-significant during emergence to physiological maturity for hybrid (Table 4).

Table 4. Correlation coefficients between calendar days and GDD and PTI during different pheno-phases of maize under different planting date.

Pheno-phases	OPV		Hybrid	
	GDD	PTI	GDD	PTI
Emergence	-0.65	0.64	-0.36	0.50
Tasseling	0.30	0.54	-0.18	0.34
Silking	-0.80	0.55	-0.01	0.34
Physiological Maturity	-0.80	0.47	-0.39	0.32

In case of early sowing, the accumulation of less temperature for both OPV and hybrid genotypes, but was found to increase steadily in case of later sowing. The average temperature (22c) recorded in various time was depicted and mentioned in Figure 1. The correlation was found variable and non-significant on GDD during emergence to physiological maturity due to fluctuation of temperature and sunshine hours during the longer vegetative phase of different maize cultivars sowing in different dates. OPVs maize being quite longer in duration than hybrid, and, hence tasseling stages was found to be significantly correlated.

Further negative regression equations were obtained to predict the phenology of maize using GDD and PTI in both maize genotypes reported as under:

OPV	Y= -55.33 -0.04 GDD+ 4.32PTI	$R^2 = 0.95$
Hybrid	Y= -88.24 -0.05 GDD+ 6.19 PTI	$R^2 = 0.82$

In order to forecast the phenology of two cultivars of maize step wise regression analysis was employed involving the agro-meteorological factors prevailing during sowing to physiological maturity of both cultivars. Results gave one model for OPV and next model for hybrid in predicting the phenology of maize using accumulated GDD and pheno-thermal index during emergence to physiological maturity. Therefore, for OPVs 95% physiological maturity can be predicted, while for hybrid maize 82% physiological maturity can be predicted.

Yield gap analysis

Mean yield loss of OPVs was 14.90 % and that of hybrid was 10.98 % which means yield loss was higher in OPVs than in hybrid (Figure 3). Similarly, yield gap was significantly higher in OPVs (38.18%) than in hybrid (33.0 %). Mean yield loss and yield gap of hybrid maize was less as, hybrid is easier and faster to grow, they adapt better to climatic stress, and they produce plants with higher yields, disease resistance, and longer shelf life than OPVs. Generally, a hybrid will produce 18% more grain than most of the better OPV (Pherson, 2011).

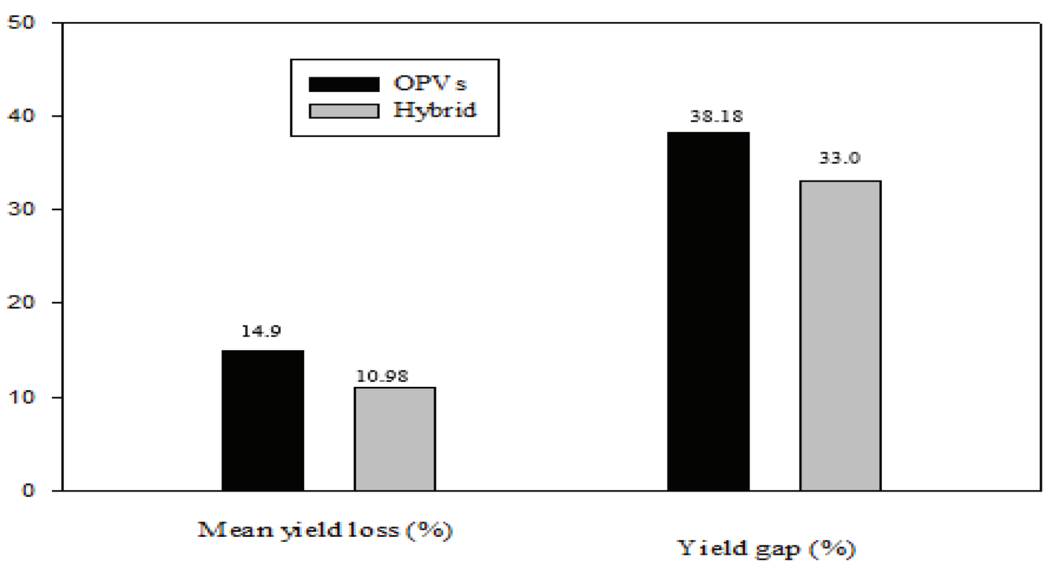

Figure. 3 Mean yield loss percentage and yield gap percentage of maize cultivars as influenced by sowing dates at NMRP, Rampur, Chitwan, Nepal during 2019.

CONCLUSION

GDD for maize required to reach various phenological stages was higher in early spring than late spring plantings. Higher GDD and short days to reach to different phenological stages cause higher pheno-thermal index in late spring. Physiological maturity can be predicted using GDD and PTI in maize cultivars of diverse genotypes if agro-meteorological indices are calculated precisely. By planting maize on March, the stable heat use efficiency and higher grain yield were achieved. RML 95/96 had less yield reduction with stable HUE over the planting dates, and, therefore it could be concluded that hybrid is the best cultivar for spring planting at inner-terai condition of central Nepal.

ACKNOWLEDGEMENTS

The data sets presented in this study was taken from the M Sc Ag experimentation of the first author being done at NMRP, Rampur farm. The supportive helps on seeds, fertilizers laborers and the daily weather records to accomplish this study from NMRP Rampur was kindly thankful. Juniors from the M. Sc. Ag. Agronomy of 2018 batch are also equally acknowledged for helping in bio-monitoring activities.

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FACTORS AFFECTING THE ADOPTION OF ORGANIC VEGETABLE PRODUCTION IN KAVREPALANCHOWK DISTRICT, NEPAL.

Tilak Raj Chaulagai[1]

ABSTRACT

Organic agriculture sector has increased in past decades due to increasing awareness of its positive impact on health and the environment. The rate of adoption of organic farming in Nepal is observed at a much slower rate than expected. This study assesses the factors that determine adoption of organic vegetable farming by Nepalese farmers. The study was conducted in Kavrepalanchowk District of the country. A logistic regression analysis was used to analyze the effect of selected 17 variables on the adoption decision. Result suggested that better educated farmers with greater awareness of the impact of non-organic products on public health and the environment are likely to adopt organic vegetable farming. Other variables including age, gender, participation in extension activities, visits to extension workers, farm size, family size, affiliation to farmers' organizations, number of organic farms in the vicinity, external support availability, price perception, cost of production, availability of collection centers, distance to market center, availability of external inputs and organic fertilizers were non-significant. The result suggests that better education and farmers' awareness raising programs regarding the health and environmental benefits of organic farming helps foster this sector.

Keywords: Farm characteristics, Farmer's characteristics, Logistic regression, Organic farming, Socio-economic factors

INTRODUCTION

Nepalese economy bases primarily on agriculture. About 66 per cent of the populations living in rural areas depend on agriculture for their livelihoods (CBS, 2011). The country possesses a diverse array of topographies ranging from plain area to high mountains. The majority portion of the country is hilly. About 3091 thousand hectares of land are under the agricultural use, which is about 21 percent of the total land area of the country (MOALD, 2020). Agricultural land is fragmented and scattered. The average size of holding per household of the country is merely 0.7 hectares and the average number of parcels is 2.9 (CBS, 2011).

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The growth of the organic sector in the country has relatively short history. The establishment of commercial organic farms in Nepal has started in the early 1990s (Pokharel and Panta, 2009), but the area under organic agriculture and the total number of organic producers have not been increasing at a remarkable rate. For instance, the total area under organic agriculture was 7762 hectares in 2006, which had increased to 9789 in 2010; the total organic producers were 1183 in 2006, which had increased to 1470 in 2010 (FiBL, 2013).

Nepalese organic sector is characterized with slow adoption of organic farming, poor market infrastructure development and limited resource availability (Bhatta et al., 2008). The term "organic farming technology" sounds like a new farming system in the Nepalese context; however, the concept is not new in farming practices. Over a century, resource-poor and subsistence farmers have been practicing organic farming in a traditional way.

The growth of the organic sector holds immense importance due to the large domestic and international market possibility. Existing Nepalese agriculture development policies have also paid greater attention to the organic farming. Karnali Province of Nepal has declared itself an organic state and has formulated and enacted Karnali Province Organic Agriculture Act, 2019 (MLMAC, 2076) for the implementation of organic programs in the state. Growing concern over whether or not food is safe has opened new opportunity for organic products, especially fresh vegetables. This implies that the organic vegetable sector could present a remarkable alternative for raising the standard-of-living conditions of the Nepali people. Due to the poor market infrastructure and road facilities, the organic vegetable growers concentrate in the adjoining areas of the city centers, and the city residents are the major consumers of the organic vegetables. Enact

I conducted the study in Kavre District of Nepal which is the main vegetable suppliers of Kathmandu Valley, the largest market center of the country. Generally, the farmers in the study area grow cereals and vegetables using traditional methods. The farmers have been using a huge amount of fertilizers and pesticides to produce vegetables. The produces are basically sold to consumers in the Kathmandu Valley. However, some of the farmers in the district have been growing vegetables safely without using chemical fertilizers and pesticides. In Nepal, certified organic production system is in very primitive stage. For instance, as of 2019 data the total area under organic farming in Nepal was only 9,360 ha that is merely 0.02 percent of total agricultural land area of the country (FiBL, 2021). Therefore, in this study, the safe vegetable production, a production system without using pesticides has been considered as the organic system of production based on the method of cultivation. In this regard, this study aims to assess the important factors governing the organic vegetables adoption decision of the farmers.

METHODOLOGY

Measurement of variables

Eighteen variables (17 independent and one dependent) were selected for the study. Some of the variables was measured directly and other variables using the items as suggested by previous studies. The farmers' health and environmental awareness were measured using the items as suggested by (McCann et al., 1997) in five points Likert scales where 1 indicating strongly disagree and 5 indicating strongly agree. The three additional items (from 8 to 10) was proposed to measure the 'health and environmental awareness' construct. The items adopted from (McCann et al., 1997) were as follows:

1. Farmer's decisions can have an important effect on the environment.
2. Agricultural pollution is a serious environmental problem.
3. Agricultural pollution is a serious threat to human health.
4. Soil erosion is a serious problem in Nepal.
5. Soil erosion is a serious problem on your farm.
6. Pollution from the use of agricultural chemicals is a serious problem in Nepal.
7. Pollution from the use of agricultural chemicals is a serious problem on your farm.
8. The application of the chemical pesticides is hazardous to the user.
9. The use of chemical fertilizers deteriorates the soil quality.
10. The use of chemical pesticides deteriorates the soil quality.

Definition and measurement of other variables are presented in Table 1.

Table 1: Definition and Measurement of Variables

S.N.	Variables Name	Definition	Measurement scale
1	Edu (X1)	The level of education of the farmer (the number of years of formal education)	Continuous variable
2	Age (X2)	The age of the farmer in years	Continuous variable
3	Gender (X3)	The gender of the farmer	=1 for male, =0 for female
4	Part_ext (X4)	Participation of the farmer to extension activities – training, exposure visit, demonstration, workshop, seminar	=1 if the farmer has participated any of the extension activities before, =0 otherwise
5	Visit_ext_worker (X5)	Number of visits of the farmer to the extension worker	Continuous variable
6	Heal_env_cons (X6)	Health and environmental consciousness of the farmer	Continuous variable – defined by the items, which were measured in 5 points likert scale (Higher value = higher level of health and environmental consciousness of the farmer)
7	Farm_size (X7)	The size of the farm (ropani[1])	Continuous variable
8	Avail_flabor (X8)	Number of family member available for vegetable farming	continuous
9	Affi_org (X9)	Affiliation of the farmer to farmer's organization and/or group	=1 if the farmer is a member of farmer's organization and/or group, =0 otherwise
10	No_org (X10)	Number of organic farms within the ward[2] where the farmer's field belongs	Continuous variable
11	Avail_ext_sup (X11)	Availability of external support in the form of either subsidy, seed or fertilizer to the farmer	=1 if available, =0 otherwise
12	Price (X12)	Perceived price of organic vegetables compared to conventional vegetables	=-1 if the perceived price of organic is lower, =0 if same, =1 if higher
13	Collect_centre (X13)	Availability of collection center with in one kilometer periphery of the farmer's field	=1 if available, =0 otherwise
14	Dist_market (X14)	Distance of the farm from the market center (in Kilometers)	Continuous variable
15	Avail_ext_input (X15)	Availability of external organic inputs including fertilizers and pesticides	=1 if external input was not at all available, = 2 if available but not sufficient, = 3 if available in required quantity and at required time

2*Ropani: a measurement unit for land area; 1 ropani = 0.05 hectares; 20 ropanies = 1 hectare*

3VDC ward: a then Village Development Committee (VDC) comprised with 9 wards. Now, VDC has changed into Rural Municipalities (RM) after the implementation of Federal System in Nepal since, 2015. A RM is the lowermost political unit of the country, which has certain boarder. VDCs contribute to a District and the Districts contribute to the country. There are 77 districts in Nepal.

S.N.	Variables Name	Definition	Measurement scale
16	Amt_dom_fert (X16)	Amount of domestically produced fertilizers including FYM and compost	=1 if a farmer was not at all producing, = 2 if producing but sufficient for less than half of the farmer's field, = 3 if producing and sufficient for more than half of the farmer's field, = 4 if sufficiently producing
17	Cost_prod (X17)	Perceived cost of production of organic vegetables compared to conventional vegetables	= -1 if the cost of production of organic vegetable was lower, =0 if same, =1 if higher
18	Method_culti (Y)	Method of cultivation	=1 if producing organically, =0 if producing conventionally

The dependent variable (Yi) 'has been adopting the organic farming or not' was measured by asking for three alternatives namely – organically or conventionally or both. For the analysis purpose, if a farmer was growing the vegetables by employing the organic methodology in one field and conventional methodology in another piece of land, he/she was considered as an organic farmer. The farmer who was growing the vegetables only conventionally was considered as a conventional farmer.

Data collection

Data was collected from the farmers in Kavre district following a sample survey using a structured questionnaire in local Nepali language. The survey was conducted during 2013. The sample farmers were selected using stratified random sampling technique. The total sample size was 114 including 41 conventional and 73 organic farmers.

Empirical estimation

The variables was assessed simultaneously by employing them into a single model. logit model was used because the dependent variable was a binary, adopting organic or conventional method of cultivation. A binary choice model assumes that individuals are faced with a choice between two alternatives and that the choice depends on identifiable characteristics (Pindyck and Rubinfeld, 1998). The logit model predicts the likelihood of performing certain behavior. The model is to determine the probability that an individual with a given set of attributes will make one choice. The following paragraphs include the basic concepts of the logit model (adapted from Pindyck and Rubinfeld, 1998).

Logit model is based on the cumulative logistic probability function and is specified as

$$P_i = F(Z_i) = F(= = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Where, P_i is the probability of an event (probability of adopting organic vegetable farming). We assume that there exists a theoretical continuous index Z_i, which is determined by the explanatory variable *X*.

Thus, we can write

$$Z_i =$$

Z_i is not an observed variable. Instead, it is a latent variable. Data used to distinguish an individual observation is in one category (high values of Z_i) or in the second category (low values of Z_i). Furthermore, in equation (i), *e* represents the base of natural logarithms, which is approximately equal to 2.718. P_i is the probability that an individual will make a certain choice (either organic or conventional vegetable production), given X_i. Logit model solved the problem to obtain the estimates for the parameters.

The theoretical index $Z_i =$ is for a single explanatory variable *X*. We can extend the function for *n* number of variables (n = 18 in this study) as follows,

$$Z_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots + \beta_{18} X18_i$$

As, the logit model is non-linear in parameters we cannot use ordinary least square estimates. Instead, we use Maximum-Likelihood (ML) method to estimate the parameters.

Prediction with Logit Model

The expression for the logit model is,

$$P_i = \text{-----------} \text{ (where)}$$

The model predicts the probability on $Y_i = 1$ and the outcome ranges between 0 and 1. It does not give $Y_i = 1$ or $Y_i = 0$ as outcome, but approximates these outcomes with a probability. For making the decision on whether the respondent chooses an option ($Y_i = 1$) or not ($Y_i = 0$), Pindyck and Rubinfeld (1998) have suggested a rule of thumb with a cut-off point 0.5. This implies that,

if predicted $P_i > 0.5$, then $Y_i = 1$ and,
if predicted $P_i \leq 0.5$, then $Y_i = 0$

Quality of Logit Model

To obtain the measure of goodness of fit *McFadden's* R^2 is used, which is defined as,

$$McFadden's\ R^2 = 1 - L(\beta^*)/L(0) \text{------------------------- (ii)}$$

Where,

$L(\beta^*)$ is the value of log-likelihood function of estimated model, and

$L(0)$is the value of log-likelihood function with all parameters zero, except intercept (i.e. the model with only intercept).

The *McFadden's* R^2 is also known as *Likelihood Ratio (LR) index* or *Pseudo* R^2. The *McFadden's* R^2 has a value between 0 and 1. When the model predicts all outcomes perfectly, then $L(\beta^*) = 0$ and *McFadden's* $R^2 = 1$. When βs do not add to the model, then $L(\beta^*)=L(0)$ and *McFadden's* $R^2 = 0$. Usually, the *McFadden's* R^2 is not very high, and the value in range of 0.1 – 0.5 is considered as normal.

Another indicator to measure the goodness of fit is *Count* R^2, which is defined as,

Count R^2 = ---------------(iii)

Usually the *Count* R^2 is very high because there are always a number of predictions correct, even without a model.

Marginal Effects

If we are interested to measure the effect of a marginal change in one of the independent variables (say X_{ij}) on the probability of prediction (P_i), we have to follow the relation as,

$_j .P_i (1 - P_i)$, this gives

$\delta P_i = \beta j \,.\, Pi\ (1\text{-}Pi)\ .\delta X_{ij}$-- (iv)

The estimates of the parameters are not the marginal effects in Logit model. Marginal effects depend on initial probability for observation and are valid for small changes only. For big changes, we have to make a new prediction for observation.

RESULTS

Sample characteristics

Table 2 depicts the analysis of mean differences of variables under study between conventional and organic farmers. Out of the seventeen independent variables under study, the mean differences of only two variables namely 'education' and 'health and environmental consciousness' were significant between the organic and conventional farmers (Table 2: edu P-value 0.0002; heal_env_cons P-value 0.0001) . This implied that organic farmers were more educated (Table 2: conventional only mean edu 6.73; organic mean edu 9.56) and conscious about the health and environmental issues (Table 2: conventional only mean heal_env_cons 3.72; organic mean heal_env_cons 4.21) than the conventional farmers were. With respect to the other variables, the organic and conventional farmers were statistically similar (Table 2: P-values >0.1 for those variables).

Table 2: Comparison of the variables between conventional and organic respondents

Variables	Conventional only			Organic			t-test for Mean difference		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Mean Difference	t-value	Sig. (P-value) 2 tailed
age	41	40.88	11.38	73	39.37	8.43	1.51	0.81	0.4219
edu	41	6.73	4.07	73	9.56	3.64	-2.83	-3.82	0.0002
gender	41	0.73	0.45	73	0.68	0.47	.05	0.52	0.6042
part_ex	41	0.46	0.50	73	0.60	0.49	-.14	-1.44	0.1537
visit_ext_~r	41	1.85	1.54	73	2.64	3.05	-.79	-1.55	0.1244
farm_size	41	8.07	5.68	73	7.75	7.22	.33	0.25	0.8043
avail_labor	41	3.24	1.26	73	2.97	1.49	.27	0.98	0.3272
affil_org	41	0.66	0.48	73	0.78	0.42	-.12	-1.42	0.1575
no_org	41	0.17	0.54	73	0.95	4.14	-.77	-1.12	0.2370
avail_ext_~p	41	0.61	0.49	73	0.59	0.52	.02	0.21	0.8306
price	41	0.39	0.67	73	0.19	0.70	.20	1.47	0.1424
collect_ce~e	41	0.58	0.50	73	0.63	1.31	-.04	-0.47	0.6410
dist_market	41	8.48	10.34	73	9.33	11.31	-.85	-0.39	0.6929
avail_ext_~t	41	1.75	0.49	73	1.91	0.57	-.16	-1.52	0.1301
amt_dom_fert	41	2.88	1.05	73	2.93	0.84	-.05	-0.29	0.7668
cost_prod	41	-0.58	0.59	73	-0.38	0.72	-.20	-1.53	0.1290
heal_env_c~s	41	3.72	0.78	73	4.21	0.48	-.49	-4.12	0.0001

Analysis of measurement intruments

The variable 'health and environmental consciousness' of the farmers were measured using 10 items. The Principal Component Analysis (PCA) was performed to see whether the selected items measured the construct or not. PCA revealed a clear single factor solution (the first two eigenvalues 4.282; 0.877) explaining 55.25 percent variance in the construct. Scree plot further supported the one component solution (Figure 1).

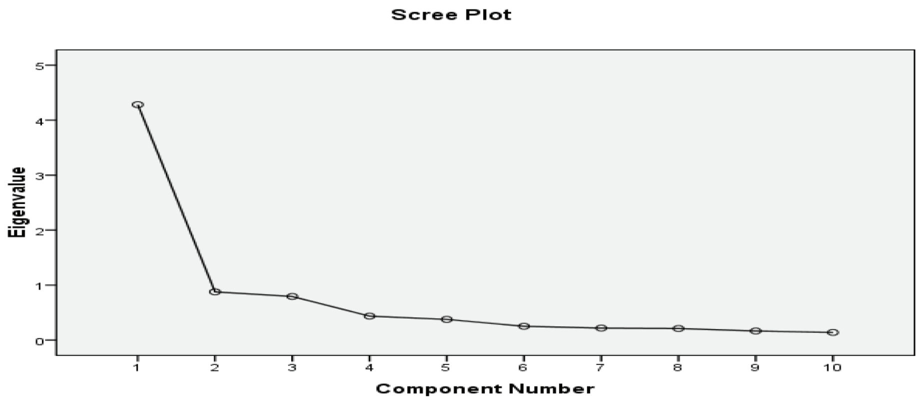

Figure 1: A Scree Plot Showing the Relation between the Eigenvalues and Components

Table 3: Component Matrix

Items	Component	
	1	2
pro_dec_env	.480	.508
env_pollu	.588	
human_health	.603	
soil_ero_country	.816	
soil_ero_farm	.638	
che_pollu_country	.704	
che_pollu_farm	.527	
pesticide_health	.684	
cfert_soil	.661	
pesticide_soil	.767	

Extraction Method: Principal Component Analysis. a. 3 components extracted.

Component matrix (Table 3) also revealed a single component solution largely. Only 'pro_dec_env' item loaded into the second component as well. Furthermore, reliability analysis showed that the items were internally consistent (Cronbach's Alpha 0.906). Based on the results of PCA and reliability analysis, I decided to use all the ten items to measure 'health and environmental consciousness' construct.

Logistic regression analysis

Logistic regression was used to see their effect of 17 variables on the adoption decision of the farmers for organic vegetable farming. The results showed that the level of education, farmers health and environmental consciousness were positively and significantly affecting the organic farming adoption decision of the farmers (Table 4: edu Coef 0.2314; P=0.004; heal_env_cons Coef 1.407; P=0.006). The result implies that the higher the level of education of a farmer the more will be the chance of adopting organic vegetable farming. Similarly, the more a farmer conscious about the health and environment, the greater will be the chance of adopting organic vegetable farming by him/her.

Table 4: Method of Cultivation as a Function of Farmer's Characteristics, Farm Characteristics and Socio-economic Variables

Iteration 0: log likelihood = -74.466629

Iteration 5: log likelihood = -55.398529

Logistic regression	Number of obs	=	114
	LR $chi^2(17)$	=	38.14
	Prob> chi^2	=	0.0024
Log likelihood = -55.398529	Pseudo R^2	=	0.2561

<table>
<tr><th>method_culti |</th><th>Coef.</th><th>Std. Err.</th><th>z</th><th>P>|z|</th><th colspan="2">[95% Conf. Interval]</th></tr>
<tr><td>age |</td><td>-.0101218</td><td>.0281231</td><td>-0.36</td><td>0.719</td><td>-.0652421</td><td>.0449984</td></tr>
<tr><td>edu |</td><td>.2314406</td><td>.0806742</td><td>2.87</td><td>0.004</td><td>.0733221</td><td>.3895592</td></tr>
<tr><td>gender |</td><td>-.3070366</td><td>.621672</td><td>-0.49</td><td>0.621</td><td>-1.525491</td><td>.9114181</td></tr>
<tr><td>part_ext_times|</td><td>-.0220987</td><td>.1514276</td><td>-0.15</td><td>0.884</td><td>-.3188914</td><td>.274694</td></tr>
<tr><td>visit_ext_worker |</td><td>.0319251</td><td>.0952046</td><td>0.34</td><td>0.737</td><td>-.1546725</td><td>.2185227</td></tr>
<tr><td>farm_size|</td><td>-.0493185</td><td>.0425582</td><td>-1.16</td><td>0.247</td><td>-.1327311</td><td>.0340941</td></tr>
<tr><td>avail_labor |</td><td>-.029527</td><td>.1854792</td><td>-0.16</td><td>0.874</td><td>-.3930597</td><td>.3340056</td></tr>
<tr><td>affil_org |</td><td>.2980424</td><td>.6616866</td><td>0.45</td><td>0.652</td><td>-.9988395</td><td>1.594924</td></tr>
<tr><td>no_org |</td><td>.137623</td><td>.2897121</td><td>0.48</td><td>0.635</td><td>-.4302022</td><td>.7054482</td></tr>
<tr><td>avail_ext_sup |</td><td>.0492113</td><td>.5655292</td><td>0.09</td><td>0.931</td><td>-1.059206</td><td>1.157628</td></tr>
<tr><td>price |</td><td>-.6620196</td><td>.4281099</td><td>-1.55</td><td>0.122</td><td>-1.501099</td><td>.1770603</td></tr>
<tr><td>collect_certre|</td><td>-.2875455</td><td>.5659289</td><td>-0.51</td><td>0.611</td><td>-1.396746</td><td>.8216548</td></tr>
<tr><td>dist_market |</td><td>.0400264</td><td>.0258125</td><td>1.55</td><td>0.121</td><td>-.0105651</td><td>.090618</td></tr>
<tr><td>avail_ext_input |</td><td>.1915652</td><td>.5265296</td><td>0.36</td><td>0.716</td><td>-.8404138</td><td>1.223544</td></tr>
<tr><td>amt_dom_fert |</td><td>.1660302</td><td>.2833312</td><td>0.59</td><td>0.558</td><td>-.3892889</td><td>.7213492</td></tr>
<tr><td>cost_prod |</td><td>.567985</td><td>.4542821</td><td>1.25</td><td>0.211</td><td>-.3223916</td><td>1.458362</td></tr>
<tr><td>heal_env_cons |</td><td>1.407132</td><td>.5140201</td><td>2.74</td><td>0.006</td><td>.3996708</td><td>2.414593</td></tr>
<tr><td>_cons |</td><td>-6.744816</td><td>2.777294</td><td>-2.43</td><td>0.015</td><td>-12.18821</td><td>-1.30142</td></tr>
</table>

Measuring the Quality of the Model

The *Pseudo* R^2 was 0.2561 (Table 4) implying that the independent variables altogether explained around 26% variation in the organic vegetable adoption decision of the farmers.

The model predicted that 80 farmers adopted and 34 did not adopt the organic vegetable farming (Table 5). In reality, 73 farmers adopted and 41 did not. It was found that 65 out of 80 predictions 'adopted' were correctly predicted and 15 were not. Similarly, of the 34 predictions 'not to adopt', 26 were correct and 8 were not. So, in total there were 65+26 = 91 correct predictions. Here, out of 114 farmers in the sample, 73 of them were adopting organic vegetable farming. Without the model, if we predicted that everybody was adopting the organic vegetable farming, we already had 73 correct predictions. This is the baseline to assess the model contribution to predict the adoption decision. Therefore, the baseline is, 73/114 = 0.6403.

Table 5: Classification statistics after logistic regression

Logistic model for method_culti

Classified	True D	True ~D	Total
+	65	15	80
-	8	26	34
Total	73	41	114

Classified + if predicted Pr (D) >= .5
True D defined as method_culti != 0

Sensitivity	Pr (+| D)	89.04%
Specificity	Pr (-|~D)	63.41%
Positive predictive value	Pr (D| +)	81.25%
Negative predictive value	Pr (~D| -)	76.47%
False + rate for true ~D	Pr (+|~D)	36.59%
False - rate for true D	Pr (-| D)	10.96%
False + rate for classified +	Pr (~D| +)	18.75%
False - rate for classified -	Pr (D| -)	23.53%
Correctly classified	79.82%	

Thecount R^2 is given by,

Count R^2 = *Number of correct prediction/total number of observation*

= 91/114 = 0.7982.

We can read this figure directly from the stata output (last row in the table 5: correctly classified = 79.82%). So, the explanatory variables in the model gave us additional 91-73 = 18 correct prediction. In other words, with introducing the model, we could increase the correct prediction by 79.82 - 64.03 = 15.79%.

Predictions with the model

The resulted model was,

P_i= ------------------------(v)

This model predicts the probability of a famer to participate in the production of organic vegetables. The model approximates the outcomes with a probability. For instance, for a farmer with the number of years of education 12 and the level of health and environmental consciousness 4, and keeping other variables constant, the predicted probability to participate in organic farming is calculated as follows. The propensity to participate (Z_i) is,

$Z_i = -6.74 + 0.23 * 12 + 1.41 * 4 = 1.66$

Here, since Z_i is a positive integer we have to calculate the probability of the farmer not to adopt organic vegetable farming(1-P_i) that is given by,

$$1-P_i = \; = \; = 0.16$$

Now, the probability of the farmer to participate (P_i) = 1-0.16 = 0.84

Comparing the figure with the cut-off point 0.5 as suggested by Pindyck and Rubinfeld (1998), the farmer is likely to participate in the organic vegetable farming (P_i>0.5).

These results also suggest that the higher the level of education and the level of health and environmental consciousness of a farmer, the higher is the probability to adopt organic vegetable production.

Measuring marginal effects

For instance, for an average farmer, if we increase the level of education by 1 unit the change in his/her probability to adopt organic vegetable farming is given by (from equation iv):

$\delta P_i = \beta j \, . \, Pi \, (1\text{-}Pi) \, .\delta X_{ij}$

Here, βj = 0.23, Pi = 0.71, $1\text{-}Pi$ = 0.29 $\delta X_{ij} = 1$

Therefore, δP_i= 0.23 * 0.71 *0.29 *1 = 0.047

This implies that if the number of years of education of an average farmer increases by one unit, his/her probability to participate in the organic vegetable production increases by 0.047.

DISCUSSION

The study aimed to assess the factors affecting the farmers' adoption decision to organic vegetable farming. Result revealed that out of 17 explanatory variables only two namely the level of education and the health and environmental consciousness of the farmers had significant effects on the organic vegetable adoption decision. While discussing with the organic farmers, they had a realization that chemical based farming has adverse effects on their own health, and on the physical and biological environment. Therefore, they are adopting chemical free farming. In contrast, the conventional farmers thought that the organic farming was not a profitable, and the availability of organic inputs was a major problem. Therefore, they were growing the vegetables conventionally.

The result was analyzed using the logistic regression. Result showed that the probability of a farmer to adopt organic vegetable farming increases with the increase in the level of education of the farmer. The finding is in line with my expectation and in line with the previous studies. See, for example,(Adebayo & Oladele, 2011; Demiryürek, Ceyhan, & Bozoğlu, 2012; Isin, Cukur, & Armgan, 2007; Koesling et al., 2008; Kumar, Godara, Mehta, & Singh, 2008; Nazarko, Van Acker, Entz, Schoofs, & Martens, 2004; Oxouzi & Papanagiotou, 2010. We can imagine that the educated farmers are easily convinced and learn about the new farming technology. Organic farming is a new, innovative and emerging concept among the Nepalese farmers. Educational attainment can help develop a favorable attitude towards innovation (Quazi & Talukder, 2011) and, in turn, towards organic farming adoption.

Similarly, as expected, the chance of adoption was positively associated with the health and environmental awareness level of the farmers in the study area. Previous research findings also support the result. For instances, see (Burton et al., 2003; Flaten et al., 2006; Karki et al., 2011; Koesling et al., 2008; Läpple & Rensburg, 2011; McCann et al., 1997; Panneerselvam et al., 2012). Organic vegetable farming is a healthy agricultural practice in which the farmers do not use synthetic pesticides and fertilizers that have adverse effect on the human health and environment. Therefore, the farmers with higher level of environmental and health consciousness are likely to follow organic vegetable farming.

In contrast to my expectation and the previous research findings, other variables were non-significant to influence the probability of a farmer to take organic farming adoption decision. The extension programs from various organizations in the study area have been targeting on both the organic and inorganic farmers. Conventional farmers are also equally emphasized while forming farmers' groups. The organic farms are not isolated and both the organic and conventional farms are found in the same location in the study area. The extension workers are equally accessible to both types of farmers. Major market center and potential consumers for both types of products are located in the same city centers. Similarly, the collection centers are common for both the organic and conventional products in the study area. These might be the possible reasons why the variables including number of visits to the extension workers, number of participation to the extension activities, affiliation to the farmers' organization and the distance to the market centers are not influencing the organic farming adoption decision.

Moreover, the average rating of relative market price and production cost of organic and conventional vegetables were not significantly different (Table 2: P-values>0.1 in both the cases). Both types of respondents think that the market price of the organic vegetables is slightly higher (Table 2: conventional price mean 0.39; organic mean 0.19) and the cost of production of the organic vegetables is slightly lower (Table 2: conventional cost mean -0.58; organic cost mean -0.38) than the conventional vegetables. These values indicate that the marginal profit of the organic vegetables is higher than that of the conventional vegetables. The question arises here is, if so, why they are not producing the organic vegetables commercially. The possible reason behind the lower adoption rate of purely organic vegetable farming might be the lower amount of production of those vegetables compared to the conventional vegetables.

The study is not free of limitations. The major weakness of the study is the small sample size. The sample consists with only 114 respondents.

The study has some noteworthy implications. Different level extension agencies can benefit from this article as a guide while designing organic sector development programs. I have explained the methodological and practical aspects of logistic regression analysis in details. In this regard, this document may work as a guideline for those readers who are interested in the methodological and practical aspects of logistic regression analysis.

CONCLUSION

Overall, the study suggests that the agriculture extension authorities have to integrate health and environment related awareness raising programs while designing and implementing organic farming expansion programs. Moreover, inclusion of organic agriculture in the curriculum of formal school education might be noteworthy to better develop this sector.

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VALUE CHAIN ANALYSIS OF COFFEE PRODUCTION IN CENTRAL NEPAL

Gaurab Luitel[1] and Thaneshwar Bhandari[2]

ABSTRACT

coffee is expanding in Nepal in terms of consumption and production. However, because of the insufficient market information, value chain schemes and scattered production area, a few traders and processors primarily govern the present marketing channel. This paper analyses functional and economic linkages of Nepalese coffee through its value chain analysis from the samples of 120 coffee farmers, 10 pulper operators and 3 secondary processors from two central hill districts viz Sindhupalchowk and Kavre. The data were analyzed using descriptive and analytical methods with SPSS (16) and MS Excel 2013. The study identified key players of coffee VC as i)input suppliers – supplying seedlings; ii)coffee producers – producing fresh cherry; iii)pulping operators – producing dry parchment; iv)secondary processors – producing green beans; v)market actors – delivering it to consumer; and vi)consumers – drinking coffee. The cost of production of fresh cherry, dry parchment and green bean was found Rs 69.03/kg, Rs 411.46/kg and Rs 478.4 /kg respectively for farmers, pulper operator and secondary processor. Benefit Cost analysis of these key players showed that coffee enterprise is a profitable business with BC ratio 1.20, 1.04 and 1.24 respectively. We found that secondary processors were most benefited in the value chain.

Keywords: Coffee, Cost of production, Economic analysis, Value chain

INTRODUCTION

Coffee is a popular beverage worldwide. It is estimated that over 2.25 billion cups of coffee are consumed worldwide daily (Ponte, 2002). Out of which, 65% consumes coffee as a hot beverage each morning and their average coffee consumption is 100.5 litres per capita per year (NACS, 2013). While coffee consumption is high mainly in the developed countries, more than 90% of the production is contributed by developing countries (Ponte, 2002). Globally speaking, 25 million small holders earn their living from coffee and 5 million people are engaged in coffee farming, harvesting over 3 billion coffee plants (FAO, 2007). In Nepalese context, coffee cultivation has spread in over 41 districts of the mid-hill regions, 23 being the commercially producing districts. According to the statistics of fiscal year 2015/16, 434 MT of coffee was produced in 2,618 ha of area (NTCDB, 2016).

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Although tea marks the traditional drink of average Nepalese, because of the growing coffee culture in the cities – which stems from rapid opening of café houses – coffee is gradually becoming popular beverage in Nepal, especially among youths. A record shows coffee consumption has grown up to 427.87 MT in 2016 (NTCDB, 2016). However, because of the insufficient market information, quality improvement, value chain schemes and also due to insufficient pre-processing facilities and scattered production area, a few traders and processors primarily govern the present marketing channel (Kattel, 2009).

Moreover, there's a huge gap between demand and supply of Nepalese Coffee. While its demand is over 7500 MT annually (Bhandari, 2014), the national production in fiscal year 2015/01 was merely 434 MT (NTCDB, 2016). To make the matters even worse, it is always subject to inconsistent market system both at domestic and international level.

This study aimed to identify the players of the coffee sector involved in each section of the value chain and their interrelationships with other actors; the value they add to the product. The value chain analysis of coffee business is a useful tool to identify efficiency and competitiveness of a coffee enterprise and the activities enabling a competitive market environment. The research also attempted to examine the profitability at each steps of the coffee value chain so that it can help to enhance coffee business in a sustainable manner.

METHODOLOGY

Study sites and sample size

Respondents for producer farmers within district were selected using simple random sampling from purposefully selected two districts and five local government units in each districts - Sindhupalchowk and Kavre as they are the major coffee producing districts of central Nepal. Sampling frame was prepared in each district after discussion with key informants from DCCU of both districts. Finally, coffee farmers were randomly selected based on the sample size as illustrated in Table 1, making 120 sample size of producers for household survey – 60 sample size in each districts.

Table 1. Summary of sampling sites, population and sample size for HH survey of coffee farmers

Districts	Sampling sites	Population Size	Sample Size
Sindhupalchowk (n=60)	Ichowk	353	20
	Sangachok	362	20
	Shikharpur	232	10
	Talamaran	125	5
	Barhabise	124	5
Kavre (n=60)	Chyamrangbesi	369	20
	Nayagau	352	20
	Jaisithok	235	10
	Pokharichauri	119	5
	Phoksintar	121	5
Total (N)		**2392**	**120**

Similarly, 5 pulper operators were randomly selected in each districts, making 10 sample size of primary processors. Furthermore, 2 secondary processors were selected from Kavre and 1 was selected from Sindhupalchowk as they were the only secondary processors in the study site.

Field survey was carried out in October 2016.Three years of data regarding price and quantity of input supplies and sold product; labour cost; production and processing cost; marketing cost; demographic and socio-economic information were collected via household survey.

Value chain mapping

A value chain map of coffee sub-sector was prepared based on information from Focal Group Discussion (FGD) and survey in order to understand the traits of the value chain players and the interrelationships among them with all attempt to make the maps easily comprehendible.

Cost of production

Cost of production refers to the summation of all the costs which are incurred while producing goods or services which in return increases the revenue of a firm. Cost of production (CoP) of fresh cherry, dry parchment and green bean was estimated. While only variable costs were considered in calculating CoP of fresh cherry, both fixed and variable costs were taken into account in case of CoP of dry parchment and green bean.

Cost of fresh cherry production

The cost of production of fresh cherry was calculated by summing the expenses of labour, manure, plant protection, irrigation and other costs, if included.

Cost of dry parchment production

The cost of production of dry parchment was calculated by summing up fixed costs like depreciation of equipment used in pulping centre and certification cost; and variable costs like input cost of fresh cherry, labour cost, washing cost, packaging and other costs, if included. For our study, depreciation rate of 10% was used.

Cost of green bean production

Similarly, for the estimation of cost of green bean production as well, variable costs like input cost of dry parchment, labour cost for hulling and hand sorting; electricity and fuel; packaging cost and other costs, if included, were summed with the fixed costs of deprecation and certification.

Gross margin analysis

A gross margin is a simple and quick method to analyse the performance of a farm business. It is calculated by deducting the total variable cost gross return as shown in formula below.

Gross margin (GM)=Gross return (GR)-Total variable cost (TVC) ……………. (equation I)

Where,

Gross return (GR)= Sales quantity of coffee product X Price of coffee product…………(equation II)

Net profit

Net profit refer to the net earnings after deducting all the expenses not included in the calculation of gross margin as in the following equation. It can also be expressed into percentage.

Net profit = Gross margin – Total Fixed cost……….(equation III)

Benefit cost analysis

Benefit cost analysis is the benefit of the farm business relative to its cost, expressed both in monetary value. The Benefit cost ratio is calculated by taking the ratio of total revenue and total cost. Here in our study, the total revenue denotes gross income and total cost represents summation of all the Fixed Cost and Variable cost including the marketing costs as well. It was calculated by using following formula.

$$B/C\ ratio = Gross\ income / Total\ Cost \quad \ldots\ldots\ldots\ldots(equation\ IV)$$

B/C ratio >1: profitable;

B/C ratio<1: business at loss;

B/C ratio =1: farm at indifference

Price spread

Price spread from farm to retail is the difference between the farm gate price and the price paid by the consumer at retail market. It exhibits the processing and marketing charges. The formula for calculating price spread can be expressed as in following formula

$$Price\ spread = P_R - P_F \ldots\ldots\ \ldots\ldots\ldots(equation\ V)$$

Where,

Retail price

Farm gate price

Producers' share

Producers' share is the ratio of farm gate price to retail price expressed in percentage. The formula for calculating Producers' share is expressed in following formula.

$$Producers'\ share\ P_S = \frac{P_F}{P_R} * 100\% \ldots\ldots\ldots(equation\ VI)$$

RESULTS AND DISCUSSION

Socio-economic and demographic analysis

The socio-economic and demographical characteristics is presented in Table 2. It showed that majority of the respondents were male (75.50%) and belonged to Brahmin/Chhetri ethnic group (69.17%). 61.17% of the sampled HH population were economically active and most of the respondent had received primary education (32.50%). The average family size of the coffee producers was 6.27. Similarly, the average age of household head was estimated as 51.26. Majority of the household sampled were farmers (84.17%), growing other crops besides coffee and were organised under cooperatives (64.17%). Only 20.83% of the coffee farmers didn't have access over training on coffee production. The average land holding of coffee farmers was estimated to be 8.21 *ropani* of upland, 5.52 *ropani* of lowland and 1.45 *ropani* of private forest and *khoriya* land. Since the average area of coffee plantation per household in the study area is found to be 2.97 *ropani*, there's still some area for extension of coffee.

Table 2. Socio-economic characteristics of sampled population

Characteristics	Frequency	Characteristics	Frequency
Gender of respondent		6-10 years of school	32 (26.67)
Male	87 (75.50)	>11 years of school	15 (12.50)
Female	33 (27.50)	Occupation besides coffee	
Caste/Ethnicity		Farming other crops	101 (87.17)
Brahmin/Chhetri	83 (69.17)	Service	5 (4.17)
AadibashiJanajati	23 (19.17)	Self employed	9 (7.50)
Dalit	10 (8.33)	Multiple	5 (4.17)
Others	4 (3.33)	Involvement in Farmers' organisation	
Age distribution of sampled HH		Cooperatives	77 (64.17)
>17	208 (27.66)	Farmers' group	37 (30.83)
18-59	460 (61.17)	None	6 (5.00)
<60	84 (11.17)	Access on coffee production training	
Literacy		Yes	90 (79.17)
Illiterate	34 (28.33)	No	25 (20.83)

Source: Field survey (2016)

Figures in parenthesis indicate percentage.

Value chain mapping

Value chain mapping of coffee in study area is illustrated in Figure 1 which showed the interrelationship between the actors, their functions and the institutions providing the enabling environment at each level. The study revealed that the key players of the coffee value chain were i) input suppliers – supplying seedlings / equipment / other inputs; ii) coffee producers – producing fresh cherry; iii) pulping operators or primary processor – producing dry parchment; iv) secondary processing units – producing green beans/ roasted beans/ powder coffee; v) market actors delivering it to consumer; and vi) consumers – drinking coffee. Functional roles of these actors of value chain are briefly described below:

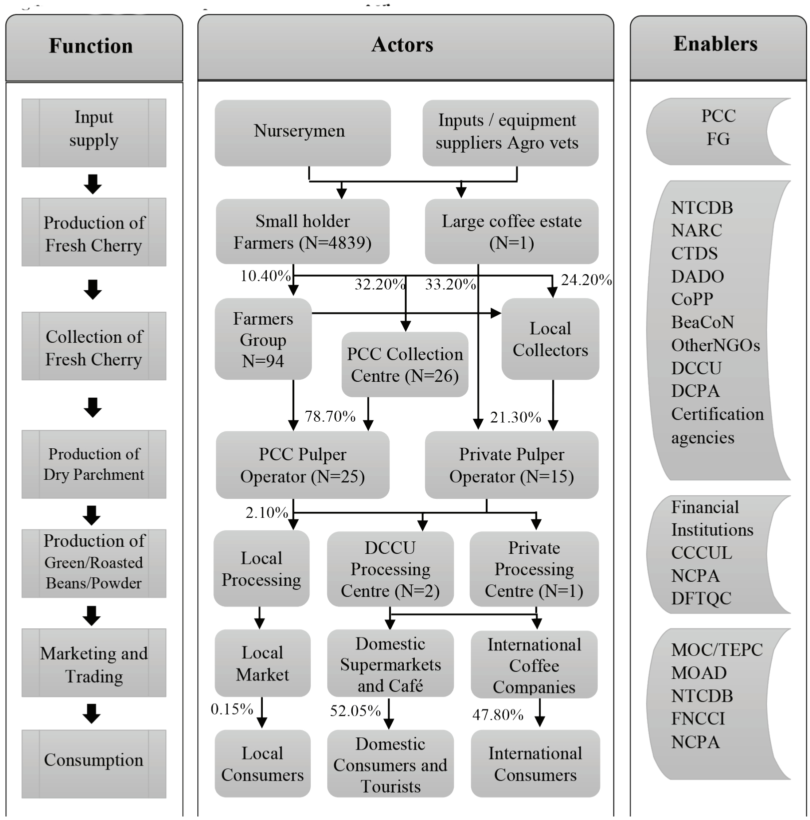

Figure 1. Value chain map of coffee in study area

Source: Field survey (2016)

Input suppliers

The major input supplies used in coffee farm were manure, seed/seedling, organic pesticides and tools & equipment. For manure, majority (115 out of 120) of the coffee farmers used Farm Yard Manure from their own cattle shed. Seeds/seedlings were locally available in nurseries. It was evident that at least one of the member in Primary Coffee Cooperatives (PCC) served as nurseryman who had to supply the seedlings in next planting season. Similarly, while PCC had provided organic pesticides and tools for pruning like pruning knife, saw and secateurs to its members.

Coffee producers

Coffee producers refers to those actors who have coffee plants and harvest fresh cherry. Farmers have to send the fresh cherry for primary processing within 24 hours of harvesting in order to maintain quality. Two types of coffee producers were identified in the study area: i) Large coffee estate and ii) Small scale farmers. There was one large coffee estate and 4839 small holder coffee producers in the study area (3261 in Kavre and 1578 in Sindhupalchowk) as per the data of NTCDB (2016). Large coffee estate was owned or leased by private company and was equipped with processing facilities - primary processing in farm itself and secondary processing in Kathmandu owned by the company. The value chain of such producer was short. On the other hand, value chain of small holder farmers is much more complex and basically had three options to sell their fresh cherry -- i) Local collector, ii) Primary Coffee Cooperatives' pulper operator and iii) Private pulper operator.

Collector and pulper operators

Collectors were the actors in the value chain who buy fresh cherry produced by farmers and sell it to pulper operators. In most cases, pulper operators themselves played the role of collectors as well. Pulper operators did the primary level of processing by peeling off fresh cherry within 24 hours to produce dry parchment after drying. Dry parchment can be stored for few months before it is sold to the secondary processing facilities. There were 9 pulping centres in Sindhupalchowk managed by cooperatives and 31 in Kavre of which only 16 were managed by cooperatives.

Secondary processors

Secondary processors are the actors who buy dry parchment from the pulper operators and does further processing by hulling to produce green beans which is the final product for export market. However, for domestic market, the green beans undergo further processing called roasting to produce roasted bean. Some processing facilities also have grinding machine which makes the roasted coffee into powder form. The powder coffee is packed into small packs and sold in market as filter coffee. Small sized, uneven and broken dry parchment is considered to be lower grade which are separated from the higher grade and processed locally by the coffee farmers themselves by using traditional de-huskers (such as *dhiki* and *jato*) and eventually roasting it using kitchen utensils for home and local consumption. The higher graded dry parchment was processed either in private or in District Coffee Cooperative Union (DCCU) controlled processing units to produce final or intermediary products - green bean, roasted bean or powder coffee, depending on the market for which it is intended to be sold. It was found that 47.80% of the green bean produced in the study area was exported and 52.05% was further processed to produce roasted beans or powder coffee for domestic market. Rest 0.15% was roasted locally for home and local consumption.

Traders and market actors

Basically, three types of markets were noticed in the study area viz; local, domestic and export markets. The lower graded green beans processed by using household kitchen utensils were used for home and local consumption. Since small holder coffee farmers themselves do such processing, they give it to relatives and neighbours for free or in nominal price. They form the local market for low graded coffee.Evenly sized green beans produced by DCCU Sindhupalchowk more than 14-16 mm were considered to be of high quality and were exported to South Korea. Less than 14 mm were considered to be medium to low grade and were further processed to form roasted bean and/or powder coffee for domestic market. Majority of the final and intermediaries coffee product of Kavre district was found sold in domestic market.

Moreover, it was learnt that the secondary processors themselves act as a wholesale traders in the study area. While Kathmandu based various outlets of Bhatbhateni supermarkets, other superstores and café house like Himalayan Java serve as the major retailer of domestic market. Similarly, Fair Trade buyer Beautiful Store of South Korea acts as the major retailer of the export market.

Consumer

Foreign and domestic customers of the café house like Himalayan Java, Beautiful Coffee Café and so on located in Kathmandu were found to be the primary consumers of the domestic markets. Besides that, the coffee aficionados who buy final or intermediaries coffee products from superstores also contribute substantially in consumption of coffee. On the other hand, Fair Trade consumers of Beautiful Store Korea, were learnt to be the end consumer of export market for the coffee produced in study area.

Enablers of coffee value chain

Government, private and international development agencies have been promoting coffee by policy formulation, extension, research and development. The enabling environment providers were government bodies like National Tea and Coffee Development Board (NTCDB), Nepal Agriculture Research Council (NARC), District Agriculture Development Office (DADO), associations of cooperatives and private sectors like Central Coffee Cooperative Union Ltd (CCCUL) and Nepal Coffee Producers' Association (NCPA). Besides that financial institutions, I/NGOs and certification agencies support the coffee value chain of the study area.

Marketing channels of coffee

Four marketing channels were identified in the study area as illustrated in Figure 2. First was shortest with coffee producers catering to 0.15% demand, for home consumption and local market with relatively lower grade coffee which was processed by using locally available utensils. Second marketing channel represented private processing units collecting 21.30% of the fresh cherry produced by coffee producers and deliver final product to the domestic market with 24.50% share. Third channel consumes 76.66% of the fresh cherry by cooperatives operated primary and secondary processing units which provides 27.55% of the consumption demand, in the domestic market. Fourth channel is the extension of third channel to the export market which has 47.80% consumption share from the coffee produced in the study area.

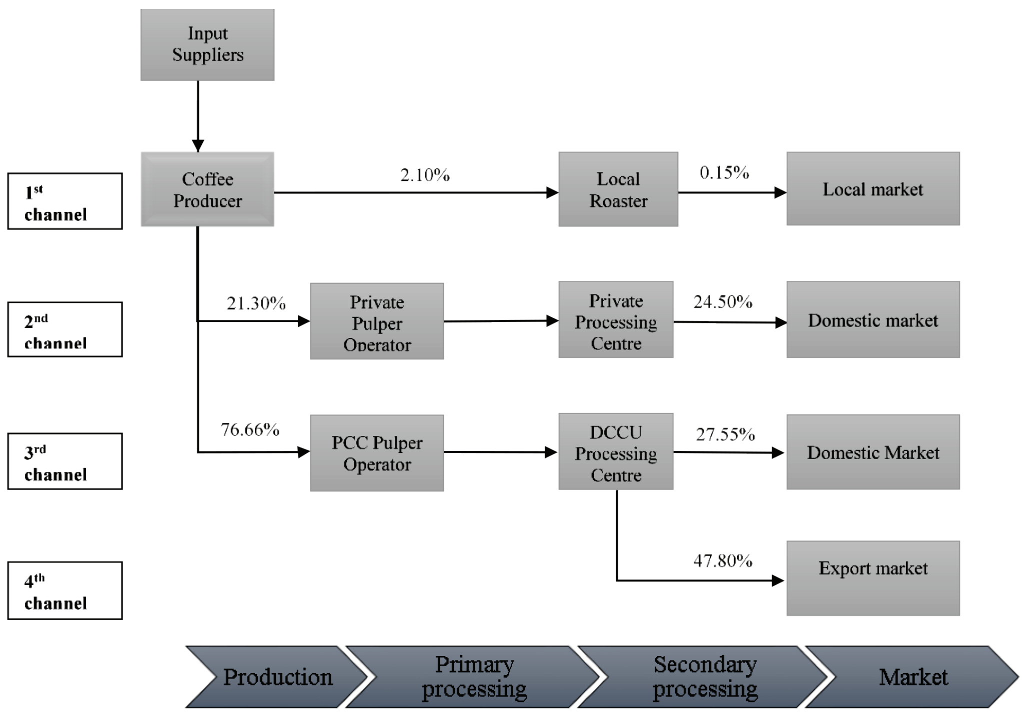

Figure 2. Marketing channels of coffee
Source: Field survey (2016)

Cost of production

Cost of fresh cherry production

Share of each variable costs in CoP of fresh cherry are illustrated in Figure 3. Because of asynchronised ripening nature of coffee, harvesting is quite troublesome and requires repetitive plucking which contributed 49.18% of the total cost of production. It was followed by manuring cost (22.35%) and labour cost for other cultural practices (20.21%) like weeding, pruning etc.

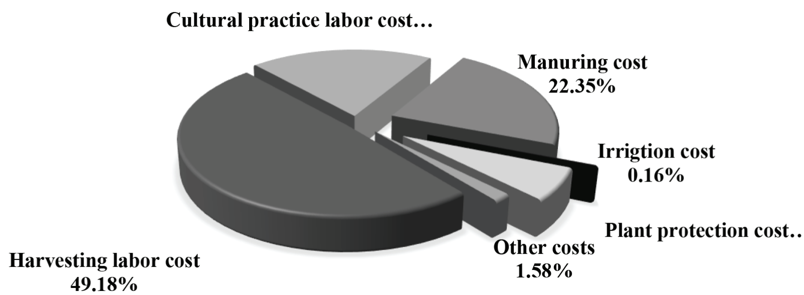

Figure 3. Contributions of different variable costs in cost of fresh cherry production
Source: Field survey (2016)

The cost of fresh cherry production was Rs 169631.03 per ha as presented in Table 3. Technically, while 2000 plants could be planted in a ha of land, the average density of plantation in the study area was only 1388.45 plants per ha. High cost of production coupled with low productivity has reduced the competitive strength of Nepalese coffee (FNCCI/AEC, 2006).

Table 3. Details of cost of fresh cherry production per ha

Particulars	Mean ± SE (N=120)	sd
Labour cost for harvesting	83424.15 ± 6392.72	70028.70
Labour cost for cultural practice	34288.81 ± 2346.66	25706.38
Manuring cost	37909.50 ± 3887.31	42583.31
Plant protection cost	11052.24 ± 3205.67	35116.33
Irrigation cost	277.76 ± 116.77	1279.11
Other costs	2678.57 ± 401.55	4398.78
Total Cost of production per ha	169631.03 ± 9101.68	99703.91
Cost of production per bush	151.55 ± 11.15	122.15
Cost of production per kg of FC	69.03 ± 2.78	30.41

Source: Field survey (2016)

Cost of dry parchment production

The total variable cost and total fixed cost of producing a kg of dry parchment at pulping centre was Rs 402.62 and Rs 8.84 respectively presented in Table 4. Hence, studying 10 pulping centres of the study area, the average total cost of dry parchment production was estimated as Rs 411.46 per kg.

Table 4. Details of cost of dry parchment production per kg

Particulars (NRs/kg)	Mean± SE (N=10)	sd
Input cost of fresh cherry	331.32 ± 16.21	51.26
Electricity cost	2.88 ± 0.86	2.73
Washing cost	9.87 ± 3.11	9.83
Packaging cost	1.44 ± 0.28	0.88
Labour cost	55.98 ± 10.26	32.46
Other cost	1.12 ± 1.09	3.44
Total Variable Cost of production	402.62 ± 14.84	46.94
Total Fixed Cost of production	8.84 ± 1.73	5.46
Total Cost of Production per kg of DP	411.46 ± 14.34	45.35

Source: Field survey (2016)

Cost of green bean production

The total variable and fixed costs incurred in producing a kg of green bean was NRs 449.48 and NRs 28.82 respectively as presented in Table 5. Hence the total cost of producing green bean was NRs 478.40 per kg.

Table 5. Details of cost of green bean production per kg

Particulars	Mean ± SE (N=3)	SD
Input cost of Dry parchment	381.33. ± 113.31	196.27
Electricity cost	2.02 ± 0.07	0.11
Fuel cost	0.91 ± 0.05	0.09
Hulling labour cost	10.87 ± 0.74	1.27
Hand sorting labour cost	35.04 ± 11.87	20.56
Packaging cost	2.43 ± 0.56	0.98
Certification cost	16.56 ± 13.52	23.42
Other cost	0.42 ± 0.09	0.16
Total Variable Cost of production	449.58 ± 102.67	177.83
Total Fixed Cost of production	28.82 ± 15.34	26.56
Total Cost of Production per kg of GB	478.40 ± 23.41	40.55

Source: Field survey (2016)

Profitability analysis

In order to appraises a business if it is worthwhile or not, profitability analysis was made. Gross margin, net profit and Benefit Cost analysis was estimated to evaluate the profitability of coffee farmer, pulper operator and secondary processor.

Profitability analysis of farmer

The profitability analysis of producing fresh cherry per hectare is presented in Table

6. The gross return from cherry was estimated to be Rs 211281.60 per ha and gross margin was Rs 41650.57 per ha. After deducting the marketing cost (Rs 8728.71), the net profit from a hectare of coffee was estimated as Rs 32,921.86, which can be expressed into percentage as 29.91%. Similarly, Benefit Cost ratio was calculated as 1.20, which indicated that the coffee farming was a profitable business.

Table 6. Profitability analysis of fresh cherry production per ha

Particulars (NRs/ha)	Mean± SE (N=120)	sd
Total Cost of Production (CoP)	169631.03±9101.68	99703.91
Gross Return (GR)	211281.60±11683.44	127985.68
Gross margin (GM=GR- CoP)	41650.57±6092.19	66736.60
Marketing Cost	8728.71±963.22	10551.59
Total Variable Cost (TVC)	178359.74±9296.57	101838.86
Net Profit (NP=GR-TVC)	32921.86 ± 6074.94	66547.65
Net Profit %	29.91 ± 3.55	38.85
BC ratio	1.20±0.04	0.39

Source: Field survey (2016)

Profitability analysis of pulper operator

The profitability analysis of producing dry parchment per kg is presented in Table 7. The total fixed cost and variable cost of producing 1 kg dry parchment was NRs 8.84 and NRs 402.62 respectively. With NRs 411.46/kg as cost of production and NRs 436.87/kg as gross return, the gross margin per kg of dry parchment production was estimated as NRs 25.41 only. Subtracting the marketing cost of Rs 10.40 per kg, the net profit was calculated as NRs 15.02 per kg which is expressed in percentage as 4.10%. Similarly, BC ratio was calculated as 1.04 which indicates that the pulping business is just fairly profitable business.

Table 7. Profitability analysis of dry parchment production per kg

Particulars (NRs/kg)	Mean ± SE (N=10)	sd
Total Fixed Cost	8.84 ± 1.64	5.18
Total Variable Cost of Production	402.62 ± 14.08	44.53
Total Cost of Production	411.46 ± 13.60	43.02
Gross Return	436.87 ± 12.79	40.46
Gross Margin	25.41 ± 13.64	43.13
Marketing Cost	10.40 ± 2.04	6.46
Net Profit	15.02 ± 13.11	41.47
Net Profit %	4.10 ± 3.22	10.18
BC ratio	1.04 ± 0.03	0.10

Source: Field survey (2016)

Profitability analysis of secondary processors

The profitability analysis of producing green beans per kg is presented in Table 8. The fixed and variable cost of producing a kg of green bean was NRs 28.82 and Rs 449.58 respectively which sums up to estimate the production cost as NRs 478.40 per kg. With gross return NRs 610.25 per kg green beans, the gross margin was calculated as NRs 160.67. Subtracting the marketing cost, net profit was estimated as 120.86 which can be expressed into percentage as 24.13%. Similarly, BC ratio was estimated as 1.24 which indicates that the secondary processing is also a profitable business.

Table 8. Profitability analysis of green bean production per kg

Particulars (Rs/kg)	Mean ± SE (N=3)	SD
Total Fixed Cost	28.82 ± 18.78	32.53
Total Variable Cost of Production	449.58 ± 23.37	40.47
Total Cost of Production	478.40 ± 28.67	49.66
Gross Return	610.25 ± 59.06	102.30
Gross Margin	160.67 ± 45.89	79.49
Marketing Cost	10.99 ± 2.13	3.68
Net Profit	120.86 ± 28.58	49.50
Net Profit %	24.13 ± 4.60	7.97
BC ratio	1.24 ± 0.05	0.08

Source: Field survey (2016)

Table 9. Income from mix cropping in coffee farm

Crop	Gross Return (NRs/ha)
Fodder tree	23811.89
Other mix crop	52943.96
Coffee	211281.60
Gross income	288037.45

Source: Field survey (2016)

Summary of economic analysis is illustrated in Figure 4

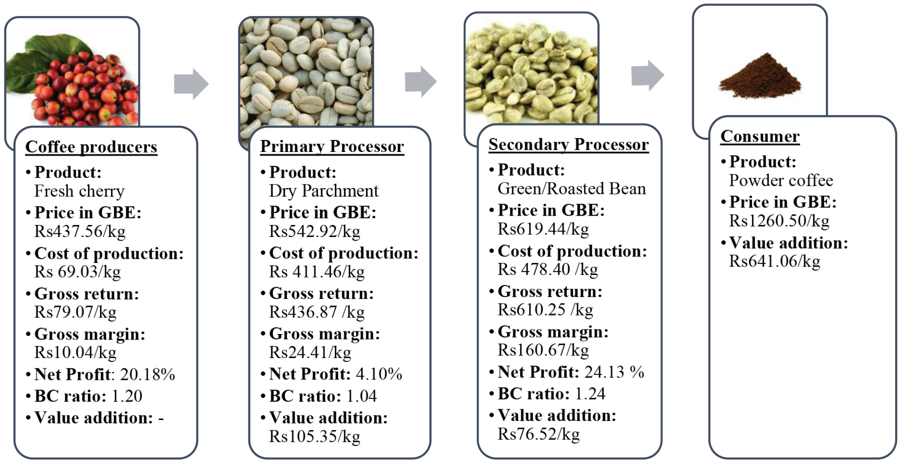

Figure 4. Summary of economic analysis in coffee value chain
Source: Field survey (2016)

Income from mix cropping

Coffee is traditionally a shade loving plant, growing under the lower canopy level of trees (Kuit et al., 2004). Shade is required to reduce direct sunlight on the berries. Coffee was cultivated in a mixed cropping system in the study area. Along with the fodder and other economically important trees like citrus, mulberry, jack fruit, rudrakshya, banana and so on, ginger, legumes and spice crops were also planted in between the rows of coffee bush, generating extra income from coffee farm.

Income from mix cropping per hectare in coffee farm of the study area is presented in Table 9. Income of Rs 23811.89 per ha was received from fodder trees. Similarly, the return from other mix cropping like ginger, legume and spice crops was NRs 52943.96 per ha. Hence, extra income of NRs 76755.85 was generated from a hectare of coffee farm, besides the gross return of NRs 211281.60/ha from coffee only; making the gross income of NRs 288037.45 per ha.

Value addition

The study revealed that there's value addition of NRs 105.35/kg from fresh cherry to dry parchment, NRs 76.52/kg from dry parchment to green bean and NRs 641.06/kg from green bean to powder coffee.

Price spread and producers' share

The retail price of Nepalese filter coffee in the outlets of super market was Rs 1500 per kg, which is the price paid by the domestic consumers. Referring to the popular online market Alibaba.com, it was known that the retail price of Nepalese filter coffee for export market was USD 21.20 for a packet of 1 kg. Hence the price paid by foreign consumers for Nepalese coffee was found to be Rs 2147.56 per kg as per the exchange rate of NRB for May 2015.

Since the price of fresh cherry in Green Bean Equivalence was calculated to be Rs 437.56/kg, price spread for domestic market was estimated to be Rs 822.94/kg and Rs 1710/kg for the export market which represents the price of processing, marketing and shipment charges. Moreover, producers' share on consumer price was 34.71% in domestic market and 24.25 % in export market channel

CONCLUSION

Coffee is a promising and potential exportable commodity of Nepal. Because of the growing coffee culture among the youths, especially in the cities, demand of coffee is increasing every year. However, its production isn't increasing in the same trend. Economic analysis of coffee farmer, pulper operator and secondary processor showed that it is a profitable enterprise with BC ratio 1.20, 1.04 and 1.24 respectively. Value chain analysis of the coffee sub-sector shows that secondary processors are harnessing more benefit in the chain. Despite premium price received by the farmers, farmers are not getting modest benefit because of high cost of production and low productivity.

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INTEGRATED PACKAGE OF PRACTICES FOR MITIGATING THE SEASONALITY AND IMPROVING THE PRODUCTION PARAMETERS OF BUFFALO IN THE CONTEXT OF CLIMATE CHANGE IN NEPAL

L N Paudel[1*], N R Devkota[2], C R Upreti[3] and N P Joshi[4]

ABSTRACT

Buffalo is the principal dairy ruminants in Nepal. The productivity for milk and meat production of buffalo is increasing is lower pace. The reasons for low productivity include low reproduction efficiency associated with long calving interval, seasonality in breeding, problems with heat detection, seasonal milk production and adverse effect of global warming and climate change. Department of Livestock Services (DLS) and its networking have been trying to resolve these problems with the implementation of buffalo genetic improvement, artificial insemination mission, forage mission, buffalo calf fattening and dry buffalo rehabilitation. However, the effect of global warming and climate change to the buffalo farming had not been studied in detail till now. This paper examines the effect of global warming and climate change on buffalo farming which is based on a three year research project. The study focused on improving the seasonality and productivity of buffalo by using integrated package of practices focusing on breeding, feeding, health care and management in relation to the climate change in three Gandaki river basin districts, Gorkha, Tanahun and Chitwan of Nepal. The intervention of the project significantly improved ($p<0.05$) the milk production performance and seasonality and subsequently reduced the calving interval and age at first calving, which could be the model as the package of practices for mitigating the seasonality and improving the production parameters of buffalo in the context of climate change in Nepal.*

Keywords: Buffalo, breeding, climate change, production parameters, seasonality.

INTRODUCTION:

Livestock is an important sector of Nepalese agriculture system that contributes about 28% to the agricultural gross domestic production (AGDP) (MoALD, 2019). Dairy, meat and egg contribute by 63, 32 and 5%, respectively to total livestock GDP. High potentiality, up to 45% contribution to the AGDP by 2015, of livestock sector was recognized in the agriculture prospective plan (APP) which could not be materialized

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[*]Feed the Future Innovation Lab, Collaborative Research: Adopting Livestock Systems to Climate Change: Improving Nutrition and Productivity of Buffaloes (FFIL CR: ALSCC INPB) in Nepal, jointly funded by USAID, Colorado State University and Michigan State University in collaboration with Nepal Agricultural Research Council (NARC)m Department of Livestock Services (DLS) and Agriculture and Forestry University (AFU), Nepal.

during the period of APP implementation. According to agricultural information and training center (AITC, 2020) Nepal has 7.4 million cattle, 5.3 million buffalo, 12.3 million goat, 0.8 million sheep and 1.2 million pig (Figure 1). These figures show that Nepal is one of the densely livestock populated country in Asia. However, per capita availability of livestock products (milk, meat and egg) is very low in Nepal. Main reasons behind this low per capita availability include dominance of low productive local animals, poor feed and feeding practices, poor husbandry practices, limited health care to the animals, prevalence of traditional technology, high cost of production and low price for the livestock products and limited market networking.

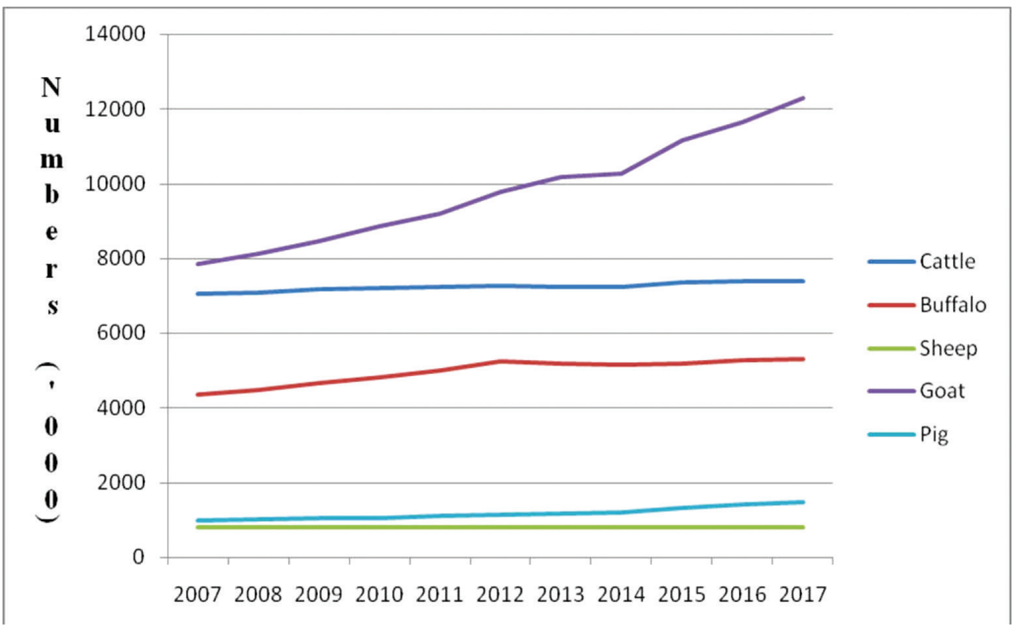

Figure 1: Livestock statistics of Nepal (AITC, 2009-2017)

The population trend analysis (Figure 1) states that the number of goat has been tremendously increased from 2007 to 2017. However, the number of buffalo, cattle, sheep and pig is almost constant over the past 5 years in Nepal. National statistics shows that availability of livestock products is below than the recommended level except for eggs (Table 1). In case of milk too, Nepal is far behind the international level. Food and Agricultural Organization of the United Nations recommends 91 liters of milk per capita per year (250 mL/capita/day) but average availability of milk in Nepal is estimated as 76 litres/person/year. It clearly shows the need to increase the production and productivity of milking animals (NLRMPO, 2019).

Table 1: Availability and recommendation of main livestock products in Nepal

Availability/Recommendation	Milk	Meat	Eggs
Availability*	76 litre/head/year	13 kg /head/year	54 /head/year
Recommended	91 litre/head/year	14 kg /head/year	48/head/year

*availability of products is estimated for year 2019

The livestock production statistics show the total production of milk in the year 2007 was 1.351 million Mt. which was increased to 2.168 million MT in 2017 (Figure 2). Though this figure shows the increase in milk production during the period of last ten years but still the productivity of the indigenous dairy animals, cattle (450 liter/lactation/animal) and buffalo (850 liter/lactation/animal) is very low in Nepal However, there is an ample possibility to improve this productivity by using improved package of practices such as improvement in breeding, feeding, health care and management. These practices are more relevant in the context of global warming and climate change in Nepal (Pathak et al, 2011; Neopane and Devkota, 2015).

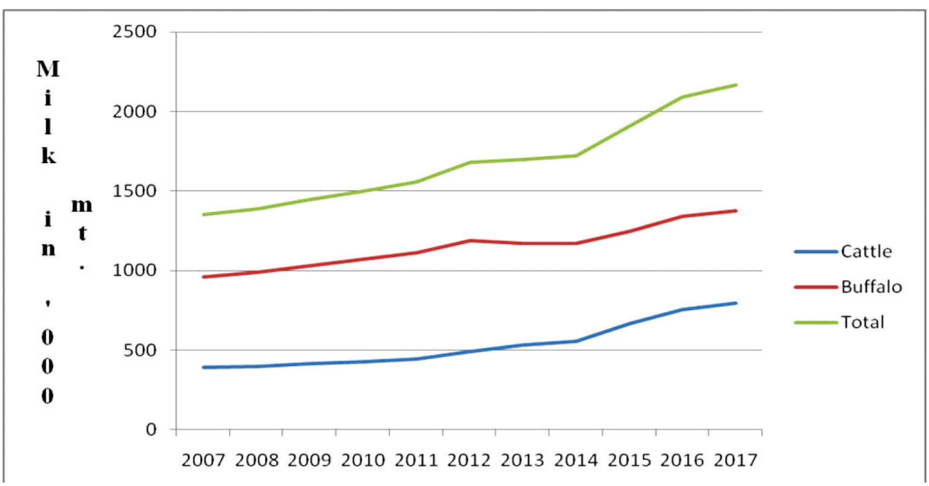

Figure 2: Milk production statistics of Nepal (AITC, 2009-2017)

In the case of meat, total meat production in the country in 2007 was 0.227 million MT which was increased to 0.357 million MT in 2017 (Figure 3).

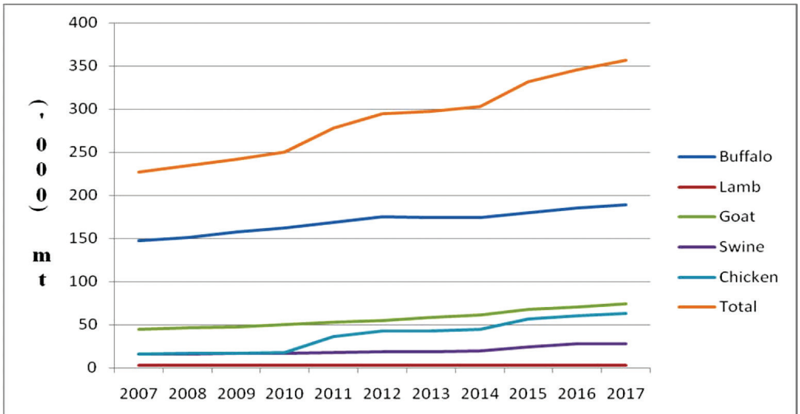

Figure 3: Meat production statistics of Nepal (AITC, 2009-2017)

Out of the total production of milk in the country, buffalo contributes higher than the cattle. Buffalo contribution to the total meat production in the country is also higher than other species. However, the trend of this contribution is declining in recent years. The contribution of buffalo to total milk and meat production in year 2007 was 71 and 65 percent whereas it was reduced to 63 and 53, respectively in the year 2017. Importance reasons for this decline are low reproduction efficiency associated with long calving interval due to seasonality in breeding, problems with heat detection, seasonal milk production and adverse effect of global warming and climate change. Among them, very important factors, e.g., seasonality, heat detection, breeding, feeding, health care and management issues have been dealt in this paper.

METHODOLOGY

Data are used from a l project " Feed the Future Innovation Lab, Collaborative Research: Adopting Livestock Systems to Climate Change: Improving Nutrition and Productivity of Buffaloes in Nepal (INPB)" jointly sponsored by USAID, Colorado State University, Michigan State University. The project was implemented as a collaborative works among the Nepal Agricultural Research Council (NARC), Department of Livestock Services (DLS) and Agriculture and Forestry University (AFU) from August, 2012 to 2016. The project sites were Gorkha, Tanahu and Chitwan, The objective of project was to study the impacts of climate change on forage cultivation, feed and forage availability, and reproductive efficiency in buffaloes in Nepal.

Selection of the research sites and households

A preliminary survey was conducted to find out the appropriate sites for the research in these three districts. Three sites, Palungtar of Gorkha, Dulegaunda of Tanahun and Chanauli of Chitwan, all sites from the Gandaki river basin, were selected for the research. Thirty households from each site were selected to implement the activities to achieve the objectives of the research works. One farmer, generally the household head, from each household was selected based upon the important criteria such as owner of at least one lactating buffalo, holding 10 *Ropanies* of land in Palungtar and Duleguada and 0.5 hectare in Chitwan, be at least literate, show willing to cooperate to implement the project's activities and agree to provide project related data to the assigned recorders at least for three years.

Sampling techniques, data collection and analysis

The farmers were selected using the purposive sampling techniques based upon the set criteria. The data on forage production, milk production, animal health and breeding related activities were recorded monthly from each of the sampled households whereas the meteorological data, especially, minimum and maximum temperature, wind velocity, precipitation and day length were recorded daily. The data so obtained were analyzed using SPSS (15) package.

Research activities

The main activities carried out for the research were as follows:

- Inception/orientation/training to the concerned farmers, technicians and the stakeholders.
- Pilot researches on round the year green forage production and utilization.
- Routine drenching of the animals with appropriate drugs.
- Provision of right time AI and natural services to the buffaloes in the research sites.
- Production and breeding related information recording systems.
- Establishment of meteorological stations and record keeping to relate climatic factors and breeding of buffaloes.

The research work was carried out in collaboration with the District Livestock Services Offices and Livestock Service Centre of the respective sites. Three groups, one in each site with thirty farmers, were formed and were given three days' training about the present situation, problems and potentiality in buffalo farming of the selected research sites. Three recorders, one in each research site, were first oriented about the research and their terms of references (ToRs) that includes to mobilize the farmer groups, record the data including symptoms shown by the buffaloes when in heat, date of mating or artificial insemination, , pregnancy diagnosis (PD), and its results , gestation period, date of parturition, monthly milk records, lactation length, dry period, calving interval, etc. related to the breeding and production efficiencies of the buffaloes.

Similarly, four different types of forage species, namely, Oat (*Avena sativa*) and Common vetch (*Vicia feba*) in winter season and Teosinte (*Euchlaena mexicana*) and forage peas (*Pisum sativum*) in summer season were planted to provide round the year green forage to the animals.

RESULTS AND DISCUSSION

Breeds of buffalo

Lime, Parkote and Gaddi are the indigenous breeds of buffaloes in Nepal and Murrah was imported for crossbreeding (Rasali, 2000). It is estimated that 35% of the total buffalo population are crossbreds in Nepal. Hence, large proportion of the buffalo population are of indigenous type having low production performance but Paudel et al. (2008) argued that there is a great potentiality to improve the productivity of indigenous buffalo with the use of improved package of practices.

We found that three research sites are considered from government's program as the buffalo production areas and owns the combination of Murrah, its crossbreds with indigenous and indigenous breeds in different proportions. In Chanauli of Chitwan district, most of the farmers are having Murrah and its crosses where as in Palungtar of Gorkha, most of the farmers are having non-descript type local buffaloes. In Dulegaunda of Tanahu, about 50% of the farmers have non-descript type local buffaloes (Lime and Parkote types), 40% farmers have Murrah cross and only 10% farmers have Murrah breeds of buffaloes. The farmers reported that the purpose of keeping buffaloes is to produce milk. farmers who own Murrah cross reported that they either inseminate their local stock with Murrah semen or mate by Murrah bulls produced in state owned Livestock Development Farm.

Average lactation yield

The average lactation milk yield of the buffaloes under the research program is given in figure 4. It shows that significantly higher ($p<0.05$) milk productivity was found in Chitwan district followed by Tanahun and Gorkha. The higher productivity was associated with better breed type, feeding practices and care and management of buffaloes. The result of survey revealed that better animal in terms of breed and more green forage was available in Chitwan followed by Tanahun and Gorkha. The milk yield/lactation was also higher in Chitwan followed by Tanahun and Gorkha. It shows that, keeping all other factors constant, there is the possibility of milk productivity increment by breed improvement and provision of round the year green forage. However, no significant average lactational milk yield production ($p>0.05$) was found between Gorkha and Tanahun districts (Figure 4).

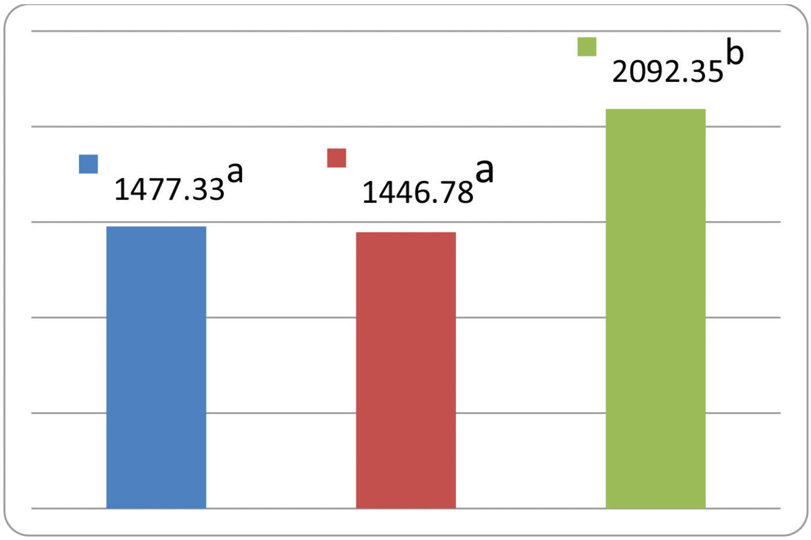

Figure 4: Average lactation yield of buffaloes in the research districts

These results are in line with the study carried out by Paudel *et al*, 2008 in Gulmi and Arghakhanchi districts where they had found that the average lactation milk yield of Lime, Parkote and Murrah cross as 1418.48 ± 45.56, 1433.39 ± 45.98 and 1726.11 ± 45.89 liter, respectively (Table 2).

Table 2: Average milk production of different breeds of buffalo in Gulmi and Arghakhanchi

Breeds	n*	Milk production (litre/lactation)
Lime	70	1418.48 ± 45.56^{a}
Murrah cross	69	$1726.11 \pm 45.89^{b***}$
Parkote	69	1433.39 ± 45.98^{a}

* number of observation

^{ab}*means in the same column with the different superscript are significantly different.*

*** $p<0.001$

Shrestha, 2004 had also reported that the lactation yield of indigenous buffaloes at Simichaur, Gulmi, was 1429 ± 72.8 litres. These results signify that Murrah and its crosses yield more milk than the local breeds and hence milk productivity in buffalo is directly related to the types of breeds.

Breeding pattern and seasonality

Very limited works have been done in buffaloes, especially in seasonality, heat detection, breeding and productivity performance in relation to climate change (Zicarelli, 1997). Some of the researchers commented on the breeding pattern and seasonality of buffaloes. Vale *et al*., 1990 stated that the seasonality in buffaloes could be due to management factors and unavailability of year-round forage. Di Palo *et al*., 1997 stressed more on climate and photo-periodism. They emphasized on role of Melatonin hormone which is secreted by pineal gland during nights play a pivotal role for the seasonality. Some reports show that mating desire in buffalo lowers during the day. Banerjee, 2002 stated that 84% of the Egyptian buffaloes commence oestrus between 18:00 and 06:00 whereas he stressed that the Indian buffaloes come on heat during the morning time. Similarly, conception rate also varies from 50 to 90% based on the feeding, health care and management. Bhat (1999) reported that average number of insemination/service per conception was 1.56 in artificial insemination (AI) and 1.6-3.1 in natural services in India where as average conception rate of buffalo was found as 48% and number of insemination per conception was found around 2 in Nepal (NLBO, 2019).

Though buffaloes are very docile in most of the time but they are very restless during mating and artificial insemination. Buffaloes are considered silent breeders and it is very difficult to detect the heat on them. Well experienced people are needed to detect the heat on buffaloes. This phenomenon also supports the seasonality in buffaloes. Pregnancy diagnosis as compare to cattle is very difficult in buffaloes (Paudel *et al*, 2008).

Present research revealed that more than 70% buffaloes delivered calf from August to October showing the seasonality in breeding pattern in buffaloes. But the results differ in those farms who had managed year-round forage, provide better housing and health care which showed that the seasonality is the management problem not the breed or species specific problem. The results showed that some of the farmers from the research sites are able to reduce the calving interval and number of insemination per conception by providing proper feeding of forage and health care and management.

This project also worked in improved forage production considering the climate change and global warming factors and found the appropriate time of showing of Oat in winter season and teosinte in summer season for the better production in the research sites (Devkota et al, 2015). Accordingly, the project recommended the time of showing, number of cuttings to be taken and proper methods of feeding roughages and concentrates to the buffaloes. The adoption of these technologies by the farmers was encouraging. Most of the farmers reported that they adopted the technology and could produce year-round forage which eventually helps to improve the seasonality, reduce the calving interval and increased the milk production of the buffaloes (Devkota et al, 2017).

Sustainable use of the findings and impact on buffalo farming in research sites

A review of the research sites and enquiries with the concerned farmers of the sites by the researchers in December, 2020 revealed that 60% farmers of the areas are using the technologies of round the year green forage production, heat detection, right time artificial insemination and natural services, selection of the appropriate breeds of buffaloes, routine stool tests and drenching with anthelmentic to the buffaloes. They have also stressed that these package of practices are very useful for mitigating the seasonality and improving the productivity of buffaloes in the context of climate change.

CONCLUSION

Buffalo is considered as the 'black gold' in Nepal. However, many issues such as silent heat, seasonality in reproduction, age at first calving, calving interval, breed performance, green forage availability, parasitic infestation, right time artificial insemination and natural services, repeat breeding problems were considered as the major barriers in the areas of buffalo development in Nepal. This research work has addressed some of these issues. These research findings revealed that year-round production green forage is possible by following recommended production technologies in the context of climate change. Provision of round the year green forage, proper breeding practices, appropriate of insemination, health care and management could mitigate the seasonality; improve the production performance of buffaloes.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the participating farmers and the technical staff of the research sites at Palungtar, Dulegaunda and Chanauli. We would also like to acknowledge the CSU, MSU, USAID, DLS, AFU and NARC authorities for their financial and technical supports for carrying out this very important research work in Nepal.

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COMPARATIVE STUDY OF STALL-FEEDING AND PASTURE GRAZING SYSTEMS OF GOATS IN SMALLHOLDER FARMS OF SHAKTIKHOR, CHITWAN, NEPAL

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ABSTRACT

To identify the appropriate feeding, health, and managemental system of goat in Kalika Municipality, Shaktikhor, Chitwan. One hundred twenty households were surveyed by purposive randomized sampling. Primary information were collected focusing on the availability of pastureland, feed resources, and prevailing management condition of the goats within farmer's management condition including seasonal effect on production.Fecal samples of 650 goats in winter and 635 in summer were collected and tested for internal parasites and result analysed by Chi- square statistics, descriptive, ranking tools using SPSS version 16. The rangeland condition was accesed including major invasive species. The fecal analysis results revealed that the goats adopting the grazing system showed significantly higher positivity($p<0.0001$) of endoparasites and ectoparasites than that of stall-fed goats in both seasons and the problem was underpinned by higher numbers of kids mortality. This result suggested that the stall-fed system was better than the grazing system in terms of parasitic infestation and forage availability though the situation would be highly dependent upon the specific location and environment. Therefore, there was the need for improvement in feeds and management condition of goats on both cross-sections and regulate the use of anti-helminthic drugs round the year especially after the cessation of the monsoon.

Keywords: *Feeding system, Goats, Infestation parasitic, Shaktikhor, Seasons*

INTRODUCTION

Goats are the major income sources for mid hills smallholder farmer in Nepal. Regular income and immediate market access underscore its importance (Sapkota et al., 2016). Some foremost problems consist of seasonal disease infestation, parasitic problems, and limited pasture. Roughage insufficiency is more severe in the winter season due to dryness in grazing land leading to scarcity of palatable grass species. Inefficient and unmanaged grazing practices have led to the invasion of toxic and unpalatable species in the rangeland (Hoste et al 2005; Sharma, 2015). This degraded situation in the pastureland and poor availability of the cut and carry grasses probably causing more disease and parasitic infestation (Hoste *et al*., 2005).

The carrying capacity of the pastureland is diminishing along with increased chances

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of spreading internal and external parasites through the contaminated grazing land. Poor management condition coupled with inadequate forage prone to different diseases. Reduced health and nutrition status reduces the production performance of animals round the year (Sharma, 2015, Dhakal *et al*., 2019). Therefore, a scientific feeding system can play a substancious role in improving animal health and ultimately towards household incomes. Feeding regimes mainly depend upon the availability of land and human resources within the households. It is suggested that the suitability and superiority of each feeding system depend upon a range of determinants such as management condition and available resources, in the specified location, and local agro climates. The better fit of regimes is considered if various productive and reproductive performance of the animals is optimum.

Furthermore, goats' feeding requirement is more diversified and adopted mainly on coarse feed, fodder trees, and shrubs. Time burden of cut and carry seasonal forage is also predominant problem. Considering the facts, this research was formulated to assess the grassland situation of the study areas and identify the appropriate feeding system in terms of for better productive and reproductive performance and grazing related health problems of the animals.

MATERIALS AND METHODS

Study area and primary information collection

This study was conducted in Shaktikhor of Chitwan districts in 2017. This area represents the goat raising areas and is suitable to compare the two types of feeding system in goat. The primary information was collected from 120 households with a well-structured close and open-ended questionnaire survey (dichotomous and multiple choice). In order to gain access to the farmer knowledge, past experiences , and opinions upon the realistic issues on grazing and stall-fed systems, PRA toolkit amended by Development Organization (SNV/ Nepal, 2004) and Cornwall and Pratt (2004) were used. Initially, there was a structured interview followed by fecal sampling over twelve months period. The herds of goats were purposively allocated. Farmers were assigned, and farms were visited once a month to assess the determinants. Indexing and ranking tool was used to identify the major problem. The relative availability of grasses was catalogued as poor (a scarcity in all season), satisfactory (sufficient in certain season), and good (sufficient in all season) and results were explained with descriptive statistics.

Identification of invasive species in the grazing land

Major invasive species of the pastureland were identified by direct observation techniques. A catalogue was prepared using household survey and forage name was identified by reviewing the major fruiting, flowering and herbaceous parts of the plants and finally documented as a listing.

Deworming strategies

Dewormers were administered (7.5 mg/kg) whereas the initial dose was administered on 1st week of February with successive other regular administration after each sample was collected. The first collection of fecal samples on 1st week of June, (winter season), and finally, 1st week of February (summer). Seasonal variation in the parasitic infestations was measured using Chi-square statistics.

Those animals which follow both grazing and non grazing practices equally were excluded for data analysis purposes The total grazing hours below 8 (a full day grazing) in a week were considered as non grazers. Therefore maximum 4 full days grazing in a month were lied in non grazer categories (Solanki, 2000). For grazing groups, all animals who graze at least 26 days in a month were considered grazing animals otherwise excluded. Those farmers who have not practiced their animals were excluded Samples were collected from the rectum as well as fresh and packed into a small tube container with 3% formalin. Collected samples were brought to the sedimentation method, smear was prepared and microscopically examined in the Lab of Institute of Agriculture and Animal Science, IAAS, TU. Eggs were distinguished according to the portrayal given by Yadhav *et al.* (2006). Data were analyzed using Microsoft Excel version 2007 and Statistical Package for Social Science.

Observation of external parasites

Clinical examination of each goats were conducted by multiple fleeces parting in the direction opposite to that in which hair normally rests and followed by physical examination of skin, inspection and palpation of the skin across all parts of the animal for the presence of parasites, and gross lesions indicating the clinical form of infestation by ectoparasites. All infested Goats were considered as positive for ectoparasites. Morphological structure of the ectoparasites were the basis for identification as described by Yadhav *et al.* (2006). In the case of ectoparasites, categories of severity such as high, medium, and mild are noticed simply by observation.

Economic analysis

The economic investment and return were analysed by using partial budgeting techniques. Major input such as feed, medicine and wages to labour were considered. FYM produced in the farm were extensively used to produce crops and grasses in the farm that was also utilized to produces grasses and animal feeds. Therefore possible benefit from farm yard manured is excluded from economic analysis (Wander, 2021).

RESULTS

Rangeland situation in the research sites

The availability of grasses is categorized as poor supply (scarcity in all season), satisfactory (sufficient for at least 6 months), and good (sufficient in all seasons) both in foraging and cut and carry system. Only a few 12 (10.00%) and 20 (16.67%) of the farmers observed the good availability of the forages in stall feeding and grazing system respectively during summer season. The acute inadequacy of forage was observed in either of the feeding regimes irrespective of the season while winter faced extreme situations. Relatively, more problematic scenarios was observed in the winter grazing (Table 1)

Table 1. Forage availability scenarios in Shaktikhor

Seasons	Feeding regimes	Grass availability			p-value
		*Poor	*Satisfactory	*Good	
Summer	Stall feeding	69(57.50)	39(32.5)	12(10.00)	NS
	Grazing	75(62.5)	25(20.83)	20(16.67)	
Winter	Stall feeding	98(81.67)	17(14.17)	4(3.27)	NS
	Grazing	111(92.25)	7(5.83)	2(1.67)	
Interactions					
Summer verses winter stall feeding					<0.01
Summer verses winter grazing					<0.01

*Figure in the parenthesis indicates the percentage (Source: household survey, 2017)

Reasons of grassland degradation

The major cause of grassland degradation was increased in the invasive species in the rangeland. A vast area of rangeland (Dong *et al*., 2009) was found to be dominant with poisonous and less palatable forage species. An unsustainable grazing pattern was also jeopardizing the sustainable grazing practices. Limited grazing land coupled with a new Community Forest Program which controls vast areas of the forest and past grazing area has increased the problems. The fallow period was not necessarily maintained which affects the flowering and fruiting of the palatable species. This leads to a negative selection of palatable species reducing the carrying capacity of grazing land (Dong *et al*., 2009). The problem is further substantiated by the selective nature of overstocked forager which always helps in the negative selection of palatable species. The unsustainable approaches such as forest firing, slash, and burn practices are already on the way causing destruction of the soil health and forage value in long term (Jordan, 2016). Mortality at a young age was always a problem due to the grazing of poisonous species. Moreover, forest firing also has some level of impact on the goat production system in the dry period (Sharma, 2015, Dhakal *et al*., 2019). But firing was somewhat occasional. Frequent outbreaks of fires may increase the ground vegetation but reduce the forbs and shrubs population, which are major forage for goats (Table 2).

Table 2. Causes of grassland degradation

Causes of grassland degradation	Index values	Ranking
Invasive species increasing	0.84	I
Unsustainable use and approaches (overstocking, frequent grazing)	0.60	II
Firing/slash and burn practices	0.54	III
Landslides and soil erosion	0.31	IV

Source: (household survey, 2017)

Distribution of invasive species

Moreover, three naturalized species *Ageratum conyzoides, Galinsoga quadriradiata* and *Spermacoce alata Aubl* (Syn. Borreria alata) (Local name: Bhainsi Jhar) have been also found to be invasive in agro-ecosystems and rangelands. A. haustonianum was found to be spreading rapidly in Tarai, Siwalik and Mid Hills from east to west while *Saccharum spontaneum* is problematic mainly in low mountains and mid hills region of western part mainly Chitwan and periphery region. Though the total number of invasive alien species in Nepal becomes 25 which belongs to 13 families (Table 3) thought major 7 families have a severe invasion in the rangeland. Asteraceae is the largest family with 10 species, followed by Amaranthaceae (2 species) and Caesalpiniaceae (2 species); the remaining 11 families are represented by single species (Table 3)

Table 3. Some invasive species responsible for changing natural grassland ecosystem and reducing productivity in the region

S.N.	Scientific name	Common name	Family	Impact on ecosystem
1	*Ageratum conyzoids* (Origin: Mexico)	Kalo Banmara	Asteraceae	Weed frequently encountered on cultivated land, fertile irrigated land, humid fertile grazing land and wasteland
2	*Ageratina adenophora* (Origin: Mexico)	Kalo Banmara	Asteraceae	Weed frequently encountered on cultivated land, fertile irrigated land, humid fertile grazing land and rangeland
3	*Amaranthus species* (Origin: N. America)	Lunde	Asteraceae	Invasive, widely distributed weeds
4	*Chromolaena odorata* (Origin: Mexico and S America)	Siam weed Seto Banmara	Asteraceae	Common weeds of grazing lands
5	*Chenopodium ambrosoides* (Origin: Trop. America	Bethe	Chenopodiaceae	Weeds of roadsides and wasteland
6	*Convolvulus arvensis* (Origin: Europe)	Halinkhur	Convolvulaceae	Common weed of wasteland and fallow land
7	*Conyza spp.* (Origin:N. America)	Mulapate	Asteraceae	Common weeds of farmland and wasteland
8	*Eupatroium adenophorum* (Origin: West Indies)	Kalo Banmara	Asteraceae	Common weed of wasteland, suppressed the regeneration of the other species
9	*Saccharum spontaneum* (Origin: India)	Kans	(Poaceae)	A common weed of wasteland suppresses the regeneration of the other species, makes the soil acidic
10	*Ipomoea carnea* (Origin: America)	Ajamari	Convolvulaceae	Common weeds of aquatic and marshy habitat
11	*Lantana camera* (origin:Trop. America)	Kirne Kanda	Verbenaceae	Common weeds of wasteland
12	Senna tora	Tapre	Caesalpiniaceae	Common weeds of wasteland
13	*Galinsoga quadriradiata*(-Mexico	Shaggy Soldier(-Jhuse Chitlange)	Asteraceae	Common weeds of wasteland
14	*Spermacoce alata*(West Indies and Tropical America	Broadleaf buttonweed(Alu Pate Jhar, Vaisi Jhaar	Rubiaceae	Common weeds of wasteland

Source: Field observation and sampling (plant family detail was obtained from Tiwari *et al*., (2005) and Shrestha (2016)

Prevalence of parasites

The parasitic infestation was found to be significantly higher (p<0.001) in grazing animals compared to stall-fed one in all seasons (p<0.00001 for summer and p<0.0007 for winter). In comparison with winter grazing, parasite infestation was more prone to immediate summer. That may be due to more infestation in the grazing land and exposure to the helminthic parasites. The Stall-fed system was superior to small ruminants in terms of parasitic infestation (Table 4)

Table 4. Seasonal variation of endoparasitic infestation in different feeding system (Cochran-Mantel-Haenszel test)

Seasons	Feeding system	Positive cases	Negative cases	Prevalence percentage	Total	Chi-square value	P-value
Summer	Grazing system	350	40	89.74	390	28.87	<0.00001
	Stall-fed system	180	65	73.47	245		
	Total	530	105	83.46	635		
Winter	Grazing system	305	95	76.25	400	11.33	0.0007
	Stall-fed system	160	90	64.00	250		
	Total	465	185	71.54	650		
Sum-total		1345	520	76.25	1865		
Interactions							
Positive cases in Summer verses winter grazing						25.37	0.00001
Positive cases in Summer verses winter stall-fed						5.15	0.023

Among the 1865 samples analyzed, 1345 (76.25%) were positive in both two cross-sections and grazing regimes. Seasonal evaluation indicated that the overall infection percentage of grazing animals was significantly higher in the rainy season (89.74%) followed by winter (76.25%) (p-value <0.0001 and 0.001 respectively). Similarly, the non-grazer animal group followed a similar pattern in both cross-sections. The results showed that the parasitic problems in goats are the frequent phenomenon in Shaktikhor Area of Chitwan Nepal. The number of eggs of Fasciola were significantly higher in case of grazing goats than that of others.

Endoparasites Categories

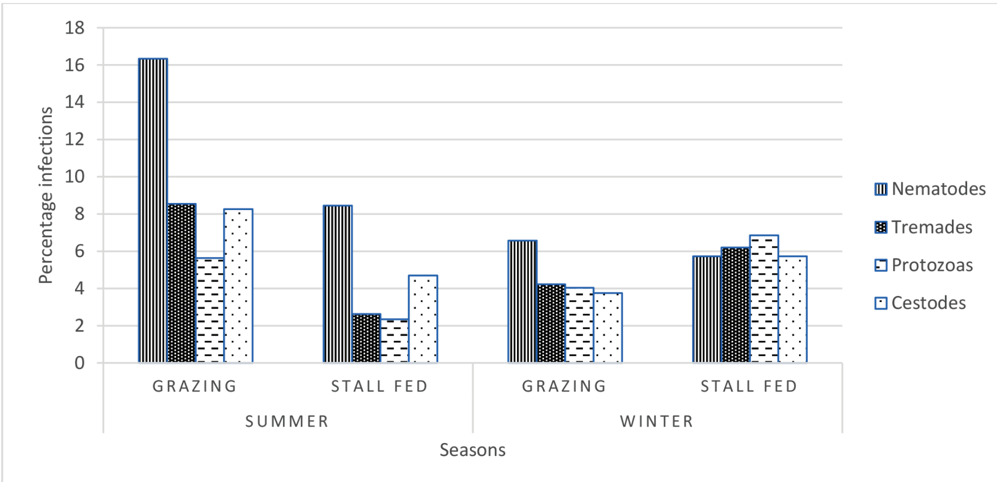

Figure 2. Endoparasites infestations in different seasons

The results revealed that the prevalence of nematodes in goats was highest followed by trematodes, protozoa and cestodes. In overall, the infestation rate was more severe during summer. The various species of parasites recorded in the present study coincided with the findings of various authors (Figure 2).

Ectoparasites Categories

The prevalence of goats for ticks was highest in all seasons and all feeding regimes. The preferred feeding sites by ticks were head/ears, scrotal/udder, vulva, tail, neck and leg. Head/earsand areas were observed as the main sites for sarcoptic mange (Figure 3).

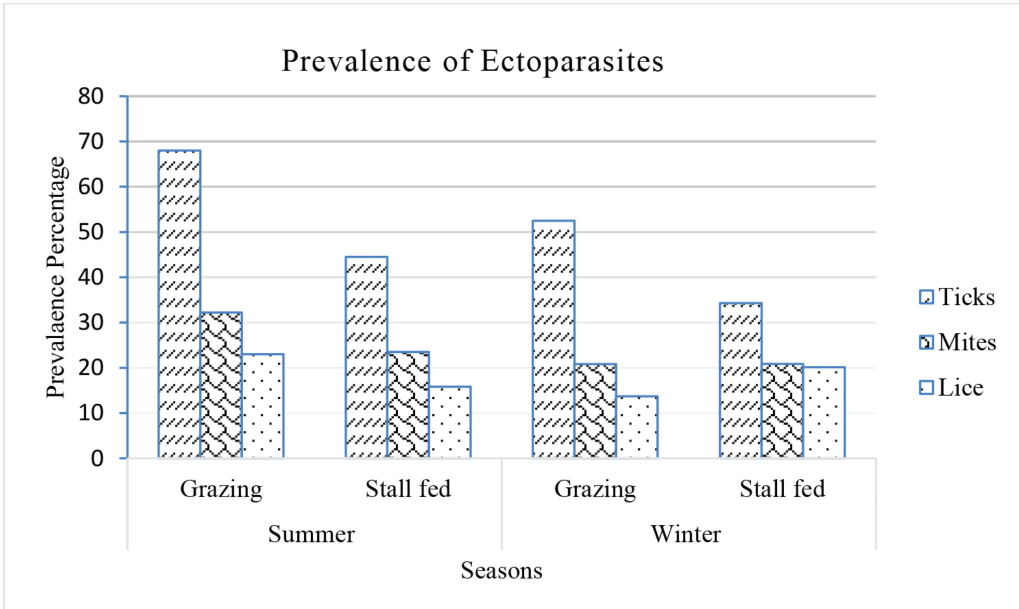

Figure 3. Ectoparasites infestations in different seasons

Mortality of kids

The mortality percentage of the kids of pasture grazed mother was higher compared to those of the stall-fed one. The significant difference ($p<0.05$) on the mortality between the feeding system was observed in the summer season. The significant differences ($P<0.05$) on the mortality of kids was observed among the seasons (Table 5).

Table 5. Seasonal variation of kid mortality on feeding system (Chi-square test)

Season	Feeding system	Live Number	Mortality number	Total birth	Mortality %	Chi-square p-value
Summer	Grazing	25	5	30	13.33	p>0.05
	Stall-fed	10	3	13	8.33	
Total		35	8	43		
Winter	Grazing	21	6	27	20.00	p>0.05
	Stall-fed	11	3	14	5.00	
Total		32	9	41		
Summer verses winter grazing						p>0.05
Summer verses winter stall-fed						p>0.05

There was no any association in the mortality rate with respect to the seasons and grazing regimes. Though the sample population for this study was very small, further verification might be necessary to draw the conclusion.

Survivability and growth performance of the kids may be improved by enhancing health conditions. The given mortality rate of 13% in the summer grazing goats' kids is higher than given by Kajauria, 2013. Improving rangeland and farmland would be a good strategy for limited land to increase available feed. The information obtained from this experiment may be helpful for the researchers and policy makers for the development of better stock of goat.

Due to loss of energy during roaming, less amount of nutrients remained for milk production. This reduces the average amount of milk production and growth rate of a kid will be retarded and some extreme condition, the mortality of the kids remains higher. In case of grazing groups, lower body weight gain found in growing youngs and this might be due to ill health, and parasitic infestation of the doe and poor quality pasture.

Economic analysis

The gross earning of the farmers, after eight months of experimental period for a unit of 30 goats the net profit was calculated. Only those household which had more than 30 goats were considered for this study. The dressing percentage for chevon was considered 55% irrespective of the size factor. The current market price of the chevon at Chitwan district was considered for this study. At least five butcher house was asked for the price and average price was considered for this study. The net possible earning in household was calculated by calculating the input cost of feeding and labor. Other fixed assets, as well as treatment of medicine and vaccination, were not considered for this study because it may vary season to season and house to house distance from the market and other external factors. The net earnings from the stall feeding goats were significantly higher (53.65%) (Table 6) than the grazing system. The net difference in the income was found to be NRs. 134,400.

Greater the size of the goats, greater will be the dressing percentage. Moreover, the body condition scoring also affects the dressing percentage of the goats. Good body scoring animals tends to have higher dressing percentage than the lower body condition scoring Therefore we have concluded that stall feeding system in more economical in terms of growth and size as well full grazing system would have more household work burden to the families who stay in the house for rearing and caring of the other animals in the households (Table 6).

Table 6. Economic analysis of the stall-fed and grazing system of goats (30 goat's model)

Stall-fed system			Grazing system			
Input cost	Income	Net profit	Input cost	Income	Net profit	Net difference in profit
@150 gram per day per goats for 8 month @ Rs 45/ kg (for concentrate feed for 8 months (150x240x45/1000) = 1620x30 (30 goats) = =NRs.48600 One labor per day @NRs.500 per day=NRs.120,000	The average weight at 8 months is 33.55kg. *Dressed meat weight is 21.13kg, Price 18.45x1000 x 30 = NRs.553,500	384900	@150 gram per day per goats for 8 months @ Rs45/ kg (for concentrate feed for 8 months (150x240x45/1000) = 1620x30 (30 goats) = =NRs.48600 One labor per day @NRs.500 per day=NRs.120,000	Average weight at 8 months is 25.4 kg. *Dressed weight is 13.97kg. Price 13.97x1000x30 = NRs.419,100	NRs. 250,500	NRs. 134,400

Average dressing percentage of chevon was considered 55% (size factor was ignored)

Market price of chevon was NRs. 1000

DISCUSSION

Besides monsoon season, all other period is feed scarcity period (Sharma; 2015, Dong *et al.*, 2009). In a commercialized farming system only, farmers use to cultivate promising winter species to feed their livestock, but in the case of goats which is known for its browsing habits, farmers were very less familiar with the improved fodder trees species. The smallholder producers are mainly dependent upon the cut and carry system from the nearby forest. Drudgery especially to women member/ female members of the households (Sharma; 2015, Dong *et al.*, 2009) has been increased in recent years due to less availability of the forages. During feed scarcity period, concentrate feed which can compensate to a certain extent, is generally not enough to compensate for the scarcity of the green forage (Jordan, 2016). The outlast cost of concentrate feed is another constraint for optimum utilization by the resource-poor farmer (Sharma, 2015). For the utilization of the grazing land, community's forest program had serious impacts by squeezing the available grazing land (Dong *et al.*, 2009). The stringent policy to conserve forest by prohibiting the local people has made catastrophic effects on available nutrients to the grazing animals of the selected area (Dong *et al.*, 2009)

Invasive and alien species would have significantly reduced the natural biodiversity and outplaces economically important native forage species. Besides disrupting prevailing vegetation dynamics, these species alter nutrient cycling ultimately reducing the natural vegetation in long run by developing adverse environments for seed germination, strangle sapling, soil health, and severely competing with light in lower gradients. Clay (2003) reported that, in particular, aggressive species was especially severe on the structure and function of vulnerable and isolated ecosystems.

The various results have suggested that the increase in the grazing pressure can decrease in the number of palatable groups and ultimately a major shift in these functional group was ultimate cause of major increase in the number of unpalatable grasses (Jordan, 2016). However, we did not rule out that grazing had solo accountable on this functional ecology instead there might be some climate change or other anthropogenic activities that have difficult to quantify. Different findings have also suggested that the development of low-quality shrublands through grassland is a natural phenomenon (Dhakal *et al*., 2019; Sharma, 2015) that was often associated with increases in grazing pressure (Peng*et et al*., 2013). Somes research evidence claims that grazing tends to reduce the cover of palatable grasses and to increase that of shrubs and weeds.

Species richness of palatable species is always inversely proportional to grazing pressure. Milchunas and Lauenroth (1993). It was also mentioned that in dry environments poor soil nutrient-poor and higher grazing pressure are expected to impact negatively on species richness. Heavy grazing might induce major modifications of soil and vegetation eco-system by altering the microclimate and/or topsoil properties resulting in the extinction of local vegetation by affecting the shooting phase of forage (Milton *et al*., 1994).

It was suggested that maintaining and enhancing the richness of palatable grass species can enhance the carrying capacity of the rangeland by maintaining the grasslands' ecosystem function. However, there was a need of regular assessment and monitoring of vegetation composition of herbs, shrubs, other palatable species and other noxious species for identifying rangeland functioning.

Heavy rainfall and high relative humidity during rainy season may have predisposed to heavy parasitic infection (Khajuria *et al*., 2013; Dixit *et al*., 2017). Climatic factors should have influenced dispersion of larvae in the herbage which increased the chance of contact between host and larvae (Khajuria *et al*., 2013; Dixit *et al*., 2017; Hoste *et al*., 2005). The observed results of endoparasites were in agreement also with the other result of (Varadharajan, 2015) in Pakistan. Higher infection during the rainy season may also be attributed to suitable molarity of salt present in the soil, an important factor for ecdysis but there need detailed study to verify these reasons.

The result was parallel with the finding of (Jeyathilakan *et al*., 2003; Palanivel *et al*., 2012) in grazing practices of goats in farmer's management condition. Whereas some researcher observed lower prevalence than this finding (Sing *et al*., 2005; Kuchai *et al*., 2011; Hoste *et al*., 2005). The finding of the various species of parasites recorded in the present study was also reported by Palanivel et *al.,* (2012). The seasonal occurrence of parasitic infection in small ruminants depicted higher infection of helminthes in rainy season followed by winter. This is in accordance with findings of other researchers (Kotoch, *et al*., 2000; Yadav *et al*., 2006; Sarothiya *et al.,* 2017, Khajuria *et al*., 2013; Turner *et al*., 2005). The observed results of endoparasites also in agreement with the other result of Varadharajan (2015) in Pakistan. The result was also parallel with the finding of Jeyathilakan *et al*. (2003) and Palanivel *et al*. (2012) who stated the lower parasitic infestation in winter seasons.

The various species of parasites recorded in the present study coincided with the findings of various authors (Palanivel *et al*., 2012). The seasonal occurrence of parasitic infection in small ruminants depicted higher infection of helminths in the rainy season followed by winter and spring. This is in accordance with findings of other researchers (Kotoch, *et al*., 2000). Heavy rainfall and high relative humidity during rainy season predisposed to heavy parasitic infection. Climatic factors also influenced the dispersion of larvae in the herbage which increased the chance of contact between host and larvae Kotoch, *et al*., 2000; Yadav *et al*., 2006: Sarothiya *et al*., 2017; Khajuria *et al*., 2013; Turner *et al*., 2005). Higher infection during the rainy season may also be attributed to suitable molarity of salt present in the soil, an important factor for ecdysis but there need detail study to verify these reason.

The immediate profit was higher in stall-fed groups as compared to the grazing group for a unit of 30 goats (Patil *et al*., 2014). It was concluded that in stall-fed goats grow healthier, gain better body weight, and are safer on health grounds (Kumar, 2007). By adopting an intensive farming system of goat rearing, progressive farmers have a large potential for gaining mojor economic benefits with positive net returns compared to the grazing system. This is important because of shrinking resources for extensive grazing. The economic analysis of feeding practices in different grazing system could be a guideline for commercial goat farming (Kumar, 2007; Patil *et al.*, 2014) practices.

CONCLUSION

Seasonal availability of forage has impacts on feeding regimes of goats whereas deteriorating rangeland in quality and quantity aspects coupled with health-related issues has compounded the challenges of goat farming in Nepal. There is an immediate need of a system for the improvement of rangeland along with the goats' production in the days to come. Moreover, the infections of gastrointestinal parasites in subsistence farming were most prevalent throughout the year. Therefore, appropriate strategic drenching should be practiced. Such a treatment regime could be strategic to get rid of the parasitic burden in these small ruminants and also minimize the pasture contamination by reducing fecal eggs counts.

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POSSIBLE IMPLICATIONS OF RECENTLY RECOGNIZED G-PROTEIN COUPLED RECEPTORS ON FERTILITY MANAGEMENT OF DAIRY CATTLE UNDER NEPALESE CONDITION

Kiran Pandey

ABSTRACT

Reproduction in animals is a complex process regulated by various hormones and affected by various factors such as nutrition, health, management and environment. Infertility, anestrus, repeat breeding, endometritis, cystic ovary and other conditions in female cattle may result from the imbalance in the normal physiological status of the animal. The major reproductive hormones GnRH, LH, FSH and estradiol bind to their respective receptors in target organs and bring signaling mechanisms to regulate reproductive functions in female animals. Various studies in Nepal have reported that livestock commercialization, especially cattle and buffalo, have not reached the maximum level due to the low production and productivity of the animals. One reason for low production and productivity is the disruption in the hormonal balance. Any disruptions at any stage of hormone action can cause temporary or permanent failure in reproduction. Researches around the globe have come through some explanations for the hormonal imbalance in cattle. The discovery of new G-protein coupled receptors (GPCRs) and their co-localization with GnRH receptors (GnRHR) in gonadotropes of the anterior pituitary (AP) gland of cattle indicate their role in gonadotropin function downstream. Similarly, the possible role of Anti-Mullerian Hormone (AMH) and some mycoestrogens for gonadotropin secretion have been described. These findings can help us find some solutions to the infertility problems in Nepalese livestock, of course, with further research to substantiate and document their implications under Nepalese conditions.

Keywords: *GPCR, hormone, infertility, livestock, Nepal*

INTRODUCTION

Every living being on this planet has the natural strength to maintain its existence and this strength is obtained through the ability to reproduce the self-like. Reproduction in animals is a complex interplay of various factors such as genetics, nutrition, hormones, environment, health and others and thus has been of the prime concern for a long time. Successful reproductive strategies should produce healthy offspring and maintain the mother for the next production cycle. In today's world of commercialization, reproduction and its efficiency has been an important determining factor and prime requisite for the success and profitability of livestock business.

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Basics of Reproductive Physiology

The Hypothalamus, Anterior Pituitary (AP) and the Gonads (HPG axis) are the major regulators and performers of the successful reproduction functions. Reproductive functions in animals are regulated by several hormones including Gonadotropin Releasing Hormone (GnRH) from the hypothalamus, Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) from the anterior pituitary, and Estradiol (E2), Progesterone (P4) and Testosterone (T) from the gonads. Follistatin and activin secreted by gonads and AP and inhibin secreted by gonads regulate the secretions of hormones from the anterior pituitary and hypothalamus as well. The HPG axis controls various reproductive functions, which include sexual development, puberty, gametogenesis and pregnancy. Defects in the HPG axis led to hypogonadotropic hypogonadism, and induce abnormal reproductive functions and sterility (Larco et al., 2013).

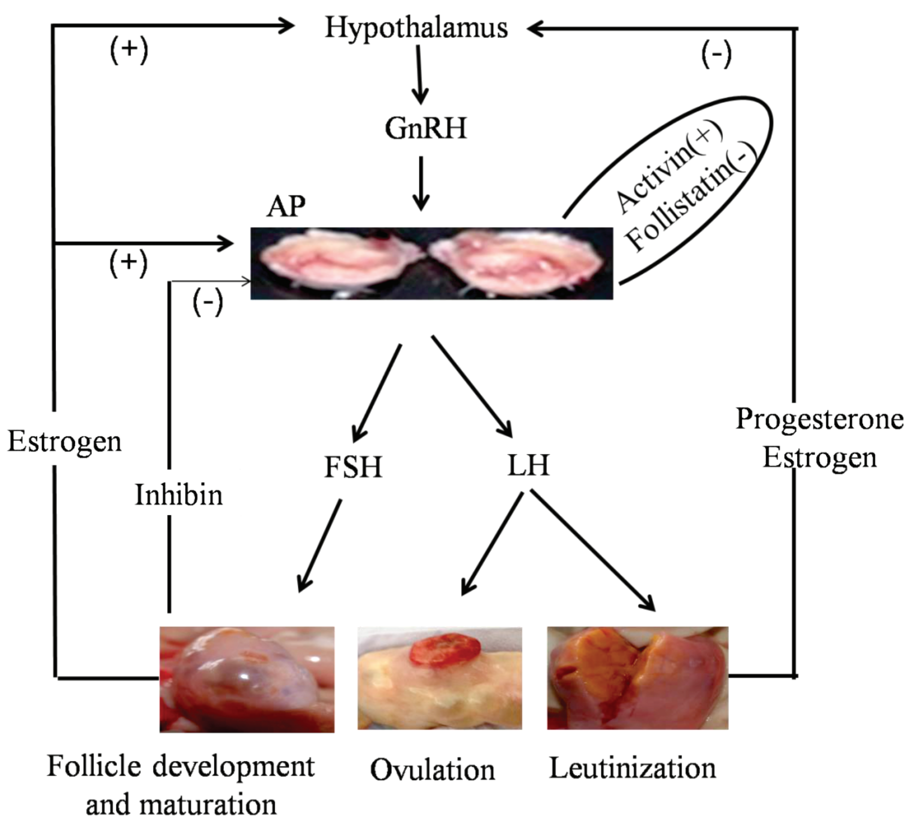

Figure 1: The Hypothalamus-Pituitary-Gonad (HPG) axis which is the major contributor and regulator for reproductive hormonal homeostasis in animals. The (+) indicate the positive effect and (-) indicate the negative effect.

The well-established mechanism of hormonal regulation in animals is summarized in figure 1. Briefly, the GnRH neurons in the arcuate and preoptic area of the hypothalamus secrete GnRH which binds to GnRH Receptor (GnRHR) in the gonadotropes of the anterior pituitary to stimulate the release of gonadotropins - FSH and LH. These gonadotropins bind to their respective receptors in gonads. The FSH helps in the maturation of the follicles and LH causes ovulation and luteinization. The gonads secrete E2, T and P4 that regulate stages of reproduction cycle and hormonal secretions through feedback mechanisms. This mechanism is mostly genomic (Hewitt and Korach, 2003), though non-genomic mechanisms have been recently reported (Arreguin-Arevalo and Nett, 2005).

Major reproductive problems of Nepalese livestock

Livestock is an important component of the Nepalese economy and have been contributing to the socio-economic development of Nepal. Livestock contributes around 12% to the national GDP and 26% to the agricultural GDP in 2019 (Poudel et al., 2020). Livestock has been greatly contributing to poverty reduction, livelihood enhancement, employment generation, ensuring food and nutrition security, and attaining sustainable food production system. Maximizing reproductive efficiency is fundamental for enhanced productivity and production of livestock to ensure food security and nutrition. However, various factors such as animal health, nutritional deficiency, poor husbandry practices, unsystematic breeding plan and reproductive problems have adversely affected the livestock production and productivity in Nepal. Various studies, though few in number, have been reported regarding the reproductive status of livestock in Nepal. Sankhi (1999) reported that anestrous, ovarian cysts, repeat breeding, freemartin, uterine tumors, nutritional deficiency and internal parasitic infestation were the common infertility problems among livestock in Western Nepal. Rasaili et al. (1998) reported anestrous, silent estrous and repeat breeding among the cattle and buffalo in different ecological regions of Nepal. Sub-functional ovary, repeat breeding, persistent corpus luteum, anestrus, endometritis and follicular cyst were found as the major reproductive problems during door-to-door infertility campaign conducted by National Livestock Breeding Office, Pokhara (Figure 2) and most importantly 33.64% (655 out of 1947) of the cattle examined were infertile for various reasons (National Livestock Breeding Office, personal communication). This data reveals an alarming situation in the cattle farming in terms of reproductive management and economic return. Raising and treating such a huge number of infertile cattle, in the Nepalese situation, is an economic burden to the farmer and a social problem to the nation.

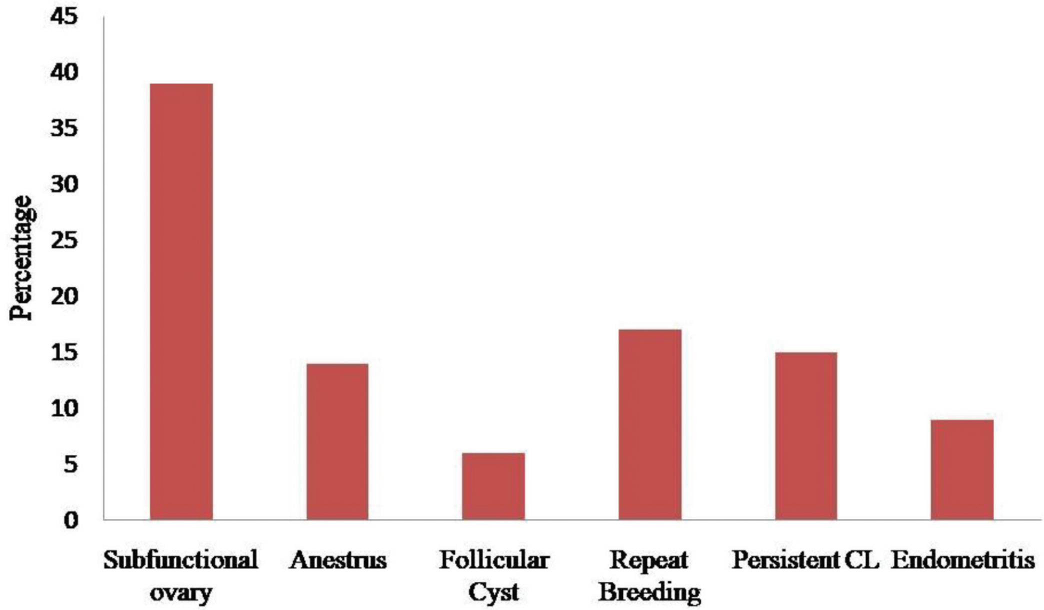

Figure 2: Various reproductive disorders identified during Door to Door infertility management program conducted by National Livestock Breeding Office (NLBO) in the year 2018

Causes of infertility in Nepal

Infertility, is defined as the absence or delay in the production of offspring by a normal animal, is one of the major problems in livestock farm worldwide. Infertility can be attributed to various genetic and non- genetic factors which include nutritional deficiency, managerial deficits, diseases, defective reproductive organs, environmental factors and physiologic conditions such as hormonal imbalance. Research works at various times have reported multiple causes for infertility in cattle and buffalo. Gautam (2020) summarized genotype, nutrition, environment, suckling, level of milk production, parasitic infestations, and periparturient disesases as the major causes of anestrous in buffaloes. Anestrus showed seasonal variation, higher occurrence in winter and spring season (March to June), among buffaloes in Southern Nepal (Devkota et al., 2012). Crossbred and exotic cattle were found to be more infertile than local breeds (Jha, 2005). Cattle suffering from sub-clinical mastitis had higher incidences of repeat breeding (NARC, AHD annual report, 2019). Brucellosis, Neosporosis, Leptospirosis, Chlamydiosis, Toxoplasmosis, Infectious Bovine Rhinotraciteitis, Bovine Viral Diarrhoea and Staphylococcosis have been reported as the infectious cause of infertility (Joshi and Joshi, 2001a; Joshi and Joshi, 2001b; Jha, 2005; Acharya et al., 2020). Poor nutrition was found the major cause of infertility among cattle (Tiwari et al, 2019; Upreti et al, 2010) and chauries (Sapkota et al, 2018). The role of insecticide and pesticide to cause infertility in animals is not reported in Nepal but these chemicals are considered as the causative factors for infertility in human (Gautam and Risal, 2017). The type of management system (intensive, semi-intensive and free range) was found to effect infertility occurrence among cattle (Rasaili et al., 1998). The deficiency of hormones is another cause of infertility but quantitative researches are lack-ing. Sah and Nakao (2010) reported that true anestrous with inactive ovaries was the major cause of anoestrus in buffaloes. Various approaches to use hormones to treat infertility have resulted in success. The use of GnRH and prostaglandin (the Ovsynch protocol), progesterone and mineral supplement have improved conception and more pregnancies were maintained (Tiwari et al, 2019; Devkota et al., 2013). Various studies to develop a breeding protocol to increase off-season calving of buffaloes are ongoing.

Some recent advancement in reproductive physiology

Successful reproduction in livestock is a concern for humans. Various studies are being undertaken for the optimization of the breeding performance of the farm livestock in different parts of the world and some of the recently recognized hormone receptors of significance are described below.

Discovery of new G-Protein Coupled Receptors (GPCRs)

The GPCRs, the largest family of membrane receptors, stimulate various intracellular signaling pathways including cyclic Adenosine monophosphate (cAMP), inositol triphosphate, diacylglycerol, calcium and enzymes (Latek et al., 2012). The GnRH receptor (GnRHR), important GPCR, are the most important receptors to initiate reproductive functions in animals and are believed to be located in the specialized areas in the plasma membrane of gonadotropes called lipid raft. Lipid rafts are distinct, relatively insoluble regions that have low density and are less fluid than the surrounding membrane. They facilitate signaling by allowing co-localization of membrane receptors and their downstream signaling components (Kadokawa et al., 2014).

Recent studies have identified various GPCRs in the anterior pituitary (AP) that can play important role in controlling reproductive functions. Next generation sequencing of AP before and after ovulation has identified some orphan GPCRs which showed significant differences in their expressions between the two stages (Pandey et al., 2017a). The important receptors are:

a. G-Protein Receptor 30: G-Protein Receptor 30 (GPR30), deorphanized recently and called as G-protein coupled estrogen receptor 1 (GPER 1), is the receptor for estradiol and some mycoestrogens (Rudolf et al., 2013; Nakamura et al., 2015).

b. G-Protein Receptor 61: G-Protein Receptor 61 (GPR61) orphan GPCR is expressed in the AP and co-localizes with GnRHR in the plasma membrane of the gonadotropes (Pandey et al., 2017b). Plasmalogen is considered as the possible ligand for GPR61, which is found to be associated with the Gs protein and stimulate extracellular regulated protein kinases (*ERK*) signalling in neurons (Zheng et al, 2019). The presence of GPR61 in gonadotropes and co-localization with GnRHR suggests their important role in reproduction.
c. G-Protein Receptor 153: Similar to GPR61, G-Protein Receptor 153 (GPR153) receptor is orphan and few information is available on it. Its co-localization with GnRHR in the plasma membrane of the gonadotropes signals of its importance in regulation of reproductive functions (Pandey et al., 2018).

The identification of ligands to these receptors may enrich our understanding of the reproductive physiology and support in identifying interventions to find solution to various reproductive problems.

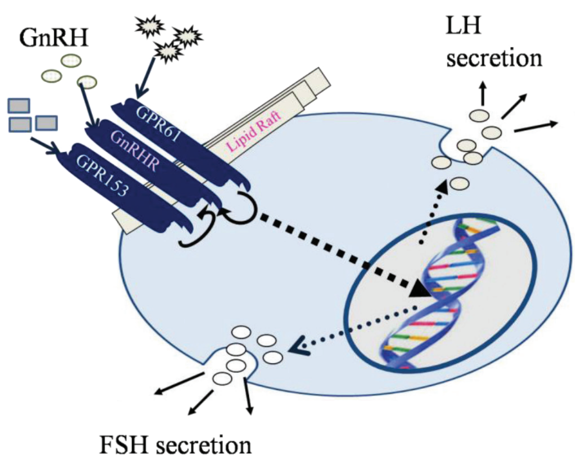

Figure 3: The G-protein coupled receptors (GPR61 and GPR153) are colocalized with gonadotrophin releasing hormone receptor (GnRHR) in the plasma membrane (possibly in the lipid raft) of the gonadotropes. Though the ligands for these receptors are yet to discovered, their colocalization with GnRHR hints of their possible role in affecting the secretion of gonadotropins, LH and FSH, from the gonadotropes.

Discovery of AMHR2 in AP and role of AMH

Anti Mullerian hormone (AMH) is secreted from pre-antral and small antral follicles of the ovaries and possibility of its use as a potential predictor of fertility, superovulation, and ovarian disorders in domestic animals are under study (Umer et al, 2019). The receptor for AMH, the Anti Mullerian Hormone Receptor 2 (AMHR2), has been reported to co-localize with GnRHR in gonadotropes of post-pubertal heifers (Kereilwe et al., 2018). The AMH has been found to stimulate basal FSH and LH secretion in post-pubertal heifers suggesting that preantral and small antral follicles regulate gonadotropin secretion in heifers.

Non-genomic effect of estradiol

Genomic mechanism of estradiol effect has been well established - estradiol binds to its receptors in the cell nucleus and brings various effects (Marino et al., 2006). But the recent findings suggests that this hormone also binds to cell membrane receptor GPR30 and suppress GnRH induced LH secretion from gonadotropes in AP (Rudolf and Kadokawa, 2013) non-genomically via the intracellular mediators protein kinase A (PKA) and phosphorylated extracellular signal-regulated kinase (pERK) (Rudolf and Kadokawa, 2016). The non-genomic pathway is rapid and can happen within 5 minutes *in vitro*.

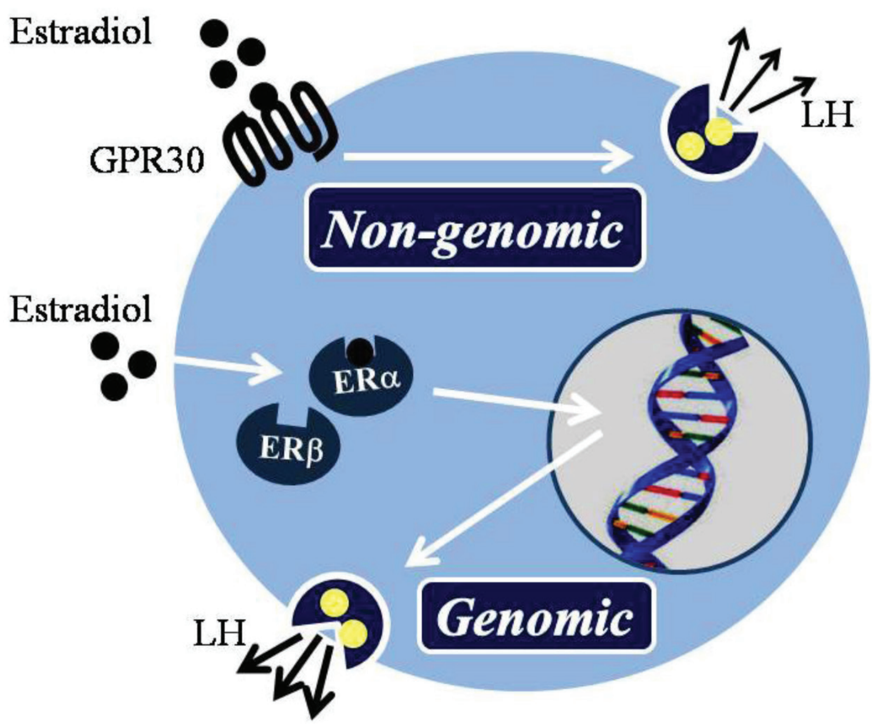

Figure 4: This figure shows both genomic and non genomic mechanism of hormonal regulation by estradiol. Estradiol binds to estrogen receptors (ER) alpha and beta and causes genetic changes in gonadotropes to regulate gonadotrophin secretion. The

recent *in vitro* findings show that estradiol can also bind to membrane receptor GPR30 in gonadotropes and alter gonadotrophin secretion in a non-genomic manner

Nonsteroidal mycoestrogen effect gonadotropin secretion non-genomically

Cereal grains and animal feed contaminated with fusarium fungi possess estrogenic compound which can affect animal reproduction. Various chemical products from fungi such as α-zearalanol (α-ZAL), β-zearalanol (β-ZAL), α-zearalenol (α-ZOL), β-zearalenol (β-ZOL), and zearalenone can alter the hormonal balance in the animal body. Zearalenone groups of mycotoxins can bind to estrogen receptor and thus are called as estrogenic mycotoxins (Liu & Applegate, 2020). Nakamura and Kadokawa (2015) reported that zearalenone binds to GPR30 and suppresses GnRH-induced LH release from the bovine AP cells *in vitro* in a non-genomic manner.

Implications in Nepal

Nepalese livestock faces the chronic problem of feed and forage deficiency and further the quality of available feed and forage is questionable. A study conducted by National Animal Feed and Livestock Quality Management Laboratory (NAFLQML) shows the deficiency of TDN (around 18%) for the livestock in Nepal (NAFLQML, 2020). The feed quality testing showed 26.83% of the feed samples could not meet required threshold for moisture and protein (NAFLQML, 2019). It is well understood that the quality of feed will directly affect the overall performance (including reproduction) of the animal. The poor physical growth of animals will cause poor development of organs such as the ovary and the poorly developed ovary can have many pre-antral and immature follicles which can be the continuous source of AMH that causes poor gonadotropin secretions (Kereilwe et al., 2018). This is justified from the field experiences that treatment with feed supplements and hormones induced ovarian activities among cattle and chauries (Tiwari et al, 2019; Sapkota et al, 2018). Similarly, infertility as a result of negative energy balance especially in high yielding breeds of cattle is also common in Nepal. The deficiency of macro- and micro- nutrients can affect the cellular signalling mechanism (Efeyan et al, 2015), which ultimately can affect the physiology and hence the reproductive function of the animal.

Various types of mycotoxins such as aflatoxin, fumonisin, ochratoxin, trichothecene (deoxyni- valenol, T-2 and HT-2) and zearalenone (ZEN) have been reported in animal feed (Liu and Ap- plegate, 2020). These mycotoxins can impair growth and reproductive efficiency in domestic livestock (Diekman and Green, 1992). The quality of feed being used for livestock feeding in Nepal is mostly questionable. Presence of aflatoxin above permissible level has been reported in livestock and poultry feeds and feed ingredients in Nepal (Aryal and Karki, 2009; Karki et al, 2003). Eighty percent of the livestock (cattle and buffalo) and 70% of poultry feed samples and 72% of feed ingredients were contaminated with aflatoxin (Khadka et al., 2000). These studies indicate that the feed used for livestock in Nepal is contaminated with various funguses that can also release mycoestrogens. In addition, it is customary in rural areas of Nepal to feed poor quality feeds to animals. Because the secondary metabolites from fungus can affect the hormonal secretion in a rapid non-genomic manner, the fungus in feed might be one of the important causes of infertility among cattle and other livestock in Nepal. But further studies are required to verify these findings in our situation.

CONCLUSION

Infertility is one of the important problems and a major hurdle in livestock development in Nepal. The recent advances in molecular research described above imply disruptions in development of gonads and follicles there-in. Moreover, availability of exogenous mycoestrogens are likely to interfere with reproductive function. As the world aims to achieve the sustainable development goals of the United Nations by 2030, the success in improving the production and productivity of cattle and buffaloes together with other species will be a major milestone to ensure food and nutrition security of the people in general and income of livestock farmers.

Cattle being the national animal and worshipped by two-thirds of Nepalese, the improvement of reproductive efficiency of cattle is vital as large numbers of unproductive cattle compete for food and water and also cause various social problems.

Rearing large number of unproductive animals will increase the overall cost of production of livestock products and thus make animal source foods expensive. Further, carbon secretion per unit volume of milk production is also greatly increased when the proportion of the unproductive cattle is large. Improving reproductive efficiency could address many social and technical problems. This improvement can be brought with good management through application of recent knowledge and technologies described above. The applied part of these recent advances may need minor modification in our context. It is recommended that the public, private and the co-operative sector explore the possibilities to contribute to the research and development on feed and fodder quality and reproduction management for enhancing reproductive performance of livestock for increased production and productivity of the livestock businesses.

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Manuscript format

1. All contents in the manuscript must be written in English and not published. Manuscripts should be typed in Times New Roman font.
2. The title should be short, clear and informative but it should reflect the contents in the paper.
3. The abstract should be in italics 9 point font size, not exceeding 200 words and contain a brief account of the introductory words, major objective, methodology, findings and conclusions. It should not include any diagram, table, references etc.
4. Key words: 5-10 words follows the abstract in alphabetical orders.
5. Main text of the technical manuscripts should include Introduction, Methodology, Result and Discussion, Conclusion, References (APA style)
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7. The manuscript should not exceed 5000 words in total . It should be in MS- word with pages set A4 size, the top and left margins at 3cm and the right and bottom margins at 2.5cm. The text format should be on Times New Roman font font of unless otherwise specified, 12-point size.

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8. References: APA style guidelines should be followed as per following description

   1. Book with single author: Last name, Initial (s). (Year). Title, Place: Publisher. For eg. Pant, P. R. (1975). Social science research and dissertation writing. Kathmandu: Buddha Academic Enterprises.

   2. Book with two authors or more: Last name, Initial (s), & Last name, initial (s). (Year). Title, Place: Publisher. For eg. Phillips, J., Ajrouch, K., & Hillcoat-Nalletamby, S. (2010). Key concepts in social gerontology. London: Sage

   3. Edited book: Last name, Initial (s). (Ed.). (Year). Title (ed.), Place: Publisher. For eg. Cash, T. F., & Smolak, L. (Eds.). (2011). Body image: A handbook of science, practice,

and prevention (2nd ed.). New York: Guilford Press.

4. Use (Ed.) if one editor and (Eds.) if two or more editors: Kozier, B., Erb, G., Berman, A., Snyder, S., Harvey, S., & Morgan-Samuel, H. (Eds.). (2012). Fundamentals of nursing: Concepts, process and practice (2nd ed.). Harlow: Pearson. Woodhead, S. (Ed.). (2013). A core care pathway children with life-limiting and life threatening conditions (3rd ed.). Bristol: Together for Short Lives.

5. Chapter in edited book: Last name, Initial (s). (Year). Chapter title. In initial. Last name (eds.)., Book title (pages of chapter). Place: Publisher. For eg. Benton, D. (2011). Diet, behaviour and cognition in children. In D. Kilcast & F. Angus (Eds.), Developing children's food products (pp. 62-81). Cambridge: Woodhead.

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7. Thesis: Author, A. A. (year). Title of doctoral dissertation or master's thesis (Unpublished doctoral dissertation or master's thesis). Name of institution, Location. For eg. Pokhrel, N. (2014). Effects of different fertilization and feeding systems on water quality and growth performance in Nile tilapia (Unpublished master thesis). Agriculture and Forestry University, Chitwan, Nepal).

8. Journal article: Last name, Initial (s), & Last name, initial (s). (Year). Article title, Volume number (issue or part number if needed), page numbers. For eg. Blann, A. (2014). Why do we test for urea and electrolytes? Nursing Times, 110(5), 19-21. Tapper, K., Shaw, C., Ilsley, J., Hill, A. J., Bond. F. W., & Moore, L. (2009). Exploratory randomized controlled trial of a mindfulness-based weight loss intervention for women. Appetite, 52, 396-404.

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13. Website: Author. (Year). Title, Retrieved month day, year, from URL. For eg. American

Psychological Association. (2015). APA style blog. Retrieved September 25, 2015, from http://blog.apastyle.org/

14. Personal communication: G. P. Mooney (personal communication, June 6, 2013) Use your judgment in citing other electronic forms of personal communication. What you cite should have scholarly relevance.

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Great Britain. Department for Constitutional Affairs. (2007). Mental Capacity Act 2005: Code of Practice. London: TSO. In text citations: APA style guidelines should be followed, as shown below, for text

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